# Impact of Climate Variability on Rainfall and Temperature Distribution on Yam Yield (Dioscorea alata) in Ngor-Okpala Local Government Area of Imo State, South-Eastern Nigeria.

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***Abstract***
*The study assessed climatic variability of temperature and rainfall distribution on yam yield in Ngor-Okpala Local government Area of Imo State, South-eastern Nigeria. The study employed the use of secondary data. Rainfall and temperature data was collected from Nimet, Sam Mbakwe international cargo Airport, Imo state. Data on yam yield was collected from Agricultural development programme Owerri for a period of 10 years (2010-2019) and was analyzed statistically using multiple regression, Pearson's bivariate correlation, scatter plot and linear time series with (SPSS version 21). From the results, annual rainfall trend chart revealed a swingy trend pattern in distribution of rainfall for the years under investigation. Average annual temperature and yam yield produced a negative slope of (-0.003) which implies that yam yield reduces as temperature increases. Multiple regression on rainfall and temperature variability revealed that variability in rainfall, maximum and minimum temperature distribution have no significant effect on yam yield within the years under study. Pearson's bivariate correlation analysis measured the extent of relationship between the variables and it revealed little or no correlation between rainfall and yam yield at -0.043, also a weak negative correlation of -0.119 between minimum temperature and yam yield while a weak positive correlation of 0.150 between maximum temperature and yam yield.*

***Key words**: climate, variability, rainfall, temperature, yam yield.*

## 1.0: Introduction

Agriculture in Nigeria is the main source of food and major employer of labour, employing about 60% of the population. It is a rain-fed system and hence vulnerable to climatic variability (1). Agriculture in Nigeria depends highly on climate variability, due to its low level of technology as temperature, rainfall, sunlight relative humidity and soil constitute the main drivers of crops growth and yield (2, 3). Climate variability will affect crop productivity and can cause food security problems (4, 5). Increasing temperature and the variability in pattern of the distribution of rainfall have a substantial impact on food production (6).

In Nigeria yams constitute staple food and contribute more than 200 dietary calories per daily consumption for more than 100 million people as well as significant source of income to farmers (7). Nigeria produced 18.3 million tons of yam from 1.5 million hectares of land respectively about 73.8 % of total yam production in Africa (8). Similarly (9) reports that yams are farmed on about 5 million hectares of land in about 47 countries in the tropical and subtropical regions of the world with more than 54% million tons of it produced in sub-Saharan Africa annually on 4.6 million hectare. The impact of climate variability affects many sectors, including agriculture and food security, health energy, infrastructure, biodiversity forestry resources and settlement patterns (10). Yam is a common name for plant species in the genus of Dioscorea (11). Dioscorea has over 600 species of which about six are identified as economically important stape and edible as major sources of carbohydrate to man's diet. They include Dioscorea rotundata (white yam), Dioscore alata (yellow yam), Dioscorea dumetorum (trifoliate yam), Dioscorea alata (water yam) are widely grown in coastal region of rainforest, world savanna, southern savanna areas (12). Yield of crops is inherently susceptible to cimate variability. Temperature and rainfall are some of climate variables which are primary determinant of crop yield. Increased rainfall variability, prolonged dry spells and droughts have significant effects on yield of crops (13, 14). The distribution of weather patterns including rainfall, temperature over an extended period of time typically decades are impacts of climatic variability (15).

Rainfall generally plays a crucial role in agriculture. It is the deposition of atmospheric moisture on the soil surface in the form of liquid which is the principal source of water for agricultural activities in the world (16). The variability in rainfall distribution affects sustainable agricultural development in different countries of the world. Increased temperature leads to increased evapotranspiration and affects soil moisture availability, which is crucial in the processes of photosynthesis (17). High temperature accelerates phonological growth which results in shortening crop growth periods and hastens heat stress (18).

Globally climate variability accounts for about a third of observed crop yield variability (19, 20). Variability in climate is a major driver of yield inconsistency mostly in Africa, where crop production is largely rain-fed. Climate variability is a major source of risk for agricultural and food system. The increasing severity and frequency of extreme weather have extensively flawed agriculture (21). Despite all recent technological and scientific development, climate and its associated factors remains a major influence on agricultural production in Nigeria due to its dependence on climatic elements.

