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# Impact of Climate Change on Growing Season Rainfall and Temperature and Crop Yields in Abia State, South-Eastern Nigeria

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## ABSTRACT

*Climate Change poses a big threat to agriculture by altering the growing season of crops thereby resulting to serious danger to food production. Therefore, this work has examined the impact of climate change on the growing season of maize (Zea mays) and cassava (Manihotesculenta) yields in Abia State, South-Eastern Nigeria. The rainfall and temperature data were obtained from Nigerian Meteorological Agency (NIMET) and crop yield derived from the archives of the Federal Ministry of Agriculture (FMA) and Agricultural Development Program (ADP) for a period of 30 years which was analyzed using the descriptive statistics, trend graph, anomalies and regression model. Thus, correlational research method was adopted. The analysis showed increasing trend in annual mean maximum with 0.0205 per annum, mean minimum temperature with 0.0143 per annum and mean temperature with 0.0199 per annum while the annual growing season rainfall showed a decrease in trend with-0.3325 per annum. There has been a persistent increase in the mean temperature anomalies especially in the past five (5) years (2012–2016) and rainfall of recent years depicts a decrease anomaly in the last (10) years (2007-2016).. The multiple regression model showed r2 values that ranged between 0.30 – 0.89 revealing that 30 % - 89 % of cassava and maize yields could be explained by rainfall and temperature in the states and the result was significant at $p<0.05$. It reveals that cassava and maize yields are significant depended on rainfall and temperature. The findings show that there is increase in temperature and decrease in growing season rainfall which needs serious attention as people in this part of Nigeria critically depend on rainfall for agricultural practice. It is recommended that government and private sectors should engage in farm irrigation and drilling of water borehole in farm sites as well as increase awareness of the farmers on climate change issues for sustainable food security of the nation.*

**Keywords:** *Climate Change, Agriculture, Food Security, Abia State, Nigeria*

## INTRODUCTION

Agriculture plays a major role in the sustenance of life and property, therefore any challenge that will lead to a reduction in agricultural products will be a threat to human life and livestock. Climate change is affecting a lot of sectors of which agriculture is inclusive. The concept of climate change is inevitably resulting in changes in the frequency, intensity, spatial extent, duration and timing of extreme weather and climate events [1]. Climate change can influence patterns of rainfall, temperature and other variables on timescales anywhere from few weeks to decades. Climate is the primary determinant of agricultural productivity in Abia state which is located the south east region of Nigeria.

Therefore any impact of climate change that will result to a decrease in rainfall or increase in temperature will lead to a decrease in yield which will affect the people of that region considering the role of agriculture in human welfare, economy of the nation call for serious attention. In recent years it has been observed that there has been an increasing trend in the annual mean maximum and minimum temperature anomalies over Nigeria. The rising temperature trend over the country has been persistent since 2000 and 2002 for maximum and minimum temperature respectively. This to

a large extent indicates a warming climate and evidence that the mean annual temperature anomalies have been increasing with time while it was observed that Rainfall experienced a decrease and increase in some parts of the country. [2] Understanding the trends of the rainfall pattern in Nigeria especially in the southern region, will help to justify the influence it has on the different sectors of the economy especially countries that depend so much on rainfall as the major source of water for their agriculture are at a risk. [3] (Ekwe et al, 2014)

