



## **Effects of Extreme Flooding on Output of Selected Crops in Anambra State, Nigeria from 1990 to 2019**

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### **Authors' contributions**

*This work was carried out in collaboration between both authors. Author UN designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author NNI managed the analyses of the study. Author UN managed the literature searches. Both authors read and approved the final manuscript.*

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### **ABSTRACT**

The study has analyzed effects of extreme flooding on output of selected root and tuber crops in Anambra State, Nigeria for the period of 1990-2019 using secondary data collected on cassava, yam and sweet potato output from the agricultural production survey of Anambra State Agricultural Development Programme and annual averages of rainfall from the Nigeria Meteorological Agency in Awka station. Data collected were analysed by using multivariate simple linear regression and trend analysis in linear trend analysis and line graph. Results respectively showed an increasing trend in output of cassava, yam and sweet potato within the researched period with a depression in output of cassava and yam in 2014 and 2015. The regression results showed that coefficients of determination ( $R^2$ ) values of yam output were (0.620), cassava output (0.560) and sweet potato (0.580), which implied that 63%, 56% and 58% changed in output of roots and tuber crops accounted for rainfall within the research period. Specifically, rainfall (0.002) was positively related to yam output at ( $p < 0.05$ ). This implied excessive amount of rainfall resulting flooding, which influenced the output of production of yam. Rainfall (-0.015) and (-0.003) were negatively related to output of cassava and sweet potato at 5% probability level, which indicated extreme rainfall translating into flooding, which adversely affected the output of cassava and sweet potato in this

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area. The result of the tested hypothesis showed that extreme flooding had significant negative effects on output of roots and tuber crops in the researched area. Based on results, it was concluded that extreme flooding deleteriously affected output of root and tuber crops in Anambra state, Nigeria. Therefore, farmers were advised to change their crop production technologies including time of planting to suit changes in rainfall pattern in order to avert their adverse effects.

*Keywords: Anambra; flooding; output; tuber; roots and rainfall.*

## 1. INTRODUCTION

Weather is the atmospheric condition of any location at a particular period. Climate, on other hand, is the average weather condition of an area over a period of time, say 30 years [1]. This period is a period during which a number of changes in the variables that determine the predominant climatic pattern in the regions are known. Among the various climatic elements, temperature and rainfall are often regarded as the most important in tropical climates. While temperature can be fairly optimal throughout the year, rainfall is occasioned by seasonality in tropical environments, thus farming seasons in the tropics are largely determined by rainfall [1].

The drastic change in climate currently being experienced globally has in most ways impacted negatively on both biotic and abiotic components of our ecosystem with manifest symptoms including global warming, extreme rainfall fluctuations and storm activities evolved from the potential consequences of the greenhouse effects and continue deforestation [2].

One sector where the effect of climate change has impacted significantly is crop production. The agricultural sector is the most vulnerable as agricultural production remains very dependent on climate resources. According to Azuet al. (2015), crop production, being an outdoor activity depends to a very large extent on weather conditions. Since most crop production activity depends on rainfall, a slight change in rainfall pattern including magnitude, intensity and frequency will have a resonated effect on crop productivity [3,4].

The amount of rainfall, intensity and distribution are characteristics affected by climate change and the uncertainties surrounding global warming have been reflected in diverse studies on climate change in Nigeria [5,6]. According to Ezenwa, [7], changes in precipitation patterns increase the likelihood of short-run crop failure and long-run production declines, thus its variability creates a huge challenge for food production and national

food security. The change drives extreme weather events such as floods, soil loss drought and thus increases the risks of crop output reduction.

According to Ayanlade et al., [8] in the study of the impact of climate variability on tuber crop in Guinea Savannah part of Nigeria reported that excess rainfall leads to flooding, water-logging and other water related stresses, which reduce the yields of cassava drastically. Verhagen, [9]; (Haverkort, [10], Okoroet al., [11] have earlier reported reduced potatoes yield due to extremely high rainfall. Olannewaju [12] in the study of the effect of changes in weather variability on yam production in Kwara state identified rainfall and sunshine to be significantly related to yam yields. An increase in rainfall and sunshine hours brings an increase in yam yields, while a decrease in the above parameters resulted in low yam yields. Therefore, increases in moisture indices results in increase in yam yields, but then thermal indices are high, low yam yields are recorded. Moreso, Afiesimana [13] in the study of yam productivity and weather variability reported that flooding incidence led to drastic drop in yam yields in the yam producing communities.

