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Climate Variability, Cassava Output and Food Security in Nigeria

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A R T I C L E I NFO

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climate variability,

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ABSTRACT

This study examined the effect of climate variability and cassava output on food security in Nigeria from 1990 to 2020. Both descriptive statistics and hierarchical multiple regression analysis were used to achieve the objectives of the study. Data for the study were gathered from the Food and Agriculture Organization Statistical database (FAOSTAT); World Bank database; Central Bank of Nigeria Statistical Bulletin and Nigeria Meteorological Agency (NIMET). The result from the study showed that rainfall was a major climatic element that affects cassava production output and food security (average value of food production) in Nigeria. The Beta weights in model 1 showed that rainfall (β= 0.372: $P<0.1$) had a positive effect on average value of food production. Also, the Beta weights of model 2 showed that cassava output (β= 0.412: $P<0.05$) had a positive effect on average value of food production. The study therefore recommended that since rainfall affects crop production, there should be adequate provision of artificial irrigation facilities in order to boost cassava production in areas with limited amount of rainfall.

1.0 Introduction

The Intergovernmental Panel on Climate Change (IPCC, 2007) defines climate change as a variation in the condition of the climate that can be distinguished by changes in the mean and the variability of its properties which continues for a drawn-out period, normally a decade or more. Climate variability has before now affected crop output in many countries (IPCC, 2007; Deressa *et al*, 2008; Rosenthal & Ort, 2012; Murniati, Widjaya, Rabiatul & Listiana, 2019). This is mainly valid in low-income countries, where climate is the primary factor of agricultural production where adaptive abilities are low (Apata, Samuel & Adeola, 2009; Amelework, Bairu, Maema, Venter & Laing, 2021). This susceptibility in Nigeria has been established by the destructive outcome of flooding in the Niger Delta region, parts of South Eastern states, Middle belt and other parts of the country while a variety of prolonged droughts are been experienced in some areas of northern region (Apata, 2012; Akomolafe, Awoyemi & Babatunde, 2018).

As the principal sector in Nigeria's economy, agriculture is of great importance because it contributes 42 percent to the country's Gross Domestic Product (GDP). It utilizes around 80% of the country's poor who live in the rural regions and work essentially in agriculture (NBS, 2018). Since agricultural production in Nigeria relies incredibly upon climate, temperature, daylight, relative humidity and water are the primary drivers of crop growth and crop output. With the rain dependent nature of agriculture in Nigeria, the area has been pronounced to be defenceless to the impact of variability of climatic elements (Agwu, Nwachukwu & Anyanwu, 2012). Climate change coupled with ecological degradation and water scarcity has curtailed food productivity, availability, accessibility, and quality at the national level. The above factors also aggravate the appearance of novel pests and diseases (Jones & Barbetti, 2012). The contemporary appearance of the fall army worm, which has obliterated maize, wheat and potato crops across Africa and Asia, is one of the adverse consequences of climate change seen in Nigeria (Amusan & Olawuyi, 2018).

The current reliance on traditional crop commodities that compete in export markets and reduce imports has opened windows to promote cassava production in Nigeria. Cassava is dry season safe and resilient to climatic variability, high temperatures, and poor soils, which makes it an important crop for the twenty-first century (Mupakati & Tanyanyiwa, 2017). Water scarcity presents difficulty in cropping maize, wheat and potato. Cassava can fill in a more extensive scope of climatic circumstances and soil types than other tropical staple crops. Relative to grain crops, cassava is more tolerant of low soil fertility and is more resistant to drought. Hence, cassava can provide Nigeria with choices for economical food security, while other significant staples crops like maize and wheat face difficulties. Likewise, cassava can possibly produce and store more carbohydrate than some other significant grain or root crops (El-Sharkawy & De Tafur, 2010). It can give a choice to the advancement of an improved crop, with in excess of 300 industrial items including the production of tire, glues, ethanol, drugs, domesticated animals feeds, biofuels, cold meats, and liquor.

