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# Effect of Climate Change on Maize (*Zea-mays*) and Cassava (*Manihot-esculenta*) Yields in Selected States of South Eastern Nigeria

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## Abstract

Agriculture is one of those activities of man that is greatly affected by climate. Therefore, a change in climate would in no small measure impact on agriculture, location notwithstanding. This work as a result examined the impact of climate change on maize and cassava yields in Southeastern Nigeria. Expost-facto research method in the context of quasi experimental research design was adopted for the study. Data for rainfall and temperature were obtained from Nigerian Meteorological Agency (NIMET); and those for crop yields came from Federal Ministry of Agriculture of Nigeria and Agricultural Development Programme (ADP) of selected states. The data were analyzed using descriptive statistics, multiple linear regressions and analysis of variance. Results showed that, there are evidences of climate change in Southeastern Nigeria, with notable fluctuations in the identified trends. Employing the trend analysis represented by the least square line, Abia State rainfall is increasing at 0.1026mm per annum, while Imo State is decreasing at -1.1255 mm per annum. All the states recorded positive slopes in mean temperature which shows an increase in their trends. The multiple regression model showed R2 values that ranged between 0.25 – 0.29 revealing that only 25 %- 29 % of cassava and maize yields could be explained by rainfall and temperature across the states and the result was significant at $p<0.05$ revealing that cassava and maize yields significantly depended on rainfall and temperature. Crop yields were also significantly different spatially. As a result of the findings the study strongly advocates, development of better and sustained environmental policies that will be beneficial to climate systems while creating sustainable food security.

**Keywords:** Climate Change; Maize; Cassava; Food Security; Southeastern Nigeria.



## 1. Introduction

In recent times climate change has posed as a threat to agriculture and other sectors in the world [1, 2]. Climate change connotes non-conformity with the established climate (known climate patterns) derived using statistical tests or physical science models on observed means of the weather elements, that is sustained over a normal or two [3]. The concept of Climate change has become an important environmental, social and economic issue. It is an unprecedented challenge every nation is facing and its impacts over the past decades are tending towards global warming, indicating that an urgent action needs to be taken towards preparedness and adaptation [1]. Consequently, regional weather and climate dynamics are key influential aspects of the global changing climate. The hour-to-hour, day-to-day, and season-to-season changes in the atmospheric conditions, implies weather; and when these processes are viewed in terms of extended time series of decades, centuries and up to interval of millions of years, then it is known as climate [2]. Climate change in IPCC usage refers to a change in the state of the climate that can be identified (e.g. using statistical tests). Therefore, changes in the mean and/or the variability of its properties, that persists for an extended period, typically decades or longer is referred to as climate change.

However, agriculture continues to be the mainstay of the Nigerian economy, (apart from oil) it is an important contributor to employment and food security of rural households [4]. Nonetheless, Climate change has significantly affected global agriculture in the 21st century and the Intergovernmental Panel on Climate Change (IPCC) assessment report, indicates that, most countries will experience an increase in average temperature, more frequent heat waves, more stressed water resources, desertification, and periods of heavy precipitation [5, 6]. This is particularly, dangerous for sustainable agriculture in the developing world and hence on food security. Reason being that, the system of agriculture is vulnerable to harsh weather conditions and climate, since they are climate dependent. Thus the improvement in seedlings and irrigation support systems, have not amounted to much for crop yield in the developing world [4], since farmers are perpetually in penury.

Nevertheless, climate change impacts have become significant for crop yields [6] in the developing world and studies have shown [7-10] that the region under review has witnessed increasing trends in the annual mean, maximum and minimum temperatures for periods between 1986-2015 and 2000-2002. While rainfall in the past two decades shows a positive an anomaly which corresponds to the wet /flood years recorded in Nigeria [7]. The effects of these changes on crop yield are low returns on agricultural investments and hence on food security. Food is essential to human life, health and well-being. As a result, quantity and quality is essential and sufficiency is required, given rapid human population increases. However, this is not going to be attainable in the face of changing