The climate is continuously changing, especially the rainfall pattern and the signal which indicates that the alterations such as tuber yield are occurring can be evaluated over a range of temporal and spatial scales. In light of the above, this study was designed to evaluate effects of extreme flooding on selected root and tuber crops output in Anambra State, Nigeria over a period of three decades (1990-2019).

## 2. MATERIALS AND METHODS

### 2.1 Study Area

The study was conducted in Anambra State, Nigeria. The state is located in the Southeast Geo-Political Zone of Nigeria. Anambra State covers an area of 4,816.2 square kilometres and lies at latitude 6°20' North and longitude 7°00' East. It has a population of over 4,177,828 with a

population density of 860 people per square kilometre. The state accounts for 3.0% of Nigeria's total population. Hills, lakes, caves, forest reserves, and tablelands constitute some of its natural features [14].

Anambra State's vegetation is predominantly grassland, with scattered forests and woodland areas as well as tropical rainforest. The soil of the area is a TypicHapludult(Federal Department of Agriculture and Land Resources, 1985; Nwaogu and Ebeniro, 2009). The air temperature is generally high all year round and the current temperature range is 32°C -21°C with total annual rainfall exceeding 3,500 mm (Njoku, 2006).

Agriculture is important in the state: oil palm, corn, rice, yam and cassava are its main cash crops. Fishing in inland waterways and trading were significant commercial activities. The principal minerals found in the state are zinc, bauxite and lead. Anambra State also has natural gas and crude oil. The major industries in the state are motor manufacturing, breweries, textiles and soft-drink bottling. Locally-produced sculptures of wood and metal are also of commercial importance.

## 2.2 Data Source

The data used for the study were secondary data sourced from Anambra state Agricultural Development Programme reports on agricultural production survey, where data on agronomic parameters (output of roots and tuber crops) from 1990-2019. Similarly, data on rainfall was collected from Nigeria Meteorological Agency (NIMET), Awka Meteorological station from 1990 to 2019.

## 2.3 Analytical Techniques

Data collected were analysed using a multivariate simple linear regression model, and the pattern and trend of data were analysed using linear trend analysis and line graphs. Multivariate linear regression is a form of regression analysis that predicts the value of one or more response variables from a set of predictor variable(s). The predictor variable(s) can be continuous or categorical or a mixture of both [15]. For the purpose of this study, only one predictor variable was involved and as such the model applicable here is the multivariate simple linear regression model. The model was specified thus:

$$Y_i = f(X) \quad \text{implicit form}$$

$$Y_i = \beta_0 + Bx + et \quad \text{explicit form}$$

Where:

$Y_i$  = output of selected roots and tuber crops  $i = 1, 2, 3$  for output of sweet-potato, yam and cassava (kg)

$X$  = Extremeflooding i.e annual average rainfall (mm)

$\beta_0$  = Intercept

$\beta$  = Regression coefficient

et = error term

The stated hypothesis: extreme flooding has no effects on selected root and tuber crops output in the area was tested using Pillai's Trace value. Pillai's trace is one of the test statistics used in multivariate regression. It involves positive values ranging from 0 to 1. Increasing values means that effects are contributing more to the model; thus, the null hypothesis should be rejected for larger values [16].

