INNOVARE JOURNAL OF AGRICULTURAL SCIENCE

Vol 10, Issue 3, 2022

ISSN - 2321-6832

Research Article

ASSESSMENT OF TREND AND EFFECT OF CLIMATE CHANGE ON OUTPUT OF PALM OIL IN NIGERIA (1975–2018)

ARUOCHA NO, NNAMERENWA GC*

Department of Agricultural Economics, Michael Okpara University of Agriculture, Umudike, Nigeria. E-mail: mannestnnamdi@gmail.com

Received: 30 September 2021, Revised and Accepted: 12 January 2022

ABSTRACT

The broad objective of this study was to analyze the impact of climatic change on palm oil output in Nigeria (1975–2018) and identify the trend and factors that influenced output performance of palm oil. The study covered 1975–2018 periods. Secondary data were used for the study. The data were analyzed by the use of econometric methods. Findings showed that climatic parameters of rainfall, temperature, radiation, relative humidity, and sunshine exhibited significant positive trends during the 1975–2018 periods; while palm oil output exhibited a significant negative trend during the 1975–2018 periods. Palm oil output had a compound rate of growth of −1.67% per annum; while the climatic parameters of temperature, rainfall, radiation, sunshine, and relative humidity had a compound rate of growth of 0.1%, 0.7%, 0.9%, 1.5%, and 0.8% per annum, respectively. Palm oil output decelerated in growth; rainfall, sunshine, radiation, and relative humidity accelerated in growth; while, temperature stagnated in growth during the period under study. There were no significant differences in the average rate of growth of palm oil and each pair of the selected climatic parameters considered. In the long run, palm oil output was influenced by current values of area harvested of palm oil, rainfall, temperature, sunshine, and time variable; while, in the short run, palm oil output was influenced by 1 year lag values of area harvested of oil palm, palm oil output, rainfall, sunshine, and temperature based on the specified model. There was a fast adjustment to long run equilibrium among the short run independent variables that estimated the response of palm oil output to climatic change. The conclusion of this study is that climatic change affected the production of palm oil in Nigeria within the periods under study. It is, therefore, recommended that farmers should be educated by government and other stake holders in Nigerian agriculture on possible strategies for mitigating the impact of climate change on cash crop production as well as supported financially to cope with the impact of climatic change.

Keywords: climate change, nigeria, palm oil

 DOI: http://dx.doi.org/10.22159/ijags.2022v10i3.43273. Journal homepage: https://innovareacademics.in/journals/index.php/ijags

INTRODUCTION

The discovery and exploitation of petroleum in Nigeria, the black gold led to the decline in the importance attached the major cash crop such as palm oil, nevertheless, palm oil a major export crop (Adegeye and Dittoh, 1985). Global food production and global food security are not directly linked, although there are more than 160 million people in Nigeria and 70% of these population engage in agricultural production which includes palm oil, only few percentage of these population enjoy perfect dividends from such cash crop product, others are in losses due to influence of adverse climatic condition.

Apart from providing foreign exchange to the exporting countries, palm oil is a means of conserving foreign exchange. This is achieved by producing palm oil based on products such as palm oil butter, palm oil soap, and so on locally instead of importing (Oyekale *et al.*, 2009).

In recent years, Nigeria population has been deduced to increase at an increasing rate, but the country has lost her leading role in exportation of palm oil, this was due to downward trend in palm oil production (Adegeye and Dittoh, 1985). The rural population most at risk from anticipated climate change impacts is those subsisting in arid and semi-arid zones of Nigeria who have few options for adapting to yet more water scarcity other than migration. Of all the climatic factors, the daily and inter-annual variation in precipitation and temperature regimes are most crucial for rain-fed, run-off, transpiration in the production of cash crop (IPCC, 2007).

The palm oil has been identified as a unique export agricultural product in Nigeria starting from the late 19th century (Oyekale *et al.*, 2009). Palm oil (*Elaeis guineensis*) is considered an indigenous crop of West Africa in Nigeria, where it is found mainly in areas of secondary forest throughout South Nigeria and in parts of the derived savanna.

In Nigeria, it believes that the natural habitat of palm oil are sources and banks of water curses, most valleys, especially in the forest/savanna transition zones, banks of lakes, and swamps. As the palm oil does not appear to survive in primary forest, it must have spread from these natural habitats to man-made temporary and permanent clearings in the rain forest. The oil palms in secondary rain forest are found mainly in West Nigeria and Delta State, around Benin, oil palm occur at densities of 69 per hectare, but such densities are more likely to be attained in the southern parts of West Nigeria with the possibility of some thinning out toward the north and the forest/savanna transitional zone, with the exception of Southwest Ondo and parts of Benin province. The area is considered rather dry for optimum oil yield.

Oil palm bush has been observed in parts of Asaba and Warri Division of Delta State and Kabba and Igala Divisions of 50–125 per hectare. In the Kabba and Igala examples located in derived savanna, oil palm bush occurs not only along the water courses but also in the more densely populated areas with at least 1270 mm of rainfall a year.