In Nigeria, rainfall variability has been found to have a significant impact on crop yield (22, 23). This study therefore was carried out to assess the effect of temperature and rainfall distribution on yam yield in Imo state, south-eastern Nigeria.

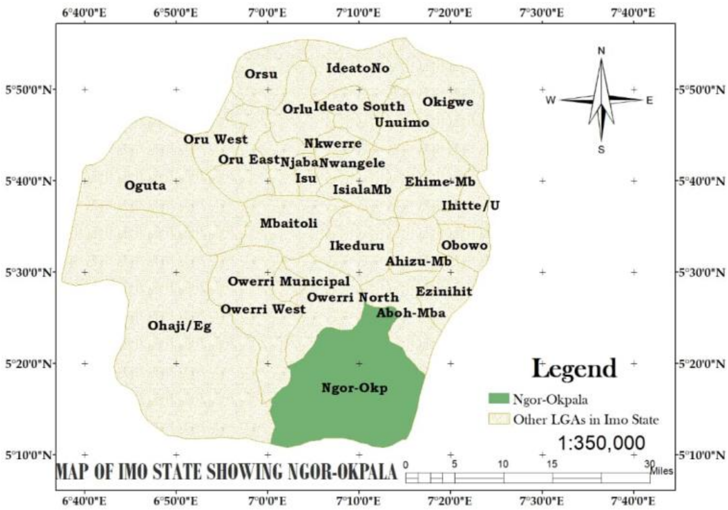
## 2.0: Materials and methods:

Data for this study were from secondary sources. Multiple regression, Pearson's bivariate correlation and, scatter plot and linear time series was employed. A time series describes the variations in the values of a variable through time. Rainfall and temperature trends were also determined using polynomial regression and linear trend analysis with the help of Microsoft Excel. Trend analysis equation is expressed thus, $y = a + bt$.

This analysis will be done using Statistical Package for Social Sciences (SPSS 21).

## 2.1: Study Area:

Ngor- Okpala local government area is located within latitude $5^{\circ}10'$N and $5^{\circ}25'$N and longitude $7^{\circ}05'$E and $7^{\circ}19'$E and occupies a land area of about 561 square kilometers. It lies within the humid tropical climate with annual rainfall and temperature of over 2000 mm and 20ºC respectively. Its heaviest rainfall mostly occurs during July, September with an average of 370mm of rain. December on average is the driest month of the year with an average rainfall of 20mm. The raining season begins on April and last until October with annual rainfall varying from 1500mm to 2200mm (60 80 inches) (Nimet, Imo Airport, 2017). Temperatures throughout the year is relatively constant showing little variation throughout typically above $20^{0}$C ($68^{0}$F). The hottest month is between January and March. It creates annual relative humidity of 75%, with humidity reading 90%, cloudiness is more of low cloud like the stratus clouds and light showers/drizzles are more prominent in the area (Nimet, Imo Airport, 2017).




**2.2: Data collection:** Data on monthly mean rainfall and monthly mean temperature was collected for 10 years (2010-2019) from Nimet, Sam Mbakwe International Cargo Airport Imo State and yam yield data from Agricultural Development programme Owerri, Imo State. The analysis was done using statistical package for social sciences (Spss version 21).

**3.0: Results and Discussion:** The result for the annual yam yield, temperature and rainfall distribution for the years under study 2010- 2019 is shown below.

| Year | Maxi Temp | Mini Temp | Average Temp | Rainfall | Yam yield (tons/ha) |
|---|---|---|---|---|---|
| 2010 | 32. 1 | 22.9 | 27.5 | 175.45 | 9.67 |
| 2011 | 31.7 | 22.2 | 26.9 | 234.36 | 9.67 |
| 2012 | 31.5 | 22.1 | 26.8 | 169.17 | 10.56 |
| 2013 | 31.1 | 22.2 | 26.7 | 203.75 | 10.73 |
| 2014 | 31.6 | 22.5 | 27.0 | 167.87 | 13.2 |
| 2015 | 31.9 | 22.3 | 27.2 | 187.27 | 10.63 |
| 2016 | 32.6 | 22.9 | 27.7 | 180.33 | 12.5 |
| 2017 | 32.0 | 23.1 | 27.5 | 177.4 | 15.7 |
| 2018 | 31.2 | 20.9 | 26.0 | 167.27 | 13.41 |
| 2019 | 32.1 | 21.4 | 26.6 | 241.3 | 14.56 |