In the tropical environment where rain-fed agriculture is predominant, the onset and cessation of the rains ascertain the cultural practices of farmers, such as land preparation, crop variety selection and planting as well as harvesting [3]. Therefore, the extent of vulnerability of crops to climate depends essentially on the development phases of the crop at the period of weather abnormality [4]. The importance of rainfall to agriculture is particularly spectacular in the tropics due to the relatively high temperature all through the year with a persistently high rate of evaporation [5]. Rainfall not only determines the length of the growing season of any location, but it's also significant to planting, germination and the healthy growth of crops [6]. These variations in rainfall influence food crops such as tubers, grains, legumes and vegetables [7]. This shows the importance of rainfall as a source of soil moisture to the overall performance of crops, especially under rain-fed system which is predominant in the south eastern region of Nigeria. Moisture adequacy at the early phase of root crops is crucial to their overall yields. The period between the onset and cessation of the rains marks the length of the growing season [3] which is march to November for south eastern Nigeria [2].Cassava and maize are very important in the tropic as food crops which are not only suitable for food alone; it can also be useful in medicine and as raw materials for industries [8] as well as intercropping with short duration crops. This research identified the trends and changes in the growing season rainfall pattern and temperature and their impact on the yield of maize and cassava.

## MATERIALS AND METHOD

### Description of Study Location

Abia State is located in South-East of Nigeria, approximately within latitudes 5° and 6° north and longitudes 7°15 and 7°45 east (Figure 1). It occupies about 6,320 square kilometers bounded in the north by Enugu, north east by Ebonyi, in south and south-west by Rivers, in the east and south-east by Cross River and Akwa Ibom states. It is bounded in the west by Imo and in the northwest by Anambra having population of 2,845,380 persons [9] [10] Farming is the major occupation of the people of Abia State; this is induced by the rich soil which stretches from the northern to the southern parts of the state. Subsistence farming is prevalent and about 70 per cent of the population is engaged agriculture.

The study deployed the correlational research method. Data for rainfall and temperature and that for crop yields were obtained from Nigerian Meteorological Agency (NIMET) and Federal Ministry of Agriculture; Agricultural Development Program (ADP) for a period of 30 years. The crops (cassava and maize) were selected for this study because they are commonly planted and consumed by the people of the state. To find out the impact of climate change on the growing season rainfall and temperature on maize and cassava, data on growing season rainfall were taken from April to November. The Mean, linear trend graph, trend anomalies were used to identify the observed changes in the climate of Abia State and the multiple linear regressions was deployed to observe the significance of climate change on maize and cassava yield. The multiple regression analysis was used to determine the relationship between the dependent variable and a case of more than two independent variables. In this study, the dependent variable used was crop yield (maize and cassava) and the independent variables were climatic elements (rainfall and Temperature).

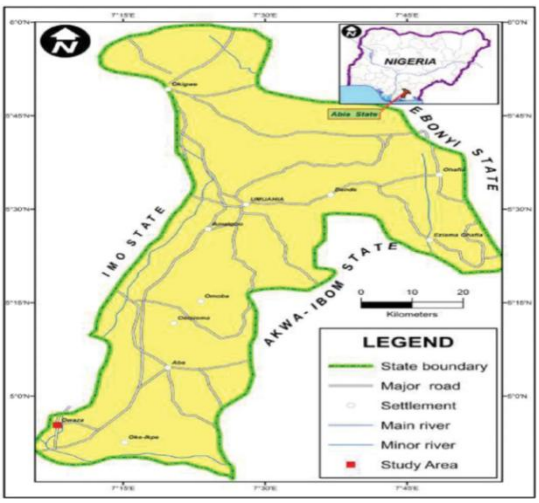


**Figure1.** *Abia State, South-East of Nigeria*

## RESULTS AND DISCUSSION

### Annual Mean Temperature Anomalies

The annual mean temperature anomalies between1987-2016 in Abia State are presented in Figure 2. The result of the fourth order polynomial shows that the annual mean temperature anomalies fluctuated with an increase in temperature between 1987 and 2016. In the period of 1987- 1997 (10 years) the curve was below the average mean, while between 1998 – 2009(12 years), it was above the mean and it decreased below the mean again for 4 years ( 2010-2013 )and in 2014 - 2016 temperature increased this shows a high level of temperature variability and warming climate in Abia state which is increasing with time.