Its attributes, for example, resilience to dry season, the capacity to fill in negligible soils and long haul storability of the roots in the ground make cassava a versatile crop for food and nutritional security (Jarvis *et al*., 2012). Cassava roots can be stored underground for as long as 24 months after maturity, and these can be harvested at any time of the year when a household needs food (Sanchez *et al*., 2013). Farmers can plant and still harvest cassava without critical inputs, utilizing negligible terrains where different crops can't be produced. Cassava commonly yields 8-10 tons ha-1 of fresh roots with zero input.

Regardless of cassava's significance as a food security crop in Nigeria, and its industrial potential, relatively little research has been conducted to examine its importance to food security in Nigeria. In this study, the significance of cassava as food, feed, and industrial crop has been reviewed. It is opined that this study will act as a manual to foster the right advances and proper methodologies for coordinating cassava into the farming system and to convey monetary benefits to both commercial and smallholder farmers. In line with the foregoing this study therefore, examines the effect of climate variability (temperature and rainfall) and cassava output on food security in Nigeria. The specific objectives are to:

i. describe the relative trend of rainfall, temperature and cassava output in Nigeria; and
ii. examine the effect of variability of climatic factors and cassava output on food security.

1.1 Hypotheses of the Study

There following null hypotheses were tested;

Ho1: There is no significant relationship between variability of climatic factors and average value of food production in Nigeria.

Ho2: There is no significant relationship between variability of climatic factors, cassava production output and average value of food production in Nigeria.

2.0 Methodology

2.1 Area of Study

The Federal Republic of Nigeria is the study area. Geographically, Nigeria occupies a landmass of 923,768sq km in the West Coast of Africa between the latitudes of 4^0 and 14°N and longitudes of 2^0 45’ and 14^0 30’E. Nigeria shares boundaries with Niger Republic to the North, Benin Republic to the West, Chad and Cameroun to the East and Gulf of Guinea (Atlantic ocean) to the South. Organizationally, the country is divided into 36 States with Abuja as the Federal Capital territory, and with a population of 140,003,542 persons (NPC, 2007). The country is blessed with abundant land, natural resources and labour.

Climate in Nigeria changes from humid tropical in the South to sub-humid tropical in the north, having wet and dry seasons. Nigeria’s atmospheric temperatures are continually high throughout the year with mean temperature ranging from 25°C in the South to 20°C in the North (Agwu, 2012).

2.2 Data Collection

Data for this study such as the mean annual temperature, mean annual rainfall, food security indices and cassava production output from 1990 to 2020 were gathered from various secondary sources. The secondary sources of data collection were; Food and Agriculture Organization Statistical database (FAOSTAT); World Bank database; Central Bank of Nigeria Statistical Bulletin and Nigeria Meteorological Agency (NIMET).

2.3 Data Analysis

Three analytical tools were employed to analyse the data collated. These include Unit Root Test, descriptive statistics and hierarchical regression analysis.

Unit Root Test

Unit root test was utilized in testing whether the time series variables were stationary or non-stationary.

Descriptive Statistics

Descriptive statistics such as line graphs were used to determine the relative trend of the climatic factors as well as the cassava production output in Nigeria.

Multivariate Regression Analysis

Hierarchical multiple linear regression was used to analyse the effect of the climatic factors (rainfall and temperature) and cassava output on food security index of the country. Hierarchical regression adds terms to the regression model in stages. At each stage, an additional term or terms are added to the model and the change in R^2 is calculated. A hypothesis test is done to test whether the change in R^2 is fundamentally not the same as zero. Hierarchical or Multi-level modelling is proper, as the name proposes, when data have impacts happening at various levels (individual, over the long run, over spaces, and so forth). Single level displaying expects everything is happening at the most reduced level. Something else that a multi-level model does is to present correlations among nested units. Thus, level-1 units inside a similar level-2 unit will be related (Raudenbush, 2002; McNeish & Hamaker, 2020). In this study, two regression models were built by adding variables to the previous model. The purpose is to determine whether newly added variables show a significant improvement in R^2 (the proportion of explained variance in dependent variable by the model). If the difference of R^2 between Model 1 and 2 is statistically significant, we can say the added variables in Model 2 explain the dependent variable (Raudenbush, 2002; McNeish & Hamaker, 2020).