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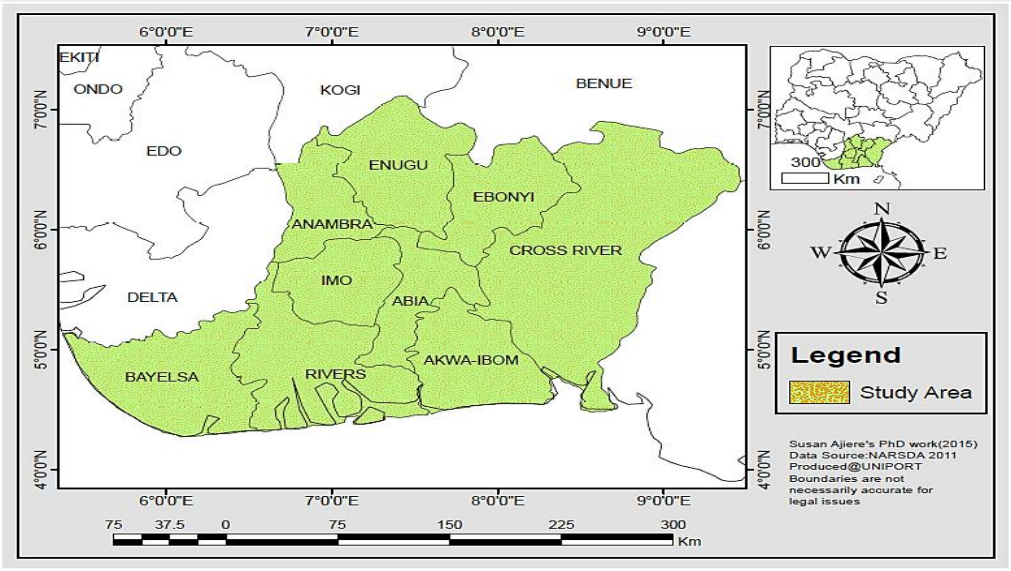
climate. It is therefore critical to examine, the effect of climate change on maize and cassava yields in selected states of south eastern Nigeria. Since these crops, account for 40% of food consumption in this region [8].

## 2. Materials and Methods

The geographical location of Southeastern Nigeria falls within latitudes 4°10'N to 7°08'N and longitudes 5°30'E to 9°27'E (fig. 1). The region has an area of 75, 488 km2, it is bounded to east by the Republic of Cameroon, to the west by Delta State, to the north by Benue State and to the south by the Gulf of Guinea. The states in Southeastern Nigeria used for this work are Abia, Enugu and Imo States.

**Fig-1.** Southeastern Nigeria Showing States




In terms of climate the area can be classified under the tropical type based on the koppen's classification. The climate there is controlled by the tropical continental and tropical maritime airmass. The seasons are; the rainy and dry seasons. There is however a short dry season which occurs between the end of July and early August and is known as August Break. Although in recent years, there has been a disruption in the occurrence of this break and [11] identifies it as evidence of climatic change. Nonetheless, anthropogenic activities, which include deforestation, oil exploration & exploitation, over-cultivation etc, have altered the climate of the area and the result is a downward trend in crop yields for farmers and hence on food security.

In terms of methods, the study deployed the expost-facto research method in the context of quasi experimental research design. Data for rainfall and temperature and that for crop yields were obtained from Nigerian Meteorological Agency (NIMET) for a period of 30 years and Federal Ministry of Agriculture; Agricultural Development Programme (ADP) also for a period of 30 years. 30 year because the Bruckner cycle assumption was imbibed. The justification for selecting the crops (Cassava and Maize) used for the study, is that the crops are the most consumed food crops in the region under review. However, to find out the spatial variation in crop yields, Analysis of Variance was used (ANOVA). The justification for this is that the researcher intended to find out the variation in yield across the three selected states. Furthermore, to find out the rates of crop yields dependence on rainfall and temperature, the multiple linear regressions was deployed. Finally, descriptive statistics, trend graph where used.