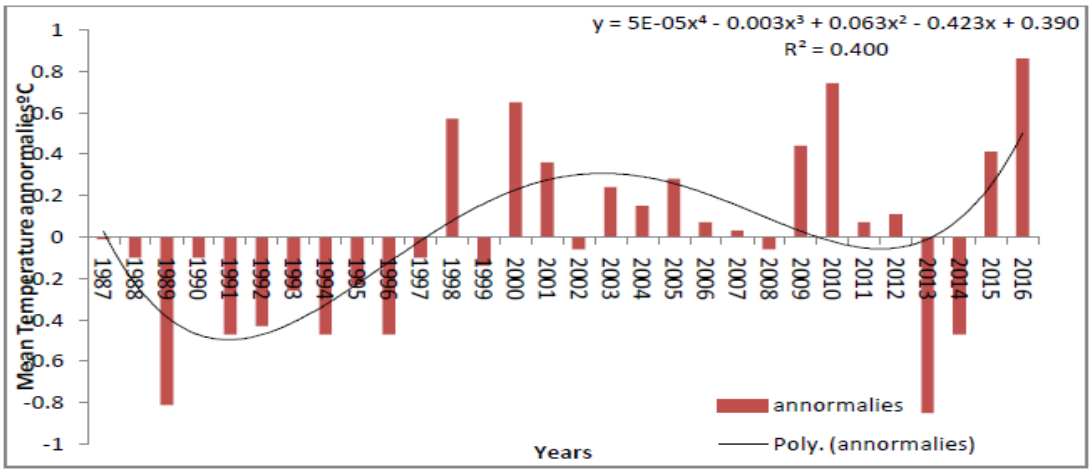


**Figure2.** *Annual Mean Temperature Anomalies in Abia State (1987-2016)*

### Annual Mean Rainfall Anomalies

The trend of annual mean rainfall in Abia State between 1987 and 2016 is presented in Figure 3. Result of the third order polynomial showed that the annual rainfall in Abia State experienced an increasing trend from 1987 up to 2000 and downward trend thereafter till 2016. This indicates a decrease in rainfall over time.

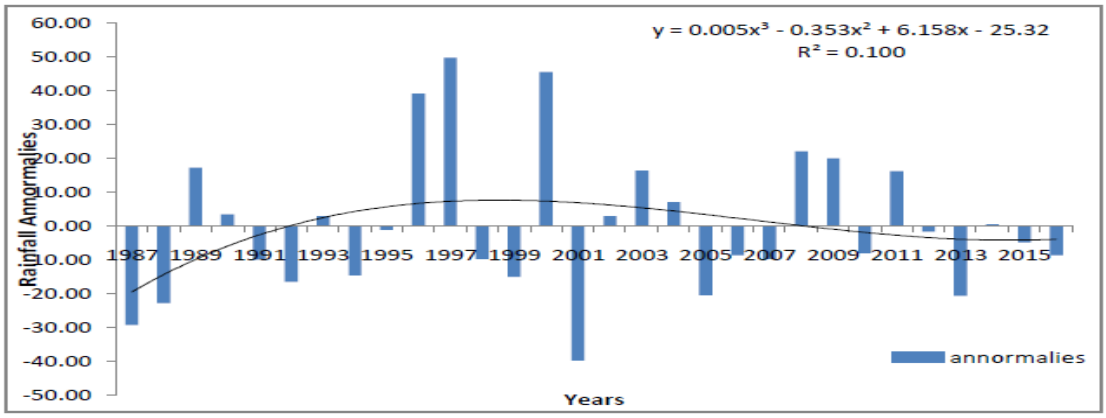


**Figure3.** *Anomalies of Annual Mean Rainfall over Abia State 1987-2016*

### Annual Trend of Mean Minimum and Maximum Temperature and mean Temperature

Maximum temperature trend analysis of Abia State (Figure 4) shows that it fluctuated greatly, with a positive increasing trend of 0.0205 per annum. The highest maximum temperature was in 2010 with value of 32.17 ºC and lowest in 1991 with the value of 30.5 ºC, from 1991 to 2010 which is 20 years, temperature was on the increase, but a sharp drop occurred in 2011 to the lowest maximum temperature in 2013 with the value of 30.75 ºC and it started rising again in 2014 which shows an increasing trend.

