International Journal of Multidisciplinary
Research and Growth Evaluation.

Climate change and Oil Palm Productivity in Nigeria. Does climatic correlations really matter?

Uduak M Ekong [1*], **Uduak Effiong Isaac** [2], **Enobong Udeme Mbobo** [3]
[1, 3] Department of Economics, Faculty of Social Sciences, University of Uyo, Uyo, Nigeria
[2] Ministry of Economic Development, Akwa Ibom State, Nigeria

* Corresponding Author: **Uduak M Ekong**

Article Info

ISSN (online): 2582-7138
Volume: 04
Issue: 03
May-June 2023
Received: 18-04-2023;
Accepted: 03-05-2023
Page No: 458-466

Abstract
This study investigated majorly the correlative impact of climatic factors on the growth of palm oil output in Nigeria in the years 1980 to 2022. We observed a demand-supply gap in oil palm output and so desire to quantitatively trace the contributions of sub-regional climate change to such gap. Three major climate factors generally agreed by the literature, rainfall (rain), temperature (tem) and carbon(IV)oxide (CO_2), were used. We also included country specific factor to climate alteration, gas flaring (gasf) in the analysis. We employed Maximum Likelihood Estimation (ML) in a transcendental logarithmic (translog) functions to analyze the variables. We found that truly, climatic factors exerted noticeable effects on oil palm production in Nigeria. At their individual capabilities,rain, CO_2 and gasf impacted positively on oil palm production while gas flared dipped oil palm output. The correlative effects of all the climatic factors on oil palm production in Nigeria were oil-palm-dipping. Infact, the combined effect of (rain) and (tem) produces approximately 18 percent decline on oil palm production; the combined effect of CO_2 and (tem) produces approximately 6.9 basis point decline on oil palm production; the combined effect of (gasf) and (tem) produces approximately 1.3 basis point reduction on oil palm production; the combined effect of (rain) and CO_2 produces approximately 0.7 percent decline on oil palm production; a 0.1 percent combined effect of (gasf) and CO_2 produces approximately 17 percent decline on oil palm production; a 0.1 percent combined effect of gasf and (rain) produces approximately 62 percent decline on oil palm production. Evidence based recommendations such as "activity ranging" for gas and oil related activities whose gas flaring are usually determinant and policy substitution in greener economy which focuses on investment in green technology be pursued.

Keywords: Oil Palm, Climate Change, Climate Factors, Output, Correlative effect, Nigeria

1. Introduction

In the Christian holy scriptures, we read,

> *"Then God said: "Let the earth cause grass to sprout, seed-bearing plants and fruit trees according to their kinds, yielding fruit along with seed on the earth." And it was so. And the earth began to produce grass, seed-bearing plants and trees yielding fruit along with seed, according to their kinds. Then God saw that it was good. Then God said: "Here I have given to you every seed-bearing plant that is on the entire earth and every tree with seed-bearing fruit. Let them serve as food for you"*
> *Rendition of the New World Translation 2013.*

This marks the beginning of an approved agricultural production both at the standpoint of God and Man. Thus, in-line with this command, all countries of the world, engage in agricultural activities and production at the level culturally accepted to be either subsistent or even commercial.

Agricultural production provides the means of attaining some of man's greatest needs – that of food, (and shelter, if we can think of other bye-products of agriculture used for building purposes like the timber logs etc). So important, and often degraded to the bottom in the discus of agricultural production and productivity is its role in health care delivery, which to my mind, should come to the main fore of man's needs, extending the basic needs to four (food, health, shelter and clothing).