Model Specification

Unit Root Test

The autoregressive integrated moving average (ARIMA) test was used for the quandary of non-stationarity or unit root in the data. ARIMA models are best built-in to time series either to better comprehend the data or to envisage future points in the series. They are useful in some cases where data show indication of non-stationarity, where a preliminary differencing step (equivalent to the ‘’integrated’’ part of the model) can be useful to reduce the non-stationarity. The regression equation to test for stationarity according to Gujarati (2004), is expressed as given below:

$$\Delta \ln FS = \alpha_0 + \sum_{t-1}^{p} \alpha_1 \Delta \ln CPDN_{t-1} + \sum_{t-1}^{p} \alpha_2 \Delta \ln RF_{t-1} + \sum_{t-1}^{p} \alpha_3 \Delta \ln TEMP_{t-1} + \beta_1 \ln CPDN_{t-1} + \beta_2 \ln RF_{t-1} + \beta_3 \ln TEMP_{t-1} + U_t \ldots\ldots\ldots\ldots 1$$

The presence of unit root problem or non-stationarity was accessed through hypothesis as follows:

H_0: $\alpha_1 = \alpha_2 = \alpha_3 = 0$ (the time series FS is non-stationary or has a unit root)

H_a: $\alpha_1 < 0$, $\alpha_2 < 0$, $\alpha_3 < 0$ (the time series FS is stationary or has no unit root)

Where:
α_0= constant term
U_t =white noise
α_1- α_3 = coefficients of the first difference variables
β_1- β_3 = coefficients of the explanatory variables
p = lag length
FS = food security index (Average value of food production)
CPDN = cassava production output (calories)
RF = Rainfall (mm)
TEMP = Temperature (^{o}C)
Augmented Dickey-Fuller (ADF) test was carried out to test the regression results to show the existence of unit roots as expressed in the hypothesis above.

Regression Model

The regression equation is given below.

AVFP = f(Temp,Rain)……………….………….2
AVFP = f(Temp,Rain,Cassava output)…………….6

Where;
AVFP = Average value of food production,
CPDN = Cassava production output (calories)
Temp = change in temperature (^{o}C)
Rain = change in rainfall (mm)
The regression model can further be expressed as;

$$Y(AVFP) = \beta_0 + \beta_1 \Delta X_1 + \beta_2 \Delta X_2 + e\ldots\ldots\ldots\ldots ..9$$
$$Y(AVFP) = \beta_0 + \beta_1 \Delta X_1 + \beta_2 \Delta X_2 + \beta_3 \Delta X_3 + e \ldots\ldots 14$$

Where;
Y(AVFP) = Average value of food production,
β_0 = intercept
β_{1-3}= Regression Coefficient
ΔX_1 = change in temperature (^{o}C)
ΔX_2 = change in rainfall (mm)
ΔX_3 =change in cassava output
e = Random error term

Measurement of Food Security Indicators (Average value of food production)

The indicator communicates the food net production value as assessed by FAO and distributed by FAOSTAT, in per capita terms. It gives a cross-country practically identical proportion of the relative financial size of the food production sector in the country.

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3.0 Results and Discussions

3.1 Unit root testThe result of the Augmented Dicky Fuller (ADF) (Table 1) shows that the variables are non-stationary in their levels. The variables only became stationary after first difference except for average value of food production (AVFP) which was found to be stationary after the second difference.