## 3. Results and Discussion

The results of the analyses show a general change in the seasonal rainfall regime the month with the highest monthly rainfall is August in Imo State and September in Enugu and Abia States (see Fig. 1) and the well-known august break was not observed. The month of August, in fact recorded a very high amount of rainfall. It was also observed that rainfall, was at its peak towards the end of the growing season and beginning of another planting season for maize, which cannot be tolerated by both crops especially maize. The results reveal, that all the states experienced the highest Mean temperature at the peak of the dry season in February for Imo state with 29.74 ºC and march for Enugu and Abia States with 29.70 ºC and 28.51 ºC respectively. This can move the onset of planting from March to April. See table 2. Mean Temperature was highest in Imo State as compared to Enugu State and Abia States.

**Table-1.** Mean Monthly Rainfall (mm) across some selected states of South-Eastern Nigeria (1987-2016)

| | **Enugu** | **Imo** | **Abia** |
|---|---|---|---|
| **Lowest rainfall(mm)/month** | 12.13 (JAN.) | 17.44 (DEC.) | 9.89 (DEC) |
| **Highest rainfall (mm)/month** | 294.03 (SEPT.) | 377.21 (AUG.) | 354.05 (SEPT) |

**Table-2.** Mean Monthly Temperature across some selected States of South Eastern Nigeria (1987-2016) ºC

| States | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Lowest | Highest |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Enugu | 27.40 | 29.27 | 29.70 | 28.75 | 27.62 | 26.79 | 26.20 | 25.98 | 26.28 | 26.69 | 27.46 | 26.75 | 25.98 (Aug) | 29.70 (Mar) |
| Imo | 28.37 | 29.74 | 29.39 | 28.87 | 28.09 | 27.21 | 26.25 | 26.27 | 26.81 | 27.26 | 28.36 | 28.30 | 26.25 (July) | 29.74 (Feb) |
| Abia | 26.88 | 28.49 | 28.51 | 28.14 | 27.45 | 26.53 | 25.84 | 25.68 | 25.98 | 26.48 | 27.23 | 26.85 | 25.68 (Aug) | 28.51 (Mar) |

The mean annual rainfall trends in Abia (Fig.2) Imo (Fig 3) and Enugu (Fig. 4) showed significant variation in spatial and temporal patterns of rainfall which affected maize and cassava yield across the states. it is observed that Abia State and Enugu State possess positive slopes and consequently upward trends though with differing steepness in slopes and a slight increase in annual rainfall while Imo State has a negative slope meaning downward trends which is a decrease in rainfall in the states. Across the states of study, Imo State has a decrease in rainfall per annum for the period of study