The minimum temperature fluctuated greatly (Figure 5) with a positive and increasing trend of 0.0143 per annum. It is observed that the highest values is in 1998, 2000 and 2010 at 23.3ºC and the lowest value in 1989 with the value of 21.6ºC, low trends in 2013 and 2014 with values of 21.9ºC and 22ºC; a sharp increase occurred in 2015 with value of 23.2ºC till 2016.

The mean temperature shows a positive and increasing trend of 0.0199 values per annum (Figure 6) with highest temperature in 2016 with the value of 27.87 ºC and lowest point in 2013 with the value of 26.16ºC this is a positive trend , which is an increase in mean temperature.

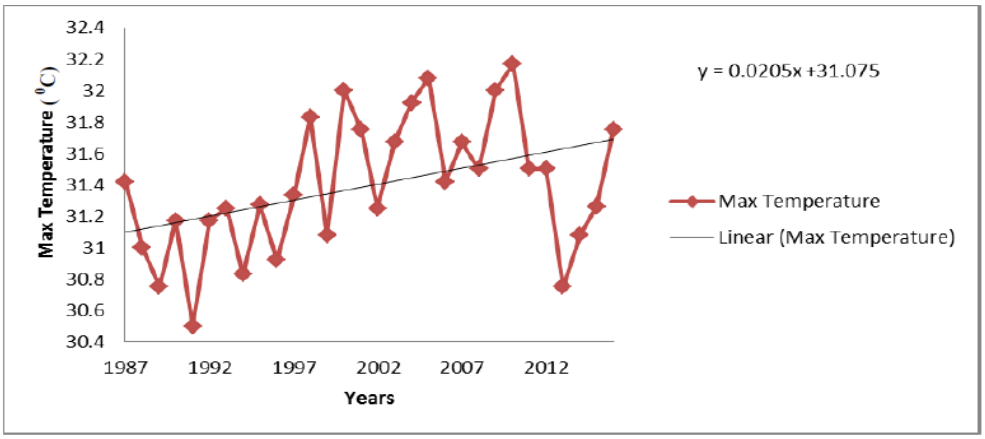


**Figure4.** *Annual Trend of Mean Maximum Temperature of Abia State*

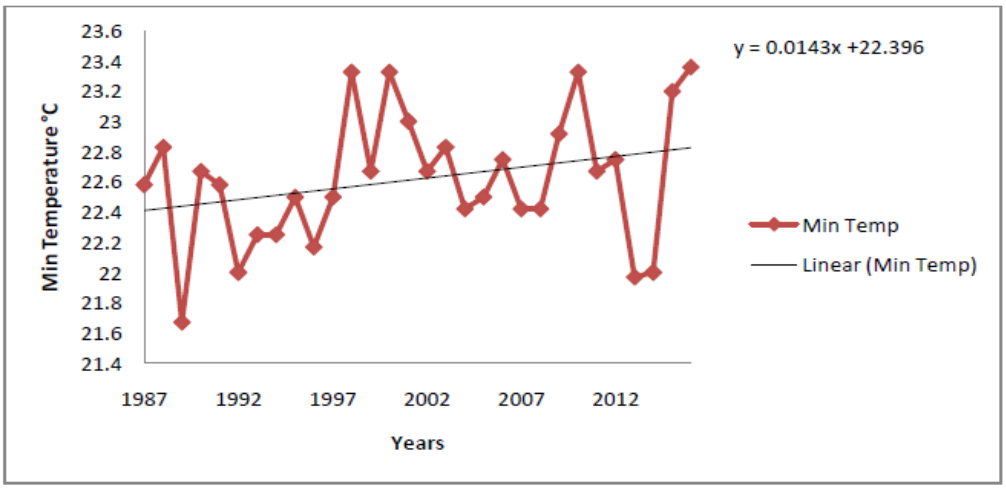


**Figure5.** *Annual Trend of Mean Minimum Temperature of Abia State*

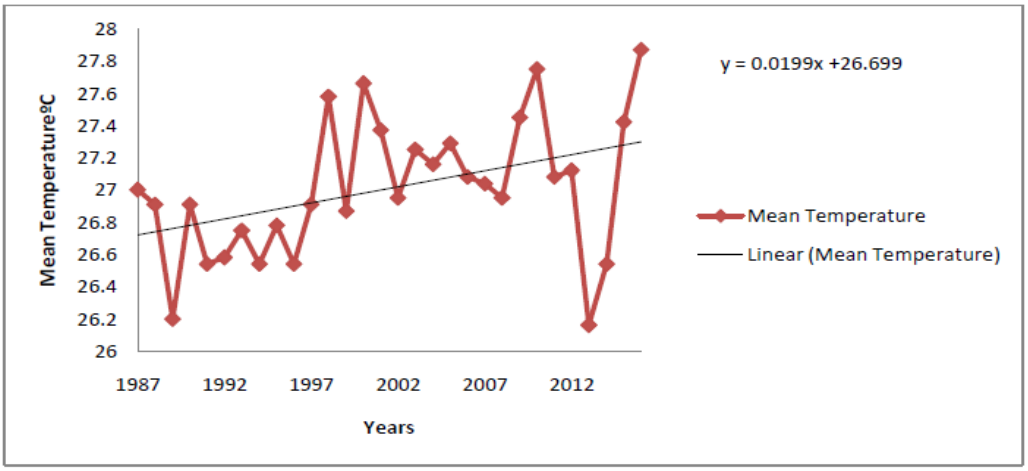