Table 1 Unit Root Test Result

Variable	Level data	Difference level	1% critical value	5% critical value	10% critical value
Mean annual temperature	-3.496371	-13.37642(D1)*	-3.769597	-3.004861	-2.642242
Mean annual rainfall	-3.127906	-7.829611(D1)*	-3.752946	-2.998064	-2.638752
Cassava output	-1.002352	-4.574412(D1)*	-3.752946	-2.998064	-2.638752
Average value of food production	-1.670545	-5.280128(D2)*	-3.831511	-3.029970	-2.655194

*Note: * indicates 5% level of confidence.*
Source: Field Survey (2022)

Note:
D1 = first difference, D2 = second difference
Decision Rule:
If ADFs > critical value- stationary
If ADFs < critical value- Non stationary

Relative trend of rainfall, temperature and cassava output in Nigeria

The figure 1 shows the trend in cassava output in Nigeria from 1990 to 2020. The result indicates an increase in the trend of cassava output. The output of cassava production steadily rose from 30.27838 billon calories in 1990 to 51.98823 billon calories in 1999, thereafter dropped to 51.98823 billon calories in 2000. In 2009 cassava output dropped to 58.547378 billon calories. It was after the year 2009 that cassava output continued to rise gradually to a peak of 91.13818 billon calories in 2020. As shown in Figure 1 the lowest production output of 30.278383 billon calories was recorded in the year 1990 and the highest production output of 91.13818 billon calories was recorded in 2020. The climatic variables also move in a similar direction. The result on temperature showed that there was an increase over the years. The result in figure 1 indicated that temperature was high in 1991 at 26.63°C and dropped in the year 1992 at 25.06°C. From Figure 1 the lowest amount of rainfall of 1344 mm was recorded in 2004 while the highest amount of1719.6 mm was recorded in the year 2007.

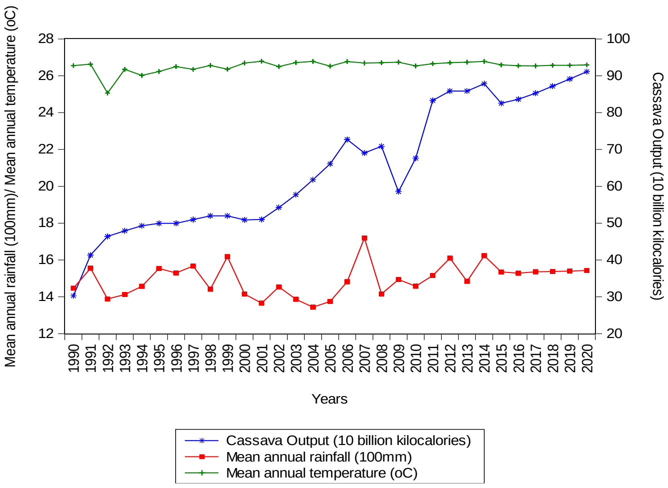

Figure 1. Relative trend of rainfall, temperature and cassava output in Nigeria

Effect of variability of climatic factors and cassava output on food security

Model 1 in Table 2 presents the result of effect of temperature and rainfall on average value of food production**.** The regression model had an R^2 of 0.141 (14%). This implies that the extent to which rainfall and temperature predicts average value of food production is 14%. The adjusted R^2 of 0.055 shows that 5% of the variance in average value of food production was accounted for by the effect of temperature and rainfall for the period under review. The Beta weights in model 1 as seen in Table 2 showed that rainfall (β= 0.372: P<0.1) predicts a positive relationship with average value of food production and hence contributes to it.

The positive value of the Beta coefficient indicates that increase in rainfall will lead to an increase in average value of food production. The null hypothesis is therefore rejected and the alternative holds true. Therefore, there is a significant relationship between variability of climatic factors and average value of food production in Nigeria.

The implication of the result in model 1 of Table 2 is that a 1% increase in rainfall will increase the average value of food productionby 0.37%. This result is an indication that increase in the mean annual rainfall in Nigeria exerts a positive effect on average value of food production. This result is in line with the findings of Sowunmi and Akintola (2009) who stated that the potential of savannah zones in Nigerian food crop production cannot be overemphasized. This is in agreement with *a priori* expectation, since farmers perception about crop production especially cassava is influenced by availability of rainfall during the production process. According to Nwaobiala and Nottidge (2015), cassava has a special attribute which is thriving well even in extreme conditions of drought and such has been called the famine security crop. The need for the development of irrigation facilities in these zones in order to make water available by augmenting the unimodal rainfall distribution of the zones is imperative. Moreover, development of short, drought resistant and early maturing variety of crops suitable for this zone so that the short-wet season can be fully utilized.