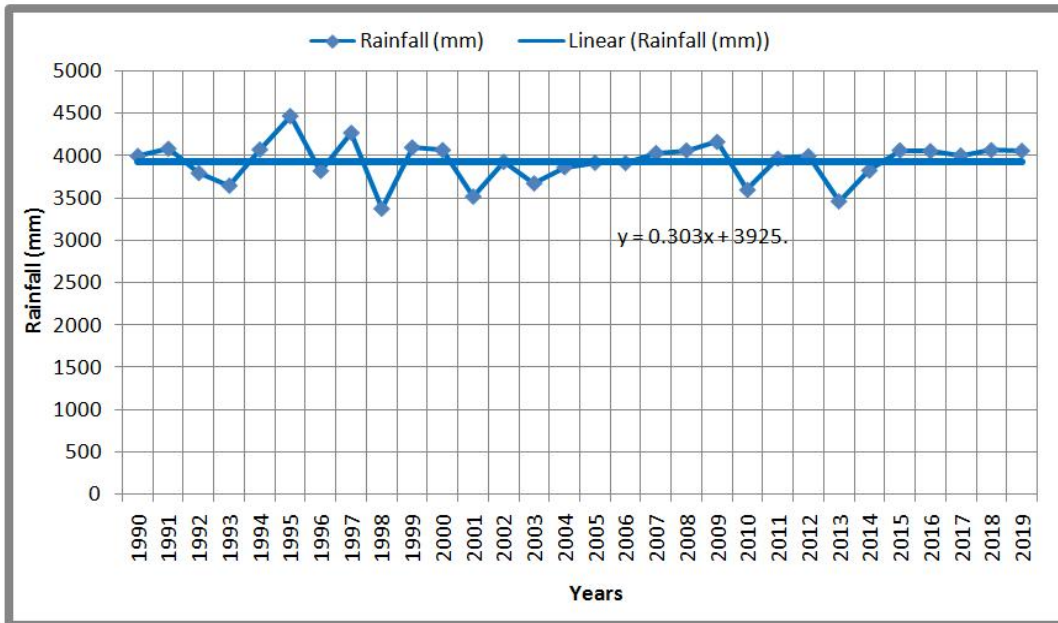
## 3. RESULTS AND DISCUSSION

### 3.1 Trends in Rainfall Variability 1990-2019

Annual average rainfall fluctuated within the period of the study is shown in Fig. 1. The fluctuations were seen in the zigzag nature of the line graph. Rainfall was at its peak (4473.5mm) in 1995, but minimum rainfall was recorded in 1998 (3373.3mm). The zigzag nature of the graph might indicate the severity of the fluctuating event of extreme rainfall over the entire period. The trend line equation showed that there was increased rainfall amount within the period of this study as observed in the positive intercept of the trend line equation and the positive coefficient of the explanatory variable. The peak values of rainfall showed higher values reported by earlier studies who reported rainfall values not exceeding 3500mm (Njoku, 2006). This could be evidence of climate change, which will invariably affect crop production.

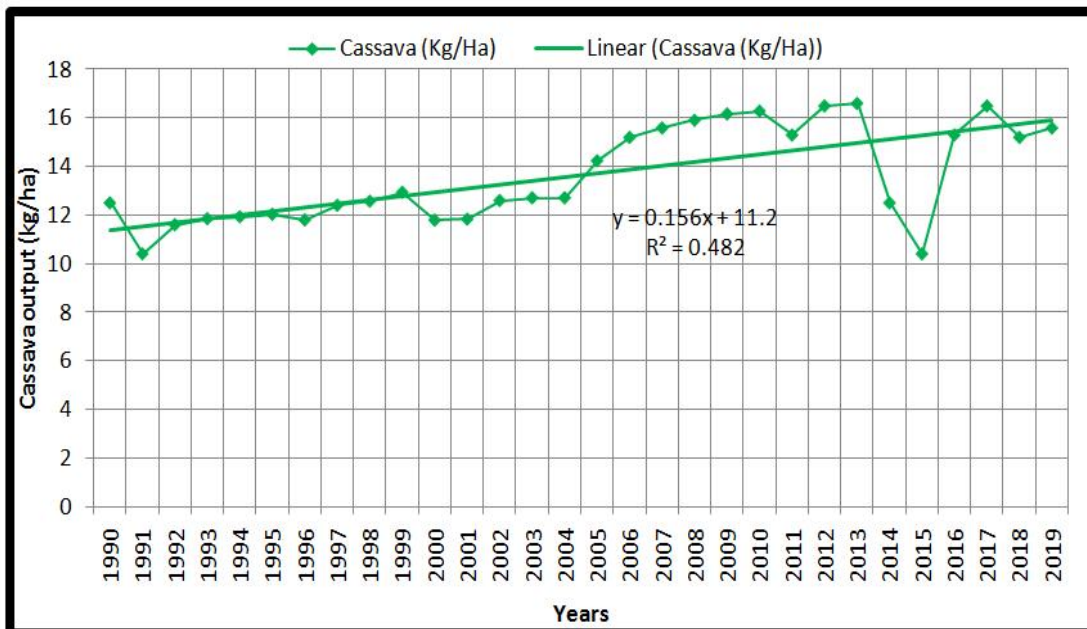
### 3.2 Trends of Root and Tuber Crop Yields: 1990-2019