**Figure6.** *Annual Trend of Mean Temperature of Abia*

## The Growing Season Rainfall

The growing season rainfall trend in Abia State (Figure 7) shows that rainfall fluctuated greatly with a negative trend in rainfall and decreasing with -0.3325 value per year which can affect the yield of crops in that region because the main source of water for agriculture is rainfall as observe d in the study period.

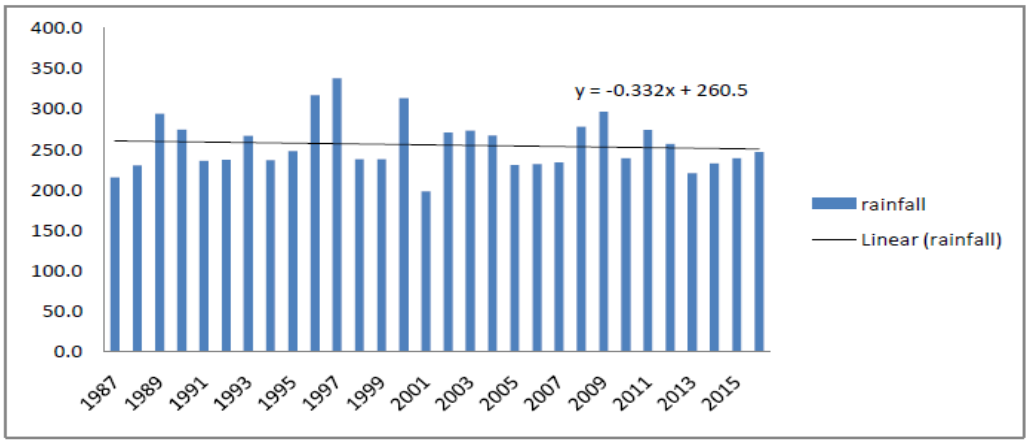


**Figure7.** *Growing Season Annual Rainfall Trend in Abia State*

## Annual Trend of Cassava Yield

The trend analysis for cassava in Abia State, shows that it fluctuated over the years (Figure 8) shows a decreasing trend with -0.6662 value per year with a recovery point in 2016 which is the highest yield with the value of 96.30 kg/ha and lowest point in 2004 with the value of 33.8 kg/ha. This indicates a negative trend of poor yield in cassava.