It is evident that climate change will have a strong impact on Nigeria, particularly in the areas of agriculture (Apata *et al.*, 2009). Nigeria like all the countries of sub-Saharan Africa is highly vulnerable to the impact of climate change (IPCC, 2007, and Apata *et al.*, 2009). The previous studies in Nigeria on the impact of climate change on food crops have primarily examined the impact of some specific cash crops using statistical modeling. Among these are the works by Enete (2010), Nwajiuba *et al.* (2010), Sowami *et al.* (2011), Ikhatua (2010), Eze *et al.* (2011), Ajewole and Lynda (2010), etc., for example, Nwadinobi (2011) in his work, using the Granger Causality approach, showed that there is a relationship between changes in rainfall and agricultural production. Ikhatua (2010) shows that in Nigeria, climate change will affect all four dimensions of food security, stability of food supplies, and food utilization.

Rudolf *et al.* (2009) stated that adverse climate effects can influence farming outputs. Any stage from cultivation through the final harvest even if there is enough rain, its irregularity can affect yield adversely that if precipitation fails to drop during the important growing stages of the crops. In areas experiencing increased rainfall and temperature, higher intensity rainfall may damage crops and erode soils (Rosenzweig *et al.*, 2002).

Odjugo (2010) noted that temperature trend in Nigeria from 1975 has given way to increase in air temperature. The main air temperature in Nigeria between 1975 and 2011 was 24°C while the temperature increase for 36 years was 1.2°C and this is obviously higher than the global mean temperature increase of 0.74°C which had been recorded since 1860 when actual scientific temperature measurement started (Spore, 2008; IPPC, 2007).

Odugo (2010) stated also that rainfall trend in Nigeria between 1975 and 2011 shows a general decline within the 36 years that are between 1975 and 2011, rainfall amount in Nigeria dropped by 81 mm, rainfall became worst from the early 1970s, and the pattern has continued till date. This period of sharp drastic rainfall decline corresponds within the period of sharp temperature rise. This is in line with what is stated by Adewum; Ajewole; Ogunlade; and Ayinde (2010) that the trend of temperature in Nigeria is relatively constant, which can also be linked to the irregular movements of rainfall, which regulates the condition of the temperature.

The temperature regime in Nigeria varies from the northern to southern parts of the country, ranging from 17°C to 32°C although high temperatures of 42°C may occur in the country during months of April/May, also in December/January, Nigeria might experience low temperatures of around 5°C. Hence, therefore, cash crop production is adequately maximized during the temperature regimes that permit optimum production, also the mean annual rainfall ranges from 500 mm to nearly 3000 mm among states in the country and these variations permit growing of major cash crop (cocoa and palm oil) in the country, Abdullah (2010). According to the fourth Assessment report of the UN Intergovernmental Panel on Climate Change (UNIPCC, 2007), the average global temperature has risen by 0.74°C since the 1800s and is expected to continue to increase by 1.8–4°C until 2100. In Egypt, results from four variants of the standard Ricardian model showed that a rise in temperature would have negative effect on farm net revenue in Egypt (model 1). In the second, third, and fourth model, adding the linear farm of hydrology, the linear and quadratic terms of hydrology, and the hydrology term and heavy machinery to the analysis improved the adaptability of farm net revenue to high temperature. Marginal analysis indicated that the harmful effect of temperature was reducing by adding the hydrology term and heavy machinery to the analysis. Also estimate from two climate scenarios showed that high temperatures will constrain agricultural production in Egypt (Eid *et al.*, 2006). It, therefore, becomes imperative to find out to what extent the changes in climatic parameters have influenced the output performance of palm oil in Nigeria from the periods 1975 to 2018. The specific objectives in the study include: To examine trend in the climatic parameters and in crop output within the period of 1975–2018, investigate whether there was stagnation, acceleration or deceleration in the output of the selected crop and climatic parameters of temperature and rainfall over the period 1975–2018, examine the mean percentage growth rate between selected crop output and each of the selected climatic parameters within the study period, and analyze the influence of climatic factors on cocoa crop production.

METHODS

This study was carried out in Nigeria, Nigeria is the most populous African Country South of the Sahara (Akpan, 2010), it is a geopolitical and sovereign entity that is composed of 36 states and the federal capital territory (FCT, Abuja). Nigeria is situated along the coast of West Africa between latitudes 4° and 14°N and longitude 3° and 15°E, it shares a common boundary with Niger on the West, Cameroun Republic on the East, and Gulf of Guinea on the South, Nigeria, occupies a land area of 98.3 million hectares of which only about 34.2 million hectares are actually been cultivated and less than 1% of the arable land is irrigated (NBS, 2018), it terrain ranges from southern coaster swamp to tropical forest, open woodlands, grass lands, and semi-desert in the far north. The country enjoys an annual rainfall ranging from 38 cm along the coast to 64 cm or less in the far north. The mean anual temperature ranges from 28° to 31°C in the south (Ibeagwa, 2018). The total population of the country is approximately 193 million people as provided by the National Population Commission (NBS, 2018). Nigeria enjoys a comparative resource advantage in the form of favorable climatic, edaphic, and ecological condition which enables the cultivation of many crop and harvesting of natural product, rearing of animals and practicing of aquaculture, major agricultural commodities produced in the country are divided into crops, livestock and fishery products, and forestry products. Crop production in the country is usually for food or export purposes (Akande, 2003). The principal food crops include maize, millet, sorghum, rice, wheat, beans, cassava, potato, yam, cocoyam, plantain, and vegetables. Export crop includes groundnut, cotton, rubber, oil palm, cocoa, tobacco, and coffee. Livestock products include poultry, goat, meat, lamb/mutton, beef, pork, milk, and egg.