The trends in cassava, sweet potato and yam output from 1990 to 2019 were presented in Figs 2, 3, and 4. Similarly, the trends in rainfall amount within the periods of 1990 to 2019 were also presented in Fig. 4.



**Fig. 1. Trends in rainfall variability 1990- 2019**

Source: Survey 2021



**Fig. 2. Trends of cassava output from 1990 to 2019**

Source: Survey 2021

From Fig 1, cassava yields varied from 10.40 t/ha to 16.50 t/ha over the entire period. The output of cassava was at its peak (16.60 t/ha) in 2013 and its trough in 1991 and 2015. This fluctuated in other years depending on the

amount and distribution of rainfall. This could be seen in the undulating nature of the line graph. The trend line indicated a positive increase in the output of cassava. The positive intercept revealed increase in output. The  $R^2$  value of

0.482 indicated that 48% of the changes in the output of cassava from 1990 to 2019 were accounted for by time.

### 3.3 Trends of Sweet Potato Output from 1990 to 2019

Sweet potatoes had a depression in their line graphs in 1990; such may be attributed to the low output of 1990 occasioned by extreme events of rainfall. Sweet potato output varied from 3.1 t/ha to 11.4 t/ha in 1990 and 2015 respectively. Results also showed an increase in potato output within the period of this study as seen in the positive intercept of the trend line equation. The coefficient of determination of the trend equation ( $R^2=0.437$ ) revealed that 44% of the variations in the output of sweet potato within the period of this study was account for by explanatory variable (time).

### 3.4 Trends of Yam Output from 1990 to 2019

The line graph of Fig. 3 showed that yam output recorded its lowest output in 1990 and 2016, whereas, the highest output was recorded in 2012 and 2017. The line graph showed an undulating trend from 1990 to 2019. From 2004, output increased till 2012 and decreased till 2014. Thereafter, it increased from 2015 to 2017 and decreased henceforth. The result of trend analysis showed that yam output increased within the period as shown by the positive intercept of the trend line equation. The  $R^2$  value of 0.215 of the trend line equation showed that 22% of the changes in yam output was accounted for by the explanatory variable (time) included in the model.

#### 3.4.1 Multivariate Simple Linear Regression Model results on Extreme Flooding Effects on yam, Cassava and Sweet Potato Output (t/ha) in Anambra State

The results of the effects of extreme flooding on roots and tuber crops output was presented in Table 1 relative to yam, cassava and sweet potato. The result showed that extreme flooding had varied effects on the selected roots and tuber crops output. The coefficients of determination ( $R^2$ ) values of yam output were (0.620), cassava output (0.560) and sweet potato (0.580). These implied that 63%, 56% and 58% changes in roots and tuber crops output were accounted for by rainfall within the period of this study. The Pillar's and F-ratios of 0.317 and

4.014, respectively which were significant at 5% probability level showed the overall significance of the model.

Specifically, the coefficient of rainfall (0.002) was positively related to yam output at ( $p<0.05$ ). This implied that the amount of rainfall that resulted in flooding influenced the production of yam that translated into output. These findings were consistent with the findings of Afiesimana [13], Ayanlade et al., [8,17], Awoke and Nte [18] in their studies of climate change effects on yam yields and productivity, found that flooding incidence in the early part of yam plant's life resulted in significant improvement in the onset of tuberizing and significant increase of yam yields. The result also corroborated with Olannewaju [12] who reported that rainfall is significantly related to yam output thus, increase in rainfall brings an increase in yam output.