**Source:** Nimet, ADP Imo State Owerri,

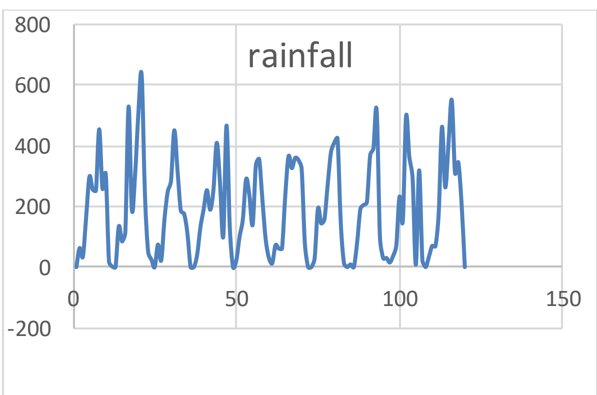



**Figure 3.1:** Monthly distribution of rainfall

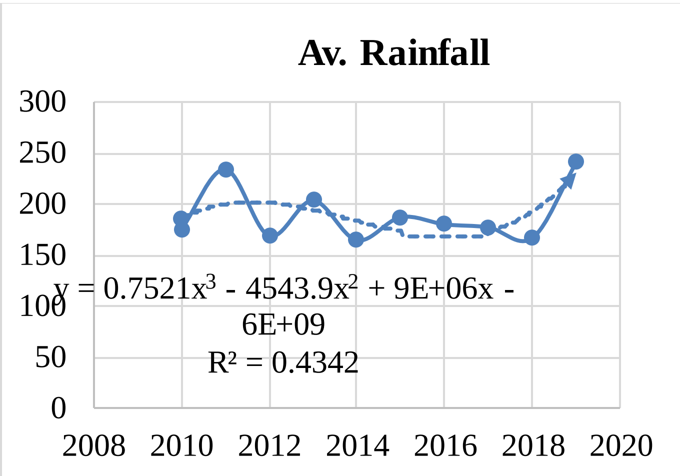



**Figure 3.2:** Annual Distribution and trend of rainfall

The chart in figure 3.1 above showed the distribution of rainfall across the years under study (Jan 2010 – Dec 2019). This witnessed an expected rise at every middle in the count of 12, and a fall at the end of each count; representing the increase in rainfall at mid-year and decrease towards the beginning and ending of the year. Furthermore, to determine annual rainfall distribution as well as its trend for the years under study (see fig 3.2). The trend chart revealed a significant variation and swingy trend pattern of rainfall distribution. polynomial regression of the third order which is the best fit model for prediction of the data was built and it produced a regression model of Y = 0.7521x3 – 4545.9x2 + 9e6x – 6e9 which shows a swingy pattern as it gradually increases with time (year). With an $R^2$ value of 0.4342 which indicates that about 43.42% of variation in yam yield is explainable by rainfall distribution.