Fishery products of the country are obtained from such activities as artisanal coastal and brackish water catches, artisanal inland rivers and lakes catches, industrial coastal fish and shrimps catches, and fish farming.

The study made use of secondary data mostly the time series. Data on the activities of the Agricultural Credit Guarantee Scheme Fund, agricultural production, and other variables were collected from the publications of CBN, National Bureau of Statistics (NBS), National Planning Commission (NPC), Nigeria Meteorological Center (NIMET) Food and Agricultural Organization (FAO), and other official sources served as supplementary data sources data utilized by the research covered the period 1975–2018.

To actualize objective one, trend analysis was performed. The annual experimental trend or log linear trend analysis was used to estimate the growth rate in climate parameters such as temperature and rainfall as well as in output of palm oil in Nigeria. The method has been variously applied in the past trend studies in Nigeria agriculture (Onyenweaku and Okoye, 2005; Udom 2006; Ojiako *et al.*, 2007, Nnamerenwa, 2012).

The exponential trend equation is given as

$$Cit=\exp(\beta o+\beta i\ ti+ei) \tag{3.1}$$

$$Cpit=\exp(\beta o+\beta i\ ti+ei) \tag{3.2}$$

Where,

Cit = Climate parameter (rainfall and temperature meter measured in millimeters (mm) and centigrade (00c), respectively.

CPit = Output of selected cash crop (palm oil) measured in tones.

t = The time interval/trend measure in years.

β_0 and β_1 = Parameters estimated.

ei = Error term.

The linear form of Equations (3.1) and (3.2) is specified as;

$$\text{Log } Cit = \beta_0+\beta_1\ ti+ei \tag{3.3}$$

$$\text{Log } Cpit = \beta_0+\beta_1\ ti+ei \tag{3.4}$$

Where,

Log Cit and log Cpit are the natural logarithm of the climatic parameters and other variables as previously defined.

The annual exponential of compound growth rate (gr) in climate change and selected cash crop production will be given in line with Onyenweaku (2004) and Nnamerenwa (2012) as

$$gr = (e^{\beta i}-1)\times 100 \quad (3.5)$$

Where;
e = Euler's exponential constant (2.71828)
βi = Estimated coefficient in Equations (3.1) and (3.2), respectively.

To achieve objective two, quadratic equation in the time trend variables was fitted to the data for the entire period (1975–2018) covered in the analysis.

The quadratic equation is as follows.

$$\text{Log Cit} = \beta_0+\beta_{1t}=\beta_{2t}2+ei \quad (3.5)$$

$$\text{Log Cpit} = \beta_0+\beta_{1t}=\beta_{2t2}+ei \quad (3.6)$$

Where;

Log Cit and log Cpit and t variables are as previously defined in Equations (3.3) and (3.4). β_0, β_1, and β_2 are parameters estimated in the specifications in Equations (3.5 and 3.6). The linear and quadratic time terms indicate the circular path in the dependent variables (Cit) and (Cpit), while the quadratic term (t2) indicates the nature of growth followed by the dependent variables (Cit) and (Cpit) (Onyenweaku and Okoye, 2005). Our major interest was on the coefficient of t^2, which is β_2. If β_2 is positive and statistically significant, it implies that there is acceleration in growth of the variables (Cit) and (Cpit). If β_2 is negative and statistically significant, it implies that there is deceleration in growth of the variables (Cit) and (Cpit). If β_2 is not statistically significant, it means that there is stagnation in the growth process for the variables (Cit) and (Cpit) (Onyenweaku and Okoye, 2005, Nnamerenwa, 2012, Anyaegbunam *et al.*, 2006).

To actualize objective three, means and percentages were employed. Thereafter, a paired sample z-test (n=44 years) was employed to test for differences between the mean growth rates in the output of the selected cash crop (palm oil) as well as in each of the examined climatic parameters.

The z-statistics is given as

$$\text{Z cal} = \frac{\bar{X}_i - X_i}{\sqrt{\frac{S^2\bar{X}_I}{ni} + \frac{S^2\bar{X}_I}{ni}}}$$

Where;
=Average growth rates for the selected crop (palm oil)
$\bar{X}_j$ =Average growth rates for each of climate parameters (rainfall, temperature, radiation, relative humidity, and sunshine)
S^2=Squared standard deviation for the selected cash crop (palm oil)
S^2=Squared standard deviation for each of the considered climatic parameters (rainfall, temperature, radiation, relative humidity, and sunshine, respectively)
n_i $\bar{X}_i$ = Number (years) of output for the selected cash crop (palm oil).
n_j X_j = Number (years) of change for each of the considered climatic parameters (rainfall, temperature, radiation, relative humidity, and sunshine).

In realizing objective four, the ordinary least square multiple regression models were employed. Long-run and short-run regression model of the response of palm oil output to climatic change was formulated. To capture the long run and short run of the response of palm oil output to climatic change, the error correction model (ECM) using the Engle-Granger methodology was estimated. The model used to estimate the responses of palm oil output to climate change in both the long-run and short-run periods is presented below.