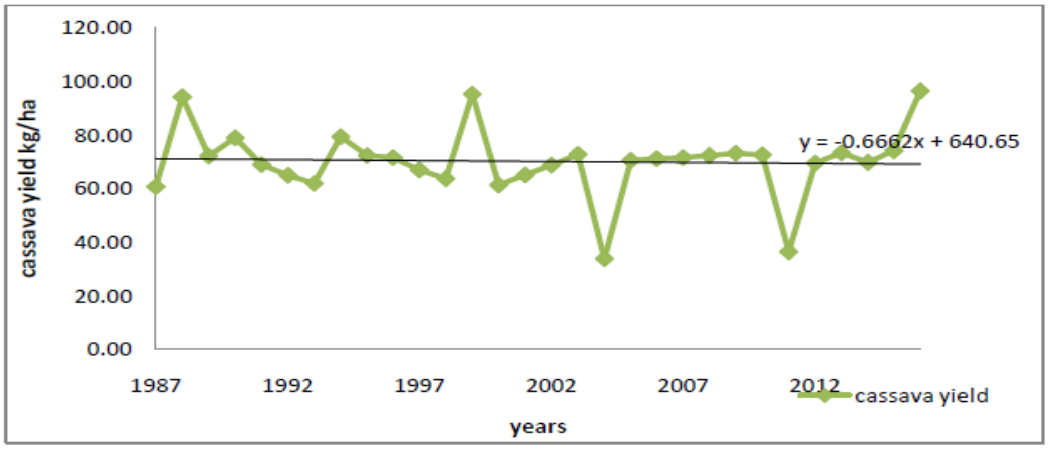


**Figure8.** *Annual Mean Trend of Cassava Yield in Abia State*

## Annual Trend of Maize Yield

The trend analysis for maize in Abia State (Figure9) shows that maize yield in Abia State fluctuated greatly indicating an increased trend with 0.0402value and highest yield in 1996 with the value of 10.4kg/ha and lowest point in 2003 with the value of 4.7 kg/ha expressing increased yield in the period.