**Fig-2.** Annual rainfall total Trend of Enugu State

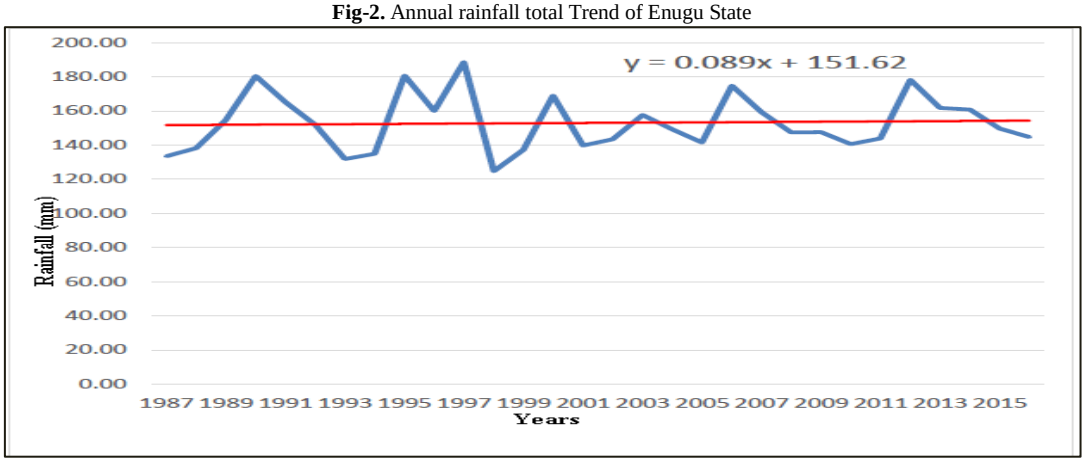



**Fig-3.** Annual rainfall total Trend of Imo State

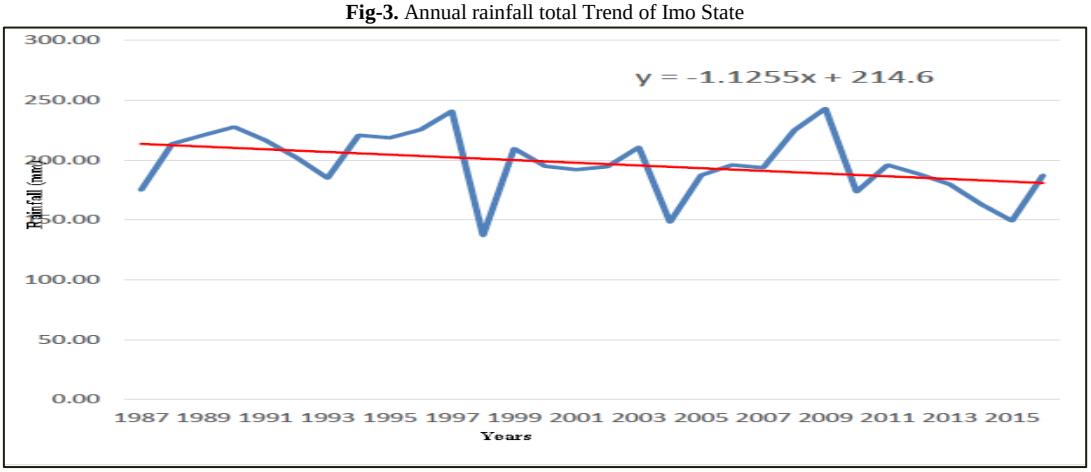
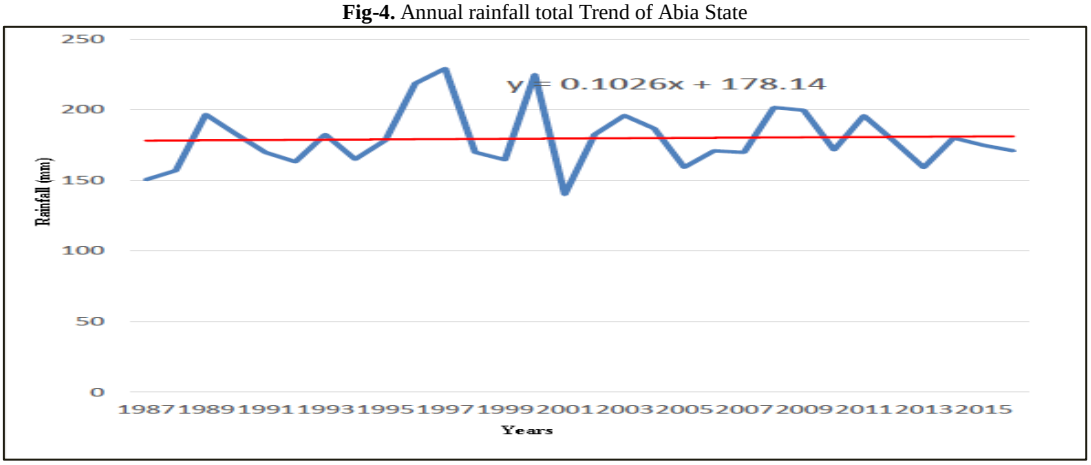



**Fig-4.** Annual rainfall total Trend of Abia State



Employing the trend analysis represented by the least square line, the annual mean temperature of Abia State is increasing at 0.0199 per annum, Enugu is increasing at 0.00009 per annum and Imo is increasing at 0.0151 per annum A further examination of the trend line of the regression, it is observed that Mean Temperature of Abia State, Enugu State and Imo State possess positive slopes and consequently upward trends, which is an increase in mean temperature though with differing steepness in slopes. Abia state has the highest rate of increase in mean temperature per annum while Enugu state has the least. See fig 4. fig 5 and fig .6