Long-run model for palm oil output

The long-run model used to estimate the response of palm oil output to climate change is given as:

$$\text{Log } Q_{it}=\beta_0+\beta_1\text{logAHC}_t+\beta_2\text{logRain}_t+\beta_3\text{logTemp}_t+\beta_4\text{logRH}_t+\beta_5\text{logRad}_t+\beta_6\text{logSun}_t+\beta_7\text{logTrend}_t+\mu_i$$

Where,
Log = Natural logarithm of the variables.
Q_{it} = Quantity of palm oil output in period t;
AHC_t = Area harvested of palm oil in period t;
$Rain_t$ = Average annual rainfall in millimeters in period t;
$Temp_t$ = Average annual temperature in centigrade in period t;
RH_t = Relative humidity in percentage in period t;
Rad_t = Radiation in percentage in period t;
Sun_t = Sunshine in hours in period t;
$Trend_t$ = Trend time (T = 0, 1. 43), a proxy for technology, which measures productivity effect.
μ_i = Stochastic disturbance term
β_0–β_7 = Parameter estimates

On a priori ground, it was expected that the coefficient estimates for AHC_t, $RAIN_t$, $TEMP_t RH_t RAD_t$, SUN_t, $TREND_t$>0.

Short-run model for palm oil output

In a bid to estimate the short-run palm oil output models, following the ECM approach, cointegration test was performed using the ADF test procedure. This tends to confirm that the residuals of the non-stationary series that were integrated at order one are actually integrated of at order zero. Cointegration test for the presence of unit roots was performed on the residual series generated from the long-run estimation of the response of palm oil to climate change using the Augmented Dickey–Fuller (ADF) test procedure. The short- run model used to estimate the response of palm oil output to climate change is given as:

$$\text{Log } Q_{it} = \beta_0+\beta_1\text{logAHC}_{t-1}+\beta_2\text{logRain}_{t-1}+\beta_3\text{logTemp}_{t-1}+\beta_4\text{logRH}_{t-1}+\beta_5\text{logRad}_{t-1}+\beta_6\text{logSun}_{t-1}+\beta 7\text{log}Q_{it-1}+\beta_8\text{ECM}_{t-1}+\mu_i$$

Where,
Log = Natural logarithm of the variables.
Q_{it} = Quantity of palm oil output in period t;
AHC_{t-1} = Area harvested of palm oil in period t–1;
$Rain_{t-1}$ = Average annual rainfall in millimeters in period t–1;
$Temp_{t-1}$ = Average annual temperature in centigrade in period t–1;
RH_{t-1} = Relative humidity in percentage in period t–1;
Rad_{t-1} = Radiation in percentage in period t–1;
Sun_{t-1} = Sunshine in hours in period t–1;
Q_{it-1} = Quantity of palm oil output in period t–1;
ECM_{t-1} = Error correction mechanism in period t.
μ_i = Stochastic disturbance term.
β_0–β_7 = parameter estimates.

On a priori ground, it was expected that the coefficient estimates for AHC_{t-1}, $RAIN_{t-1}$, $TEMP_{t-1}RH_{t-1}RAD_{t-1}$, SUN_{t-1}, Q_{it-1} >0, and ECM_{t-1}<0.

RESULTS AND DISCUSSION

The result in Table 1 shows that previous annual rainfall, current annual rainfall, current hours of sunshine, and previous hours of sunshine were the only variables found to stationary at order of integration zero (0) or at level. All the other variables including palm oil were found to be stationary at order of integration one, I(1) or at first difference. Therefore, all the logged variables used for the study were integrated of order one, I(1) except for the previous annual rainfall, current annual rainfall, current hours of sunshine, and previous hours of sunshine which were used at level, I(0). The difference stationary values for the

Aruocha and Nnamerenwa
Innovare Journal of Agri. Sci, Vol 10, Issue 3, 2022, 5-11

variables found to be stationary at order one, I(1) were generated and used for analysis.

Trend in growth rates of climate variables and output of palm oil

The results of trends, compound growth rates and the investigation of acceleration, deceleration, and stagnation of growth in the growth trend of output of palm oil and climate variables of temperature, rainfall, radiation, sunshine, and relative humidity are presented below.

Table 2 shows that the output quantities of palm oil as well as the climate parameters of temperature, rainfall, radiation, relative humidity, and sunshine significantly grew during the period under review. The estimation results showed that the estimated coefficient of the time variable was positive and statistically significant at 1% with respect to temperature, rainfall, radiation, sunshine, and relative humidity within the period under investigation. This implies that time trend variable was a major factor in determining level of temperature, rainfall, radiation, sunshine, and relative humidity within the period under review, and thus, temperature, rainfall, radiation, sunshine, and relative humidity significantly increased within the 1975–2018 periods, respectively. Table 4.1 shows further that the coefficient of multiple determinations (R^2) was high and the F-statistic significant at $p<0.01$ for significant growth in temperature, rainfall, radiation, sunshine, and relative humidity, respectively. This implies that growth in temperature, rainfall, radiation, sunshine, and relative humidity, respectively, was highly time dependent.

However, the coefficient of the time variable was negative and statistically significant at 1% with respect to quantity of palm oil output indicating significant decreases (or reduction) in palm oil output within 1975–2018 periods. This implies that time trend variable may not solely be a major factor influencing the quantity of palm oil output within 1975 and 2018 period. Table 4.1 shows further that the coefficient of multiple determinations is low ($R^2=0.16$) although, significant ($p<0.01$) during the 1975–2018 periods for significant growth in palm oil output. This implies that growth in palm oil output is weakly time dependent and indicates that there is a domestic demand pressure on palm oil production in Nigeria due to food (palm oil) insecurity in the country in recent times. Therefore, low yield, inconsistent production pattern, low adoptive tendencies to improved technology in palm oil production and processing that encourages drudgery in palm oil production and processing, high rate of dissertation of palm oil farming caused by rural-urban migration among able bodied youth, disease and pest incidence, and aging of palm oil farms may give justification to the decrease in palm oil output in the period reviewed.