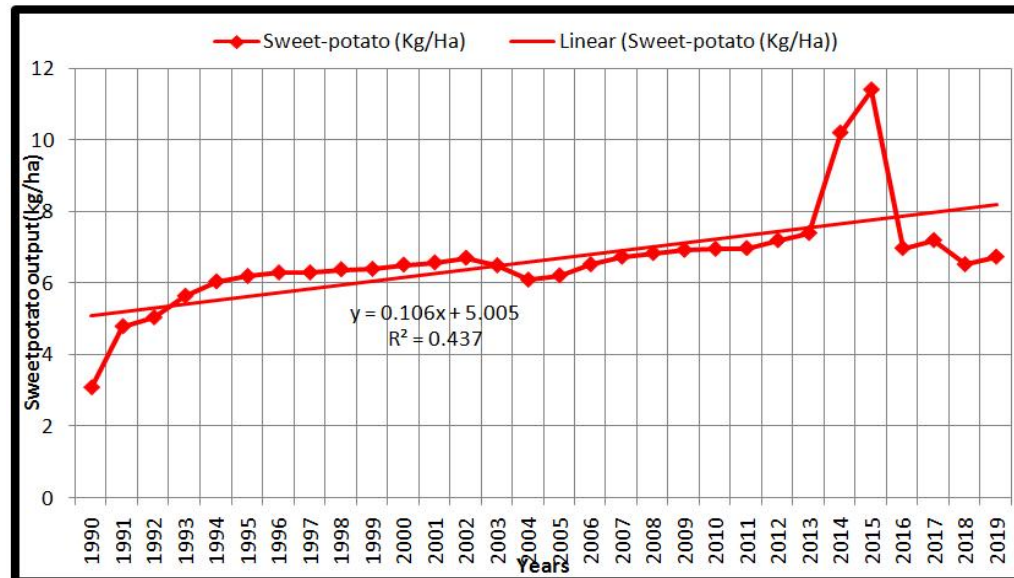
Rainfall (-0.015) was negatively related to the output of cassava at 5% probability level. This indicated that extreme rainfall which translated into flooding adversely affected the output of cassava and might be observed in loss of roots and reduction in output. This finding was in-line the findings of Ayanlade et al. [8], who in his study of the impact of climate variability on root crops in Guinea Savannah part of Nigeria reported that excess rainfall leads to flooding, water-logging and other water related stresses, which reduce the yields of cassava drastically. Moreover, annual weather conditions were responsible for the differences in the growth and productivity of cassava. The result was also supported by the findings of Ezekiel et al., [19] who reported that the quantity of cassava produced has a negative relationship with extreme rainfall, hence as years pass by the effects of flooding could be obviously seen in most agricultural products, especially in the developing countries due to their vulnerability to effects of climate change that was seen in the form of extreme flooding.

Rainfall (-0.003) has a negative significant effect on the output of sweet potatoes at 5% level of significance. This result implied that rainfall in the form of flooding had great adverse effects on the output of sweet potatoes. This finding is in agreement with the findings of Okoro et al. [11] who reported that heavy rainfall is very important in increasing variations and reduction in growth and productivity of sweet potatoes; therefore, inadequate rainfall amount is detrimental to the productivity of sweet potato in the area.