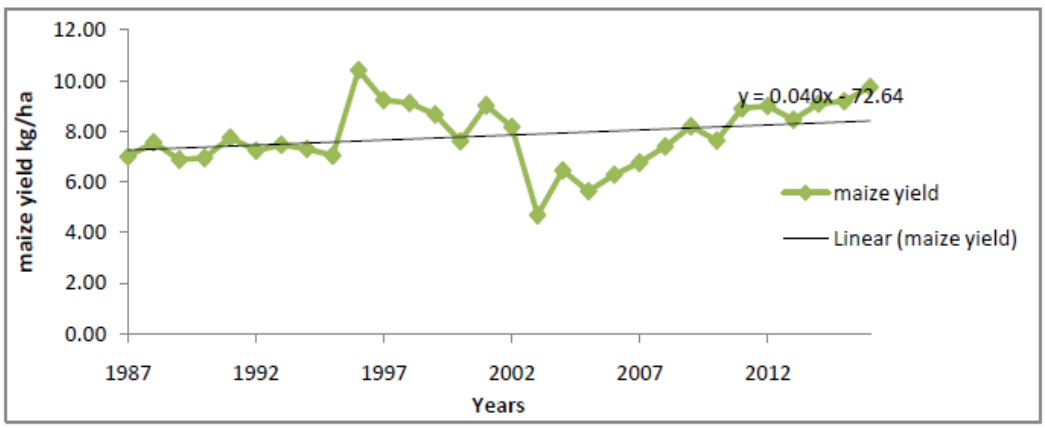


**Figure9.** *Annual Mean Trend of Maize Yield in Abia state*

## The Relationship between Climate Parameters (Rainfall and Temperature) and Maize Yield

### *Regression Model for Factors of Maize Yield in Abia State*

In Table 1 the regressions model summary for maize yield, rainfall and temperature is shown. In the table deduced that the model removed rainfall bearing collinearity issues. However, the model is significant at P<0.05 indicating that maize yield significantly depends on temperature in Abia State. The model showed that there is a positive relationship between temperature and maize yield (r=0.55), although the model could only explain 30.3% of maize yields, leaving the other 69.7% to soil moisture, rainfall, soil fertility, etc.

**Table1.** *Regression Model Summaryof Maize Yield in Abia State*

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Change Statistics | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | R Square Change | F Change | df1 | df2 | Sig. F Change |
| 1 | .945[a] | .894 | .890 | .30735 | .303 | 10.453 | 1 | 29 | .004 |

**Predictors:** *(Constant), temperature*

### Regression Model for Factors of Cassava Yield in Abia State

In Table 2 the regressions model for cassava yield, rainfall and temperature is shown. In the table we deduce that the model removed temperature bearing collinearity issues. However, the model is significant at P<0.05 indicating that cassava yield significantly depends on rainfall in Abia State. The model showed that there is a positive relationship between rainfall and cassava yield (r=0.95), although the model could only explain 89% of maize yields, leaving the other 11% to soil moisture, cassava stem, soil fertility, etc.

**Table2.** *Regression Model Summary of Cassava Yield in Abia State*

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Change Statistics | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | R Square Change | F Change | df1 | df2 | Sig. F Change |
| 1 | .945[a] | .894 | .890 | .30735 | .303 | 10.453 | 1 | 29 | .004 |

**Predictors:** *(Constant), rainfall*

The findings show that there is a significant discernible change in the pattern of climatic parameters over the years. It was observed that the rainfall anomalies using the 3rd order polynomial fluctuated greatly with decreasing trend while temperature using the 4th order of polynomial fluctuated greatly but with an increase. The trend in cassava yield fluctuated greatly with a decrease and maize fluctuated greatly with an increase. Growing season rainfall was on the decrease with highest rainfall in 1989 and lowest rainfall in 1990.Minimum, maximum and mean temperatures were on the increase. The regressions model for maize and cassava yield, rainfall and temperature showed that the model was significant at P<0.05 which showed that cassava yield significantly depended on rainfall while maize yield significantly depended on temperature.

## CONCLUSION

This work has been able to establish that there is an evidence of climate change in Abia State in the south-eastern part of Nigeria for the period of 1987 to 2016. The increase in temperature and decrease in rainfall in the region is in line with the recent warning by IPCC about evidence of climate variability and change in Africa. Also, NIMET also warned about climate change in Nigeria. It is noteworthy that Abia State experienced a decrease in the growing season of rainfall and an increased in maximum and minimum temperature which affected the yield of cassava in the state. This study is very important in south eastern Nigeria where the majorly of farmers depend on rainfall as there major source of water supply for their crops. They need to be informed on the changing climate so that alternative sources can be made available for crop planting. Therefore, there is an urgent need for the government to give more attention to farmers by supporting improved farming systems that will increase yield. The yield of maize and cassava is very important for the people of Abia State because these crops are the major food consumed by the people. Food security is very important to a nation, so the government should put in all the adaptive

measures in ensuring that there is food in the state because it is evident that the climate systems are changing. Government should develop sustained agricultural policies that will promote a better crop yield such as alternative source of water as irrigation and drilling of bore holes as they are experiencing departure in growing season rainfall, It is no longer advisable to rely only on rainfall as the only source of water for farming. The stakeholders should be educated and well-equipped with weather stations in the states so that they can be able to give accurate weather forecast.

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