Table 1: Result of unit root test for logged variable used in the analysis

Variables	Level	First difference	Order of integration
Area harvested of oil palm$_t$	-2.670	−6.888***	I (1)
Area harvested of oil palm$_{t-1}$	−2.605	−6.912***	I (1)
Palm oil$_t$	−2.073	6.152***	I (1)
Palm oil$_{t-1}$	−4.560***	-	I (0)
Radiation$_t$	−1.968	−6.995***	I (1)
Radiation$_{t-1}$	−2.069	−6.787***	I (1)
Rainfall$_t$	−3.587**	-	I (0)
Rainfall$_{t-1}$	−3.494**	-	I (0)
Temperature$_t$	−1.816	−5.389***	I (1)
Temperature$_{t-1}$	−5.633***	-	I (0)
Relative humidity$_t$	−1.933	−6.848***	I (1)
Rel. humidity$_{t-1}$	−2.076	−6.843***	I (1)
Sunshine$_t$	−3.687**	-	I (0)
Sunshine$_{t-1}$	−4.401***	-	I (0)

At level critical value at 1%=−4.234, and at 5%=−3.540 and at 10%=−3.202; at first difference critical value at 1%=−4.244, and at 5%=−3.544 and at 10%=−3.205. Asterisks *,** and ***represent 10%, 5%, and 1% significant levels, respectively

The result of growth rates analysis in Table 3 showed that palm oil output had a negative growth rate with a compound growth rate of −1.7% per annum within the 1975–2018 period.

Similarly, Table 3 shows that the compound growth rates of the considered climatic parameters maintained a positive growth rate within the period under review and recorded an exponential or compound growth rate of 0.1% per annum for temperature, 0.7% per annum for rainfall, 0.9% per annum for radiation, 1.5% per annum for sunshine, and 0.8% per annum for relative humidity. Among the selected climatic parameters, sunshine had the fastest compound growth rate while temperature was slowest in terms of compound growth rate. The compound growth rate of temperature, rainfall, radiation, and relative humidity was slower than the compound growth rate of sunshine by 1.4%, 0.8%, 0.6%, and 0.7%, respectively, per annum; while, the compound growth rate of rainfall, radiation, sunshine, and relative humidity was more than the compound growth rate of temperature by 0.6%, 0.8%, 1.4%, and 0.7%, respectively, per annum.

The result shows that the coefficient of the time variable (t^2) for palm oil production was negative and highly significant ($p<0.01$) for the period (1975–2018) under study, reflecting a case of statistical significant deceleration in the real output of palm oil in Nigeria. Thus, Nigerian palm oil production increased at a decreasing rate in growth within the period under review. For the climate change variables, the coefficient of the time variable (t^2) for sunshine, rainfall, radiation, and relative humidity, respectively, was positive and highly significant ($p<0.01$) for the period (1975–2018) under study, reflecting a case of statistically significant acceleration in the real conditions of sunshine, rainfall, radiation, and relative humidity in Nigeria. Thus, Nigerian climatic parameters in terms of sunshine, rainfall, radiation, and relative humidity increased at an increasing rate in growth within the period under study.

However, the coefficient of the time variable (t^2) for temperature was negative but not statistically significant during the period (1975–2018) under study, confirming stagnation or lack of acceleration or deceleration in the growth of temperature intensity.

Variability in the mean growth rates of selected climatic parameters and palm oil output

Evidence from the z-test results presented in Table 5 shows that the

Table 2: Estimated trend equation for output quantities of palm oil and of selected climatic parameters

Dependent variable	B_0	B_1	R^2	Adjusted R^2	F ratio
Palm oil	6.617 (46.174)***	−0.017 (−2.547)***	0.156	0.132	6.488**
Temperature	3.476 (697.890)***	0.001 (3.741)***	0.286	0.265	13.991***
Rainfall	7.076 (131.000)***	0.007 (2.818)***	0.185	0.162	7.939***
Radiation	2.548 (84.535)***	0.009 (6.209)***	0.524	0.511	38.550***
Sunshine	1.552 (72.446)***	0.015 (14.727)***	0.861	0.857	216.874***
Relative humidity	4.083 (433.127)***	0.008 (16.871)***	0.891	0.887	284.644***

*** and **Represent 1% and 5% levels of significance, respectively. Figures in bracket are t-value. Source: Computed by the author from CBN (2019) Annual Report and Statement of Accounts for the year ended December 31, 2019 and CBN (2019) Statistical Bulletin average growth rate of palm oil output, temperature, rainfall, radiation, relative humidity, and sunshine was 16%, 0.3%, 2.8%, 1.6%, 1.1%, and 1.9%, respectively, over the entire period under study. On the average for all the paired categories (i.e., the growth rate of each of the selected climatic parameters paired with the growth rate of palm oil output), the difference in the average growth rate between climatic parameters of temperature, rainfall, radiation, relative humidity, and sunshine and the output quantity of palm oil were not statistically significant for each pair, respectively (z=1.139 for palm oil – temperature pair; 0.949. for palm oil – rainfall pair; 1.104 for palm oil – radiation pair; 1.083 for palm oil – relative humidity pair, and 1.024 for palm oil – sunshine pair). The average growth rate of palm oil output in Nigeria within the period under study is low. The non-significance of the difference in the average growth rate of palm oil output and climatic parameters of temperature, rainfall, radiation, relative humidity, and sunshine suggested that growth rate in palm oil output depends more on the variability in the growth rate of temperature, rainfall, radiation, relative humidity, and sunshine. Therefore, fluctuations in the climatic parameters of temperature, rainfall, radiation, relative humidity, and sunshine affect the output quantity of palm oil in Nigeria. This result is consistent with the findings of Ajetomobi, Abiodun and Hassan (2011), and Omonona and Akintunde (2010).