**Fig-5.** Annual mean temperature trend of Imo state

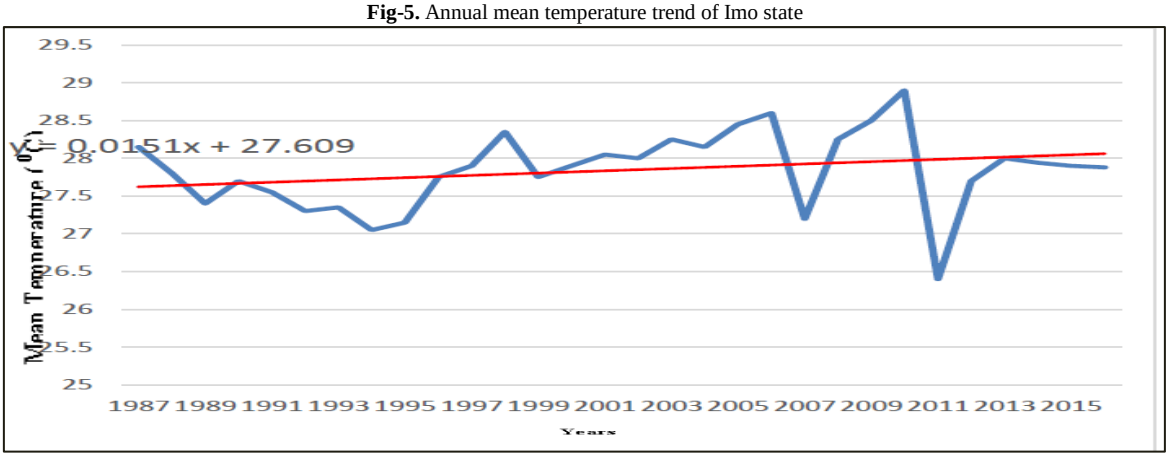



**Fig-6.** Annual mean temperature trend of Enugu state

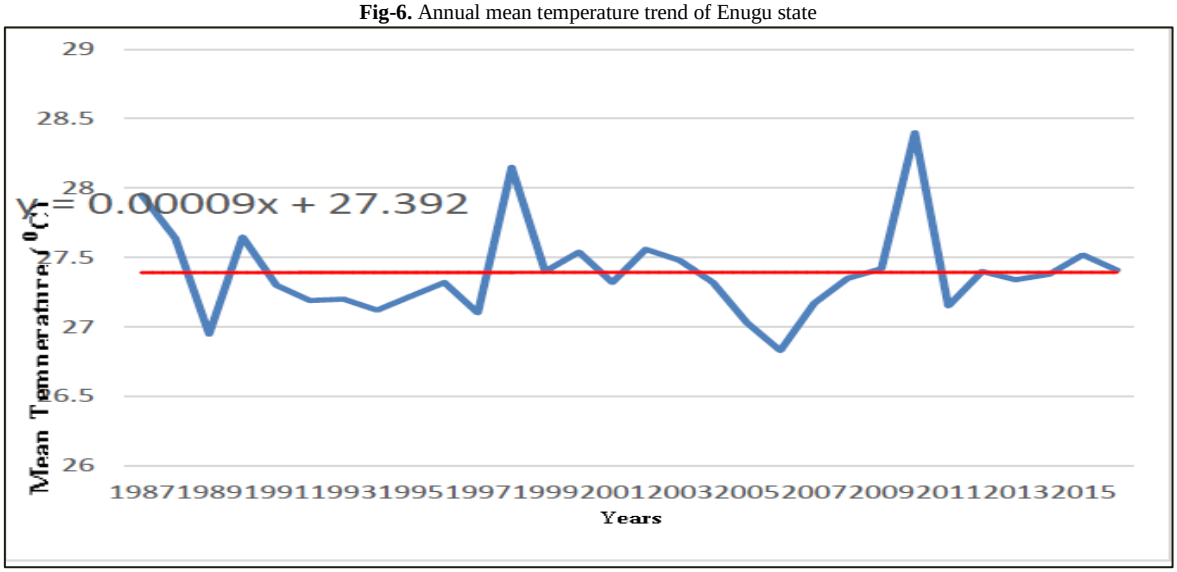
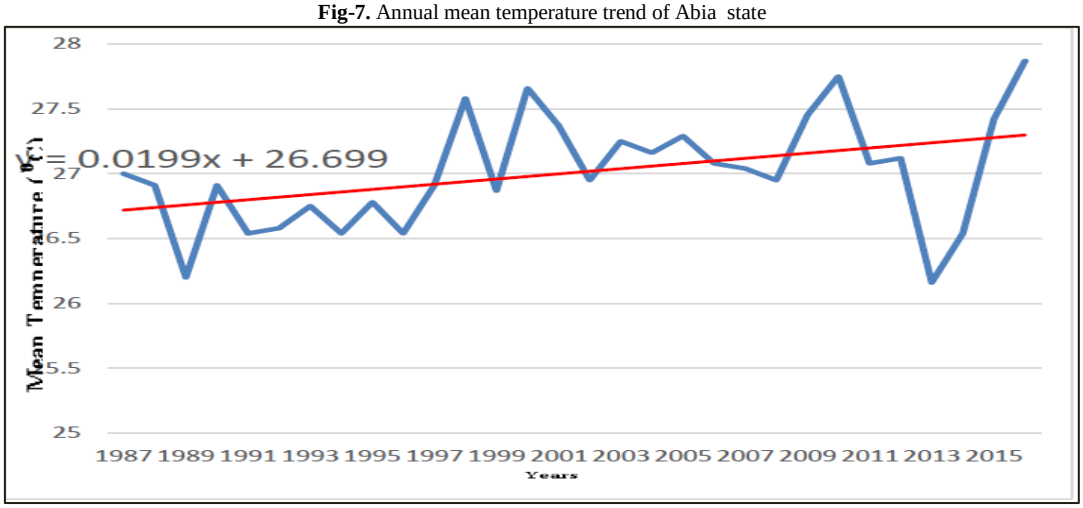



**Fig-7.** Annual mean temperature trend of Abia state




The regression analysis revealed a coefficient of determination of 27% for maize in Abia State, Enugu State is 29 %, and Imo State is 25%, revealing that there is a positive correlation between maize yields, rainfall and temperature, see table 3, table 5 and table 7.

**Table-3.** Regression Model Summary for maize yield in Abia State

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Change Statistics | | | | | Durbin-Watson |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | R Square Change | F Change | df1 | df2 | Sig. F Change | |
| 1 | .521[a] | .272 | .218 | 18.92552 | .272 | 5.034 | 2 | 27 | .014 | .529 |

a. Predictors: (Constant), Temperature_Abia, rainfall_Abia

Table 4 shows that the model is significant at F (5.034)=p<(0.05). This shows that maize yield in the area significantly depends on rainfall and temperature in Abia State and Enugu State. Table 6, shows that the model is significant at F (5.472)=p<(0.05). This shows that maize yield in the area significantly depends on rainfall and temperature.

**Table-4.** ANOVA[b] result for maize yield in Abia State

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 3605.988 | 2 | 1802.994 | 5.034 | .014[a] |
| | Residual | 9670.738 | 27 | 358.175 | | |
| | Total | 13276.726 | 29 | | | |

a. Predictors: (Constant), Temperature_Abia, rainfall_Abia

b. Dependent Variable: Maize yield

**Table-5.** Regression Model Summary of maize yield in Enugu State

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Change Statistics | | | | | Durbin-Watson |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | R Square Change | F Change | df1 | df2 | Sig. F Change | |
| 1 | .537[a] | .288 | .236 | 27.56722 | .288 | 5.472 | 2 | 27 | .010 | 2.105 |