**Table 1. Effect of budgetary allocation to agriculture on the food prices in the study area: 2003-2016**

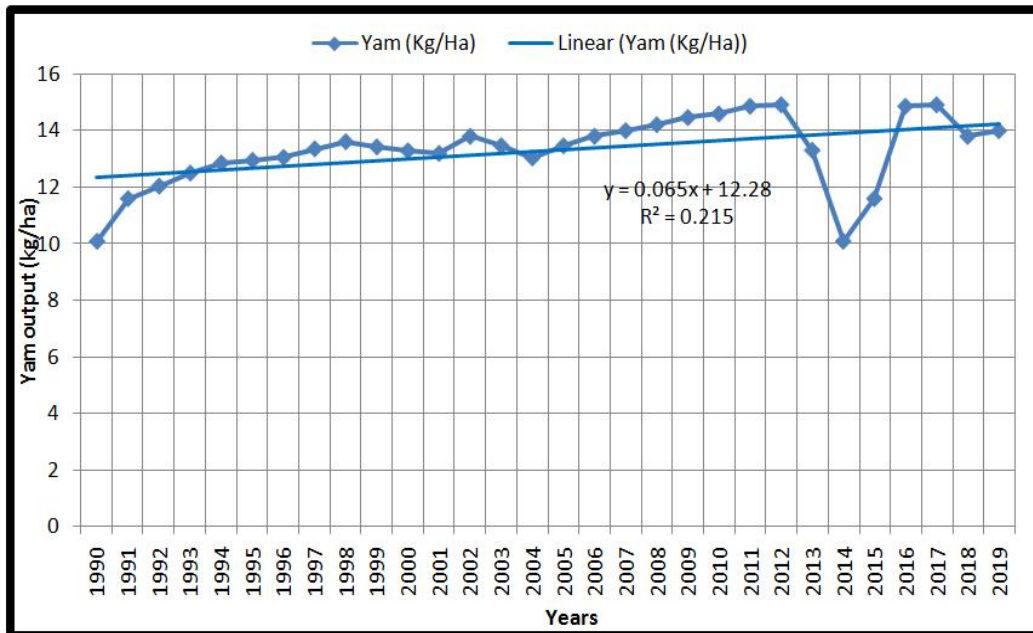
Variables	Parameters	Coefficients ( $\beta$ )	Std error	t-values	OBP	R <sup>2</sup>	Pillar's ratio	F-ratios
Yam (kg/ha)	Intercept ( $\beta_0$ )	12.500	3.823	3.270**	0.884	0.620	0.317**	4.014**
	X	0.002	0.001	2.209**	0.491			
Cassava (kg/ha)	Intercept ( $\beta_0$ )	14.235	6.139	2.319**	0.610	0.560		
	X	-0.015	0.002	-7.502**	0.894			
Sweet Potato (kg/ha)	Intercept ( $\beta_0$ )	10.140	4.363	2.325**	0.510	0.580		
	X	-0.003	0.001	-3.113**	0.784			

Source: Survey, 2021\*\* = significant at 5%, OBP = Observed powers



**Fig. 3. Trends of sweet potato output from 1990 to 2019**

Source: Survey 2021



**Fig. 4. Trends of yam output from 1990 to 2019**

Source: Survey 2021

### 3.5 Hypothesis Tested

The result of the analysis provided four different approaches to calculating F-value in multivariate regression. Four approaches were used to test whether the vector of means of the groups were from the same sampling distribution or not. For the purpose of this study, the Pillai's trace was chosen as the most preferred approach to F-value because it is the least sensitive to the violation of the assumption of the covariance of matrices. Based on the result, the Pillai's Trace value of the predictor variable (rainfall) is 0.317 with F-value of 4.014 which is significant at 5% level (P = 0.018). Based on this, we reject the stated null hypothesis and concluded that extreme flooding had significant effects on roots and tuber crops output in Anambra State, Nigeria.

### 4. CONCLUSION

This study analysed the effects of extreme flooding on selected root and tuber crops output in Anambra State, Nigeria: 1990-2019. From finding, it was observed that rainfall intensity increased from 1990 – 2019 and this led to extreme flooding which in turn had deleterious effects on roots and tuber crops output in Anambra State, Nigeria.

### 5. RECOMMENDATIONS

- Farmers were advised to change their cultural practices, including time of planting, to suit the changes in rainfall pattern in order to avert its adverse effects.
- Farmers should adopt the use of resistant varieties of root and tuber crops that can withstand the effects of extreme flooding.
- Extreme flooding in the form of climate change should be incorporated in the current agricultural transformation policy of the federal government.

### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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