Effect of climate changes on palm oil outputs

The results from Table 6 showed that the coefficient of multiple determinations (R^2) for palm oil output was 0.729. This indicates that the independent variables included in the model explained 72.9% of the variations in palm oil outputs in the long run, respectively. The F-statistics for palm oil output models were significant and confirm the significance of each of the entire models. The Durbin–Watson value of 2.153 for palm oil output models indicated that auto-correlation was not a problem in the models. The current values of area harvested of palm oil, rainfall, temperature, sunshine, and time variable were the significant factors that influenced palm oil output in Nigeria in the long run within the period under study and based on the specified model.

Area harvested of palm oil, rainfall, sunshine, and time variable was significant and directly related to the output of palm oil, an indication that palm oil output increased as area harvested of palm oil, rainfall, sunshine, and technology in palm oil production increased. The elasticity of response of palm oil output relative to area harvested of palm oil, rainfall, sunshine, and technology is 3.600, 1.949, 1.662, and 2.464. The elasticity of response of palm oil output relative to area harvested of palm oil, rainfall, sunshine, and technology was elastic. This suggests that a 10% increase in area harvested of palm oil, rainfall, sunshine, and technology will probably lead to about 36.0%, 19.5%, 16.6%, and 24.6% increase in palm oil output.

However, temperature was statistically significant but indirectly related to the output of palm oil, an indication that palm oil output decreased as temperature increased and vice versa. Crop germination and growth rely on optimal temperatures during the period of greatest growth rate (Kitano *et al.*, 2006). Therefore, non-optimal temperatures slow the growth rate or stop growth altogether. Temperature strongly affects crops during their reproductive period, from pollen formation to fertilization and low or high temperatures during this period can prevent crop fertilization and cause seed abortion (Saitoh, 2008). This suggests that a unit increase in average annual temperature will lead to a more proportionate decrease in palm oil output of about 6.94%.

The result of the cointegration in Table 7, which is a precondition for the specification of an ECM, indicates that there are presences of cointegration in the palm oil output models. This is evident as shown by the stationary of the residuals of the static regression for palm oil crop considered in Table 7.

This is evident as shown by the stationary of the residual of the static regression for palm oil outputs in Nigeria within the period under study, and therefore, ECM was specified. The one period lagged residual for annual data used to estimate the response of palm oil output to climatic variables acted as the error correction factor.

The coefficient of multiple determinations (R^2) for palm oil indicates that the regressors included in the model explained 75.8% of the variations in palm oil output. In the short run, palm oil output responded positively to changes in the 1 year lag of the area harvested of oil palm, palm oil output, rainfall, and sunshine and negatively to changes in the 1 year lag of temperature. This implies that the increases in the previous year's value of area harvested of oil palm, palm oil output, rainfall, and sunshine increased palm oil output in Nigeria, that is, to say that the increase in the value of area harvested of palm oil, palm oil output, rainfall, and sunshine in the previous year caused an increase in the current output of palm oil. Furthermore, changes in the 1 year lag of temperature do not enhance the growth of palm oil output in Nigeria as the increases in the 1 year lag value of temperature resulted to a decrease in the current quantity of palm oil output and vice versa.

The coefficient of the error correction mechanism (ECM) for palm oil was significant at 1% level of significant and carried the surmised sign. This implies that a long-run equilibrium or relationship exists between the variable. The ECM value of −0.804 for the short-run estimation of palm oil output suggests that a feedback of 80.4% of the previous year's disequilibrium from the long-run values of the independent variables was observed. Thus, there was a fast adjustment to long-run

Table 3: Compound growth rates of palm oil outputs and of climatic parameters of rainfall, temperature, radiation, relative humidity, and sunshine (1975–2018)

Variables	Parameter (β_1)	Exponential growth rates (%)
Climate parameters		
Temperature	0.001***	0.1
Rainfall	0.007***	0.7
Radiation	0.009***	0.9
Sunshine	0.015***	1.5
Relative humidity	0.008***	0.8
Crop output		
Palm oil	−0.017**	−1.7

*** and ** Represent 1% and 5% significance levels, respectively. Source: Computed by the author from the estimated coefficients of the trend variables in Table 4.1

Table 4: Estimated quadratic trend model in time variables for output of cash crop and climatic parameters