a. Predictors: (Constant), Temperature_Enugu, rainfall_Enugu

b. Dependent Variable: Crop_yield

**Table-6.** ANOVA of maize yield in Enugu State

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 8317.596 | 2 | 4158.798 | 5.472 | .010[a] |
| | Residual | 20518.689 | 27 | 759.951 | | |
| | Total | 28836.284 | 29 | | | |

a. Predictors: (Constant), Temperature_Enugu, rainfall_Enugu

b. Dependent Variable: Crop yield

**Table-7.** Regression Model Summary of maize yield in Imo State

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Change Statistics | | | | | Durbin-Watson |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | R Square Change | F Change | df1 | df2 | Sig. F Change | |
| 1 | .500[a] | .250 | .194 | 69.89793 | .250 | 4.501 | 2 | 27 | .021 | 1.138 |

a. Predictors: (Constant), Temperature, rainfall_Imo

b. Dependent Variable: Maize_yield

Also in Imo State, table 8 shows that the model is significant at F (4.501)=p<(0.05). This shows that maize yield in the area significantly depends on rainfall and temperature in Imo State.

**Table-8.** ANOVA of maize yield in Imo State

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 43979.364 | 2 | 21989.682 | 4.501 | .021[a] |
| | Residual | 131914.443 | 27 | 4885.720 | | |
| | Total | 175893.807 | 29 | | | |

a. Predictors: (Constant), Temperature, rainfall_Imo

b. Dependent Variable: Maize_yield

The coefficient of multiple determination percentages which is the strength of the relationship for cassava in Abia State is 22%, Enugu State is 25%, Imo State is 28%,, the results of the $r^2$ reveals that there is a correlation

between rainfall, temperature, and maize yield, it shows that the coefficients (temperature and rainfall) affect cassava yield more in Imo state than Enugu and Abia states, see table 9, table 11 and table 13.

**Table-9.** 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 | Durbin-Watson |
| 1 | .470[a] | .221 | .163 | 119.68220 | .221 | 3.823 | 2 | 27 | .035 | 2.020 |

a. Predictors: (Constant), Temperature, rainfall_Abia

b. Dependent Variable: cassava

In table 10 the model is significant at F (3.823)=p<(0.05). This shows that cassava yield in the area significantly depends on rainfall and temperature in Abia State.

**Table-10.** ANOVA of Cassava yield in Abia State

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 109528.390 | 2 | 54764.195 | 3.823 | .035[a] |
| | Residual | 386743.371 | 27 | 14323.829 | | |
| | Total | 496271.760 | 29 | | | |

a. Predictors: (Constant), Temperature, rainfall_Abia

b. Dependent Variable: cassava

**Table-11.** Regression Model Summary of Cassava yield in Enugu 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 | Durbin-Watson |
| 1 | .505[a] | .255 | .200 | 258.29051 | .255 | 4.623 | 2 | 27 | .019 | 1.720 |

a. Predictors: (Constant), Temperature, rainfall_Enugu

b. Dependent Variable: cassava

In Enugu state, table 12 shows that the model is significant at F (4.623)=p<(0.05). This shows that cassava yield in the area significantly depends on rainfall and temperature.

**Table-12.** ANOVA of Cassava yield in Enugu State

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 616773.944 | 2 | 308386.972 | 4.623 | .019[a] |
| | Residual | 1801277.674 | 27 | 66713.988 | | |
| | Total | 2418051.619 | 29 | | | |

a. Predictors: (Constant), Temperature, rainfall_Enugu

b. Dependent Variable: cassava

**Table-13.** Regression Model Summary[b] of Cassava yield in Imo 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 | Durbin-Watson |
| 1 | .535[a] | .287 | .234 | 674.87358 | .287 | 5.427 | 2 | 27 | .010 | .858 |

a. Predictors: (Constant), Temperature, rainfall_imo

b. Dependent Variable: cassava

Also, table 14 shows that, the model is significant at F (5.427)=p<(0.05). This shows that cassava yield in the area significantly depends on rainfall and temperature in Imo State.