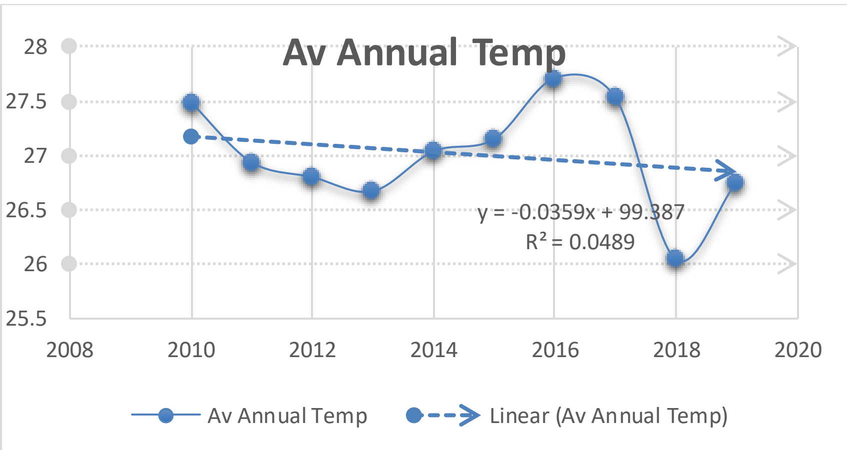



**Figure 3.3:** Annual temperature distribution.

The time series trend chart above reveals a minimal trend in temperature distribution for the periods under study. The years 2011,2012 and 2013 showed no significant trend with annual yield recorded as 9.67t/ha , 10.56t/ha and 10.73t/ha with little increase in 2014 , 2015 and sharp increase in 2016 , 2017 which is temporal as yield decreased in 2018 and slightly increased in 2019. Scatter plot and a linear time series model was built and produced a regression model as: Y = - 0.0359x + 99.387 which decreases in temperature as time increase. Where Y is average annual temperature and x is time (in year), with $R^2$ value of 0.048.

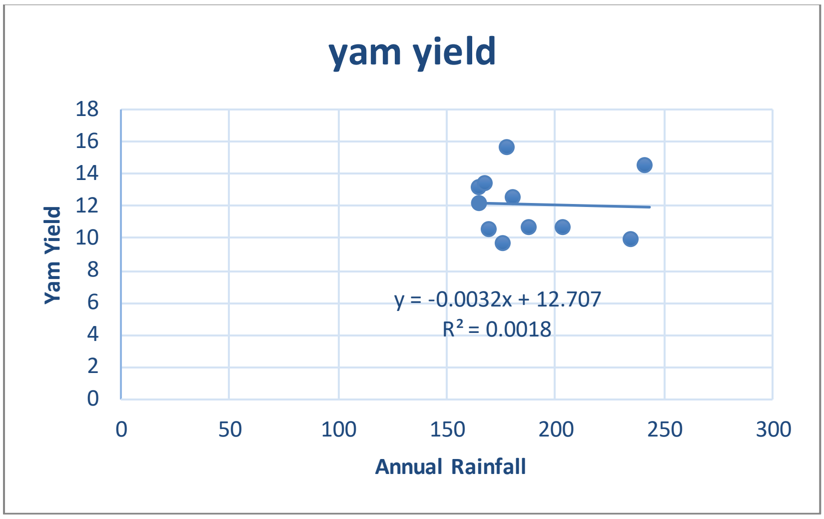



**Figure 3.4:** Time series trend of rainfall distribution and yam yield

The trend of yam yield and rainfall distribution in figure 3.4 above was modelled using a linear Regression equation in order to determine if the relationship between the two variables was significant. Thus the regression model showed Y = 12.707 – 0.0032x with 0.0018 coefficient of determination. Thus the scattered plot of the model shows that rainfall and yam yield are not linearly related.

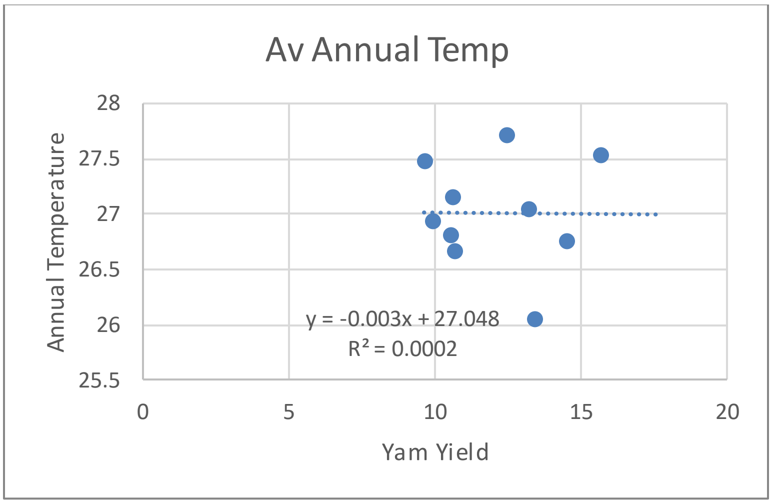



**Figure 3.5:** Time series trend of temperature distribution and yam yield.

From the time series trend above an analytical model was built for the relationship between Average annual temperature and yam yield for the years in study and it produced a negative slope of (-0.003) which implies that yam yield reduces and temperature increases. Y = 27.048 – 0.003x, with an $R^2$ of 0.0002. The determinant model built revealed that the yam yield reduces and the average annual temperature increases.

To determine if rainfall and temperature variability have any impact on yam yield.