Of much more concern in recent times is the role of agricultural production in governance and income generation. For instance, at the world level, the share of agriculture in total gross domestic product (GDP) in developing countries is about 13%, in contrast to 2% in developed countries. For central, eastern, and western Africa, this share is over 31%, and in South Asia it is around 25%. In some 25 developing countries, this share varies from about 40–60% (Fischer, Shah and Velthuizen, 2002) [19]. Many governments of the world places much emphasis in agricultural production because of the associated benefits of economic diversification propaganda, improved macro-economic performance with associated unemployment questions, youth restiveness and rural-urban drift checks. For instance, the United States of America spent not less than 198.1 billion dollars in 2022 on agricultural production to earn over 23.3 percent contribution to its overall gross domestic product (GDP) growth valued at 200.1 billion dollars in 2022 (USDA, 2022). China spent 380.7 billion dollars to achieve well over 16.05 percent growth in GDP translating to 54779.10 CNY growth in real income in 2022 (National Bureau of Statistics of China, 2022) [24]. Within the same time period, Nigeria spent a total of 291.4 billion naira on agriculture and reaped 29.67 percentage contributions to growth in GDP valued at 5625362.33 million naira in quarter three, 2022. These are few of the many cases of using agriculture to achieve sustainable growth.

Much of the successes in agricultural production of the many regions of the world has been linked to the placement and topography of the region in the world's sphere, the soil texture and the general climatic condition of the region. In-fact, the literature placed much more importance to climatic conditions and favourable crop yield in many cases. Thus, sometimes most feasibility studies in agricultural production has often centered on some of the soil and climatic conditions to favour such production. Rosenzweig and Liverman (1992) [30] compared the effect of climate change in temperate and tropical regions and found out that the regions differed significantly, both in the biophysical characteristics of their climate and soil and in the vulnerability of their agricultural systems and people to the changing climate situations.

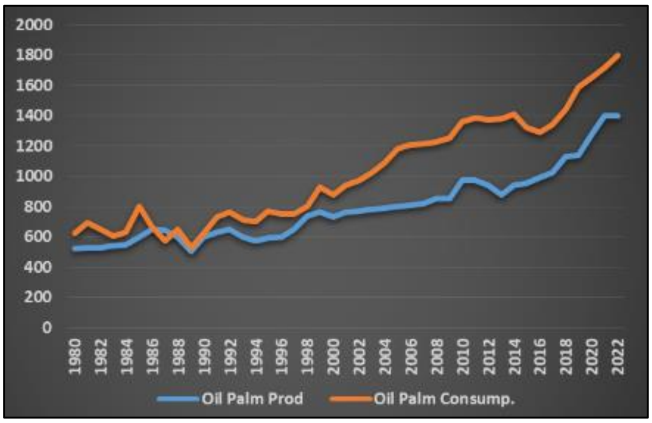
As Fischer, Shah and Velthuizen (2002) [19], indicated, Global environmental changes pose the following challenges to agricultural researches: changes in the flow and storage of materials, ecology of pests and diseases, dynamics of rainfall regimes and water accumulation, plant responses to temperature and CO_2 concentration, reduction of greenhouse-effect gases, plant-salt-tolerance affected by intrusion of salt-water due to sea-level rise, conservation of biodiversity, and adaptation of food production systems to extreme weather events.

Issues on climate change is gaining wider attention in academic literature. These include, but not limited to, concern for green house emission, changes in carbondioxide level, changes in annual rainfall level, etc.

Our interest is on examining the effect of climate change in agricultural production in Nigeria using oil palm production as a case study. Oil Palm production, as is the case with other agricultural products is totally dependent on weather and climate. Palm oil production is of strategic importance to the life wire of an economy as it serves as a ready source of raw material for untold number of products across the globe ranging from food substances to toilet utilities, biofuels and lubricant substances. Palm oil is presently the viable substitute for partially hydrogenated soy with plenty of trans fats (Brown and Jacobson 2005) [11]. Palm oil has also developed a reputation for positive environmental impact, primarily due to its influence on reforestation as is seen in parts of Asia in the form of massive palm estates and Nigeria. Within the African sub region, Nigeria is ranked the highest in oil palm consumption than production, consuming approximately 3 million metric tonnes of fats and oil as at 2018 with oil palm accounting for about 44.7 percent (or 1.34 million metric tonnes) of the consumption. By 2022, the consumption volume has jumped to 1.67 million tonnes.