Dependent variable	B_0	B_1	B_2	R^2	Adj. R^2	F-Statistic
Palm oil	6.013 (38.702)***	0.086 (4.306)***	−0.003 (−5.358)***	0.543	0.516	20.167***
Temperature	3.483 (487.040)***	0.000 (0.315)	−32780 (−1.328)	0.321	0.281	8.031
Rainfall	7.273 (112.952)***	−0.027 (−3.208)***	0.001 (4.228)***	0.466	0.434	14.822***
Radiation	2.687 (89.678)***	−0.015 (−3.840)***	0.001 (6.375)***	0.783	0.770	61.426***
Sunshine	1.488 (53.758)***	0.026 (7.318)***	0.000 (3.187)***	0.893	0.887	141.894**
Relative humidity	4.049 (355.795)***	0.013 (9.131)	0.000 (4.072)***	0.926	0.922	213.955***

*** and ** Significant at 1% and 5% levels, respectively. Figures in bracket are t-values. Source: Computed by the author from CBN (2019) Annual Report and Statement of Accounts for the year ended December 31, 2019, and CBN (2019) Statistical Bulletin

Table 5: Test of significance of the difference between the mean growth rates of selected climatic parameters and palm oil output

Sample	Mean	Standard deviation	Standard error mean	DF	Z-statistics
[a]Palm oil$_t$	15.876	82.637	13.585	43	1.139
[b]Temperature$_t$	0.338	1.555	0.256		
a – b	15.538	83.011	13.647		
[a]Palm oil$_t$	15.876	82.637	13.585	43	0.949
[b]Rainfall$_t$	2.756	15.776	2.594		
a – b	13.120	84.062	13.820		
[a]Palm oil$_t$	15.876	82.637	13.585	43	1.104
[b]Radiation$_t$	1.576	7.253	1.192		
a – b	14.300	78.765	12.949		
[a]Palm oil$_t$	15.876	82.637	13.585	43	1.083
[b]Relation humidity$_t$	1.117	2.244	0.369		
a – b	14.759	82.859	13.622		
[a]Palm oil$_t$	15.876	82.637	13.585	43	1.024
[b]Sunshine$_t$	1.903	5.083	0.836		
a – b	13.973	83.007	13.646		

[a – b]Represents paired sample differences. Source: Computed by the author from CBN (2019) Annual Report and Statement of Accounts for the year ended December 31, 2019, and CBN (2019) Statistical Bulletin

Table 6: Regression result of the effect of climate changes on palm oil outputs in the long run in Nigeria (1975–2018)

Variables	Palm oil
Area harvest of crop	3.600 (2.995)***
Rainfall	1.949 (2.995)***
Temperature	-6.942 (-2.135)**
Relative humidity	-1.693 (-0.415)
Radiation	-0.991 (-1.041)
Sunshine	1.662 (2.077)**
Trend	2.464 (2.197)**
Constant	42.351 (2.562)**
R^2	0.729
Adjusted R^2	0.663
F-statistic	11.137***
Durbin–Watson statistic	2.153

***, **, and * represent 1%, 5%, and 10% significance levels, respectively. Figures in bracket are t-value. Source: Computed by the author from CBN (2019) Annual Report and Statement of Accounts for the year ended December 31, 2019, and CBN (2019) Statistical Bulletin

Table 7: Result of cointegration test for palm oil output

	Level	1st difference	Order of integration
Palm oil	−4.643	-	I (0)

Critical values of 1%=4.244 and 5%=−3.544

equilibrium among the independent variables used to estimate palm oil output performance in Nigeria within the period under study.

CONCLUSION AND RECOMMENDATION

Palm oil output quantities as well as the climatic parameters of temperature, rainfall, radiation, relative humidity, and sunshine have significant growth during the period under review (1975–2018). Time trend variable was a major factor in determining quantity of temperature, rainfall, radiation, sunshine, and relative humidity within the period under review. The growth in temperature, rainfall, radiation, sunshine, and relative humidity, respectively, was highly time dependent. The growth in palm oil output is weakly time dependent. There is a domestic demand pressure on palm oil production in Nigeria

Table 8: Regression result of the effect of climate changes on palm oil outputs in the short run including ECM in Nigeria (1975–2018)

Variables	Palm oil
Area harvest of crop$_{t-1}$	0.732 (6.497)***
Crop output$_{t-1}$	0.468 (3.000)***
Rainfall$_{t-1}$	0.581 (2.866)***
Temperature$_{t-1}$	−0.492 (−3.224)***
Radiation$_{t-1}$	−0.361 (−0.498)
Relative humidity$_{t-1}$	−0.361 (−0.498)
Sunshine$_{t-1}$	0.576 (3.032)***
ECM$_{t-1}$	−0.804 (−2.953)***
Constant	4.043 (2.637)***
R^2	0.758
Adjusted R^2	0.687
F-statistic	10.591***
Durbin–Watson statistic	2.184

***, **, and * represent 1%, 5%, and 10% significance levels, respectively. Figures in bracket are t-value. Source: Computed by the author from CBN (2019) Annual Report and Statement of Accounts for the year ended December 31, 2019, and CBN (2019) Statistical Bulletin

due to food (palm oil) insecurity in the country in recent times. The compound growth rate of palm oil output, temperature, rainfall, radiation, sunshine, and relative humidity was slow during the periods under study.

There was stagnation in the growth rate of temperature, deceleration in the growth rate of palm oil, and acceleration in the growth rate of rainfall, radiation, relative humidity, and sunshine within the period under review. Nigerian palm oil production decreases in growth rate within the period under study. Nigerian climatic parameters in terms of sunshine, rainfall, radiation, and relative humidity increased in growth rate while its temperature remained the same in growth rate within the period under study.