**Descriptive Statistics**

| | Mean | Std. Deviation | N |
|---|---|---|---|
| Yam_yield | 12.0930 | 2.08029 | 10 |
| Rainfall | 190.0800 | 27.58495 | 10 |
| Max_Temp | 31.7933 | .44598 | 10 |
| Min_Temp | 22.2308 | .66659 | 10 |

**Model Summary**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .330[a] | .109 | -.337 | 2.40553 |

a. Predictors: (Constant), Min_Temp, Rainfall, Max_Temp

**Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | T | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | -14.998 | 57.529 | | -.261 | .803 |
| | Rainfall | -.014 | .032 | -.186 | -.440 | .675 |
| | Max_Temp | 1.753 | 2.271 | .376 | .772 | .470 |
| | Min_Temp | -1.168 | 1.567 | -.374 | -.745 | .484 |

a. Dependent Variable: Yam_yield

The descriptive analysis shows that average yam yield produced for the years under consideration is 12.09 ± 2.08
Rainfall = 190.08 ± 27.58. Maximum Temperature = 31.79 ± 0.45. Minimum Temperature = 22.23 ± 0.67. Thus A multiple regression model was built with Maximum temperature, Minimum temperature and Rainfall as the predictors and yam Yield as the Response Variable, in other to determine the effect of these predictors on the yam yield.
The model is thus produced:
$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3$
Yam Yield = $B_0 + B_1$ Rainfall + $B_2$ Max_Temp + $B_3$ Min_Temp.
Yam Yield = -14.998 - 0.014Rainfall + 1.753 Max_Temp – 1.168Min_Temp with $R^2$ of 0.109. Rainfall has a negative effect on yield for the years under consideration, the Maximum temperature has a positive effect, while the Minimum temperature has a negative effect on the yam yield. The model above produced no particular significant variable as shown in the coefficient table above (all variable have significance value greater than 0.05)
The relationship between temperature and rainfall distribution and how the influence yam yield for the years under consideration was studied using a Pearson's bivariate

correlation analysis to measure the extent of relationship between the variable. It was deduced that little or no correlation exists between Rainfall and Yam yield (r = -0.043, which is very close to zero).

A weak positive relationship (0.150) exists between maximum temperature and yam yield which implies that yam yield increases as maximum temperature increase, but this happen minimally.

A weak negative relationship (-0.119) exists between minimum temperature and yam yield which implies that yam yield reduces and maximum temperature increases, but this also happens minimally

A weak positive relationship (0.114) exists between Rainfall and maximum temperature.

A weak negative relationship (-0.268) exists between Rainfall and minimum Temperature.

A strong positive (0.547) and significant correlation value of (0.041) exist between Maximum temperature and minimum temperature.

## CONCLUSION

The study examined the impact of climate variability of temperature and rainfall distribution on yam yield in Ngor-Okpala L.G.A Imo state, south-eastern Nigeria from 2010 - 2109. Annual distribution of rainfall and temperature was examined using polynomial regression, scatter plot and linear time series which revealed an $R^2$ value of 0.4342 and 0.048. The time series trend of rainfall and yam yield showed that they are not linearly related with an $R^2$ value of 0.0018. Hence the time series trend of temperature and yam yield revealed that as yam yield reduces the average annual temperature increases with an $R^2$ of 0.0002. Multiple regression was used to determine if rainfall and temperature variability have any impact on yam yield, it showed that the relationship between the predictors are minimal, and their effect on the response variable (yam yield) are not significant *in the coefficient table above. Variability in temperature and rainfall distribution does no determine the changes or growth in the yam yield* within the years under study. Whereas the extent of relationship between temperature and rainfall distribution with yam yield was examined using Pearson's bivariate correlation analysis which revealed little or no correlation between Rainfall and Yam yield at -0.043 which is very close to zero. Based on the forgoing, it was recommended that other factors such as relative humidity, solar radiation, wind, and soil fertility status are considered to know if variability and distribution of these factors would have a significant effect on yam productivity in the study area as the dynamics of the climate system is evident.

### Author's contributions

This work was carried out in collaboration among all authors. Author ANU designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author OUO managed the analyses of the study. Author NCB managed the literature searches while author AJA helped with the discussions. All authors read and approved the final manuscript.

## COMPETING INTERESTS

Authors have declared that no competing interest exits.

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