Model 2 in Table 2 presents the result of effect of temperature, rainfall and aggregate cassava output on average value of food production**.** The regression model had an R^2 of 0.299(30%). This result implies that the extent to which rainfall, temperature and cassava output predicts average value of food production is 30%. The adjusted R^2 of 0.189 shows that 19% of the variance in average value of food production was accounted for by the impact of temperature, rainfall and cassava output for the period under review. The Beta weights of model 2 as seen in Table 2 showed that cassava output (β= 0.412: P<0.05) has a positive relationship with average value of food production and hence contributes to it. The positive value of the Beta coefficient indicates that increase in cassava output will lead to an increase in average value of food production. The null hypothesis is therefore rejected and the alternative holds true. Therefore, there is a significant relationship between variability of climatic factors, cassava output and average value of food production in Nigeria.
The result in Table 2 also revealed that the difference in R^2 between Model 1 and Model 2 was 0.158 (0.299-0.141 = 0.158). Therefore, cassava output explains an additional 16% of the variance in average value of food production and it is statistically significant.

Table 2: Effect of temperature, rainfall and aggregate of cassava output on Average Value of Food Production

Model Summary					
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**	**Durbin-Watson**
Model 1	0.376	0.141	0.055	6.92071	
Model 2	0.547	0.299	0.189	6.41335	2.452

Coefficients					
	Unstandardized Coefficients		**Standardized Coefficients**		
	β	**Std. Error**	**Beta**	**t**	**Sig.**
Model 1					
(Constant)	-0.441	1.443		-0.306	0.763
Mean annual rainfall (mm)	0.002	0.001	0.372	2.000	0.034**
Mean annual temperature (ºC)	2.489	3.188	0.165	0.781	0.444
Model 2					
(Constant)	-1.711	1.471		-1.163	0.259
Mean annual rainfall (mm)	0.002	0.001	0.270	2.000	0.037**
Mean annual temperature (ºC)	2.781	2.957	0.185	0.940	0.359
Aggregate cassava output(calories)	1.257E-6	0.000	0.412	2.071	0.022**

*(*significant at 10%; **significant at 5%)*
Model 1:Dependent Variable: Average value of food production
Independent variable: Mean annual temperature (ºC), Mean annual rainfall (mm)
Model 2: Dependent Variable: average value of food production
Independent variables Mean annual temperature (ºC), Mean annual rainfall (mm) and aggregate cassava output
Source, Field Survey 2022

4.0 Conclusion and Recommendations

This study examined the effect of climate variability and cassava output on food security in Nigeria from 1990 to 2020. The study explored two major climatic elements (rainfall and atmospheric temperature) that affect agricultural production activities in Nigeria. In the study it was observed that there was a steady fluctuation in the trends of atmospheric temperature and rainfall whereas cassava production output witnessed a steady increase during the period under review. The study reported that rainfall was a major climatic element that affects cassava production output and food security (average value of food production) in Nigeria. The study therefore recommended that; since rainfall affects cassava production, there should be adequate provision of artificial irrigation facilities in order to boost crop production in areas with limited amount of rainfall. There is need to help the indigenous farmers adaptation techniques by providing them with an extensive variety of institutional, policy, and technological support, some of it designated on poor and small-scale farmers. For this reason, the role of government and NGOs is important. As the wet seasons are as of late turning out to be increasingly erratic and unpredictable, relying upon rainfed agriculture is unlikely and thus policy driven activities to provide irrigation facilities in light of both ground and surface water are imperative. In addition, introducing non-farm income sources is significant as this assists farmers with participating in those activities that are less delicate to climate change. Besides, providing climate change data, extension services, and providing access to markets are critical. Hence, government should integrate issues of climate variability as well as adaptation strategies into the national developmental plan and project.

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