The difference in the average growth rate of palm oil and each of the climatic parameters of temperature, rainfall, radiation, relative humidity, and sunshine were not significant. The average growth rate in palm oil output in Nigeria is low. The fluctuations in the climatic parameters of temperature, rainfall, radiation, relative humidity, and sunshine affected the growth rate of palm oil output in Nigeria within the periods under study.

In the long run, the current values of area harvested of palm oil, rainfall, temperature, sunshine, and time variable significantly influenced palm oil output in Nigeria, while, in the short run, 1 year lag values of area harvested of oil palm, palm oil output, rainfall, sunshine, and temperature significantly influenced palm oil output in Nigeria within the period under study and based on the specified model. The short run independent variables that estimated the response of palm oil output to climatic changes adjusted quickly to long-run equilibrium. Temperature impacted negatively on palm oil output quantities in Nigeria. Hence, those policies which stabilize the intensity of temperature, which will equally increase the output quantities of these cash crops, are strongly advocated by the study. Technological changes, area harvested of crops, rainfall, relative humidity, and sunshine impacted positively on palm oil output in Nigeria within the period under study. Hence, those policies which increase the adoptive tendencies of farmers to new production technologies, allow more area of land to be allocated to palm oil farmers, ensure adequate and timely rainfall and relative humidity, ensure adequate sunshine hours for these cash crops, and equally increase the output of these cash crops are strongly advocated.

REFERENCES

Adegeye AJ, Dittoh JS. Essentials of Agricultural Economics. Ibadan: Centre for Agricultural and Rural Development; 1985. p. 161-6.
Akpan EO. Effect of exchange rate movements on economic growth in

Nigeria. CBN J Appl Stat 2010;2:1-14.
Ayoade JO. Introduction to Climatology for the Tropics. Ibadan: Spectrum Books Ltd.; 1983.
Central Bank of Nigeria. Annual Report and Statement of Accounts for the Year Ended 31st December 2019. Nigeria: Central Bank of Nigeria; 2019.
Chinedum N, *et al.* Effect of Climate on the Agriculture of Sub-Sahara Africa lesson from South East Rain Forest Home of Nigeria Oxford Business and Economics; 2010.
Eid MH, El-Marsafawy SM, Ouda SA. Assessing the Economic Impacts of Climate Change on Agriculture In Egypt. A Ricardian Approach; 2006.
Eze C. Climate Change and Adaptation in Nigeria, farming and Rural System Economics; 2011.
Financial Ombudsman Service. Federal Office of Statistics. Bulletin on Climate Change. United Kingdom: Financial Ombudsman Service; 1992.
Gujurati DN. Essentials of Econometrics. 3rd ed. New York: McGraw-Hill; 2006.
Ibeagwa OB. Effect of Land Grabbing on Growth in Nigeria Agricultural Sector; 1980-2016 [PhD Dissertation]. Department of Agricultural Econmics, Mchael Okpara University of Agriculture; 2018.
Ikhatua UJ. Effect of Climate Change on Global and National Food Security of Food Science and Technology Held at the University of Benin, Benin City, Edo, Niger, 5th June; 2010.
Intergovernmental Panel on Climate Change, Larry MP. Climate Change, 2007: Impact, Adaptation and Variability Contribution of Working Group 11 Government Panel on Climate Change. Geneva, Switzerland: Intergovernmental Panel on Climate Change; 2007.
Intergovernmental Panel on Climate Change. Impact, Adaptation and Variability Contribution of Working Group Governmental Panel on Climate Change. In: Parry ML, Canzion OF, Paliskof JP, Vander linden PJ, Harson CE, editor. Climate Change. Cambridge: Cambridge University Press; 2007.
National Bureau of Statistics. Statistical Bulletin. Vol. 5. National Bureau of Statistics; 2018.
Nnamerenwa GC. Analysis of Intra-sectoral Allocation of Credit under the Agricultural Credit Guarantee Scheme Fund (ACGSF) in Nigeria (1978-2009) [MSc Thesis]. Department of Agricultural Economics, Michael Okpara University of Agriculture; 2012.
NPC. National Planning Commission “Report on its Activities” NPC Abuja Nigeria; 2009.
Nwadinobi RU. Effect of Climate Change on the Production of Selected Root Crops in Nigeria (1970-2009) Department of Agricultural Economics, MOUAU; 2011.
Ojiako IA, Asumugha GN, Ezedinma C, Uzokwe NE. Analysis of production trends in the major root and tuber crops in Nigeria, 1961-2005. Res Crops 2007;8:371-80.
Onyenweaku CE, Okoye BC. Trends in Cassava Output Area and Productivity in Nigeria 1960/61-2003/04 Proceeding of the 39th Conference of the Agricultural Society of Nigeria Benin; 2005.
Onyenweaku CE. Stagnation, acceleration and deceleration in agricultural production in Nigeria, 1970-2000. J Agric Food Sci 2004;2:131-40.
Oyekale AS, Bolaji MB, Olowa OW. The effects of climate change on cocoa production and vulnerability, assessment in Nigeria. Agric J 2009;42:79-85.
Spore. J Agric Soc Res 2008;12:
Udom DS. Analyze of Nigeria meat production trends: 1961-2004. Niger Agric J 2006;37:18-23.
Wikipedia. Rudolf. J Agric Sustain 2009.