**Table-14.** ANOVA[b] of Cassava yield in Imo State

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 4943911.000 | 2 | 2471955.500 | 5.427 | .010[a] |
| | Residual | 1.230E7 | 27 | 455454.343 | | |
| | Total | 1.724E7 | 29 | | | |

a. Predictors: (Constant), Temperature, rainfall_imo

b. Dependent Variable: cassava

It also shows from the absolute standardized coefficient that the effect of temperature is higher than rainfall on maize and cassava yield in all the states except for Enugu State where rainfall has more impact on maize and cassava yield. So an increase in Temperature over a period of time can lead to a decrease in Cassava and maize yield in Imo and Abia State.

**Table-15.** Coefficientsa of cassava yield in Abia,c/river,Enugu, imo and Rivers State

| States | Model | Standardized Coefficients Beta |
|---|---|---|
| Abia cassava | Rainfall | .016 |
| | Temperature | -.470 |
| Abia Maize | Rainfall | -.053 |
| | Temperature | -.518 |
| Enugu cassava | Rainfall | .535 |
| | Temperature | .299 |
| Enugu Maize | Rainfall | .500 |
| | Temperature | -.084 |
| Imo cassava | Rainfall | -.220 |
| | Temperature | .426 |
| Imo Maize | Rainfall | .397 |
| | Temperature | .446 |

To determine the variation of maize and cassava yield across the states Table 15 shows that Imo State has the highest mean while Abia State has the lowest mean and since the p-value is less that the significant level, it means that some of the group means are different, but not which pairs of groups. Fisher Pairwise Comparisons was used to determine whether the mean differences between specific pairs of groups are statistically significant and to estimate by how much they are different. It can be seen from Table 16 that they differ significantly from Enugu state, Imo State and Abia State. Abia State recorded the least maize yield while Imo State recorded the highest maize yield and for cassava Table 16 shows that Enugu state has the highest mean while Abia State has the lowest mean and since the p-value is less that the significant level, it means that some of the group means are different, but not which pairs of groups. This shows us that there is no significant difference in the cassava yield for, Imo and Enugu State, but Abia states differ significantly from the two states. Abia State has the least cassava yield while Imo and Enugu State recorded the highest cassava yield.

**Table-16.** Grouping Information of maize and cassava yield using the Fisher LSD Method and 95% Confidence

| Factor | N | Mean of maize | Grouping of Maize yield | Mean of cassava | Grouping of cassava yield |
|---|---|---|---|---|---|
| Imo | 30 | 167.9 | A | 2175.2 | A |
| Enugu | 30 | 92.59 | C | 2301.9 | A |
| Abia | 30 | 70.36 | D | 630.3 | C |

# 4. Conclusion

In conclusion this work has been able to establish that there is an evidence of climate change in Southeastern, Nigeria. The changing patterns of rainfall and temperature in the region is in line with the earlier warning by IPCC (2007, 2014, NIMET, 2016). The fluctuation and change in pattern of rainfall showed a decrease in rainfall in Imo state and slight increase in Abia and Enugu states. It was also noted that rainfall and temperature impacted on the yield of maize and cassava in all the states as shown by the coefficients of determination. This ranged from 22% -29 %. The implication of this is that, rainfall and temperature can only explain the percentages above, leaving the other 71% to soil types, farming techniques applied, and cassava stems used. All of which have not been used as predictors in the current study, thus suggesting a need for further studies in which these factors will be included.

# 5. Recommendations

Food security is very important to a nation, so government at both regional and national levels are by this study implored to put in place adaptive measure in ensuring that three is food in the county because it is evident that the climate systems are changing as a result, Government should develop better and sustained environmental policies that will benefit agriculture, especially crop yield. Similarly, there is need to educate stakeholders, and farm agents

on the realities and effect of climate change on crop yield so that they can reach out to the farmers. Furthermore, alternative sources of water should be made available to farmers in the south eastern Nigeria because, investigations revealed that, some states are experiencing negative anomalies in rainfall. Thus it is no longer advisable to rely only on rainfall as the only source of water for farming. Individuals, industries and companies should be encouraged to go in to food processing and preservation so that any year where there is more yield the crops will not be wasted but preserved.

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