There are however, serious concern about the dwindling trend in agricultural production in recent times in some regions of the world as world climate changes. For instance, as indicated by the United Nations Human Development report for Nigeria (2016), the food production index for the country fluctuates for most of the years between 104.3 percent in 2006 to 91.5 percent in 2009 and 97.8 percent in 2011 and increased to 114.9 percent in 2013. It however fell drastically from then to 104.54 percent in 2016 before experiencing marginal growth to 105.20 percent in 2018. In 2020, the food production index for Nigeria was 106.3 percent. Much more worrisome is the declining production and supply of oil palm products and associated allies. As Figure 1 indicates, current oil palm production failed to meet current domestic demand as times increases producing a supply gap of 0.32 metric tonnes by 2018 and 0.40 metric tonnes by 2022. This is noticeable even with rising climatic fluctuations. As Figure 2 shows, major climate factors such as rainfall was on the decline with pockets of peaks in some years. Equally, carbon (lV)oxide continues to rise steadily in the period under review leaving the country's temperature on a fairly steady state.

There are at least three main approaches to studying the effect of climate change on agricultural production for food sustainability. These are agricultural systems analysis, crop yield analysis, and spatial analysis. As pointed out by Smit, Ludlow and Brklacich (1988) [34], Agricultural systems analysis assesses the impacts of climatic change on multiple agricultural activities and on the functioning of the agro-food sector, including prices, trade pattern, and employment. Crop yield analysis estimates the effects of altered environments on crop productivity levels and has been employed widely in climatic impact assessments. Spatial analysis examines the implications of climatic warming on the area and location of lands suitable for agricultural production. Our study adopts a crop yield based analysis to the assessment of climatic influence on oil palm output in Nigeria. However, unlike the other empirical studies (for instance Bello, Ganiyu, Wahab, Afolabi, Oluleye, Ig, Mahmud, Azeez, and Abdulmaliq, 2012; Chikezie, Ibekwe, Ohajianya, Orebiyi, Ehirim, Henri-Ukoha, Nwaiwu, Ajah, Essien, Anthony and Oshaji, 2015), our study differ markedly in that we explore both the integrated influence and continuous effects of climate change variables on oil palm productivity in the period under review.

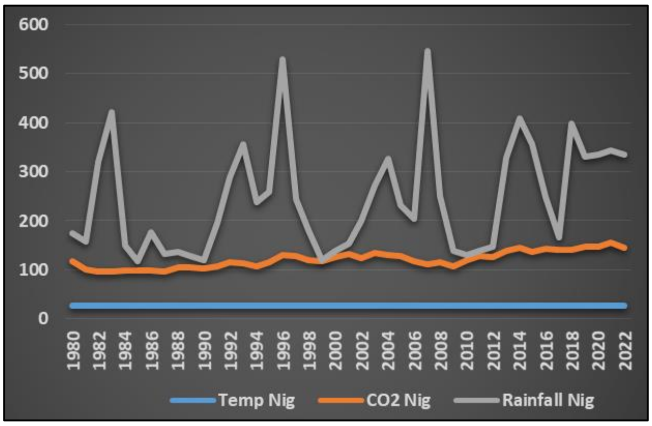


Source**:** Authors

Fig 1: Trends in Oil Palm Production and Consumption in Nigeria 1980-2022

Brief history of Oil Palm cultivation in Nigeria

In the early 1960s, Nigeria was the world's largest palm oil producer with global market share of 43%. Today, it is the 5th largest producer with less than 2% of total global market production of 74.08 million metric tonnes (Pricewater Coopers (PWC), 2019) [29]. Some have even argued that Nigeria's dominance in oil palm production predated the 1900 (see for instance Foundation for Partnership Initiatives in the Niger Delta (PIND), 2011) [20]. According to World Rain-forest Movement, oil palm is indigenous to the Nigerian coastal plain though it has migrated inland as a staple crop (Bassey, 2016; PIND, 2011) [9, 20]. The Nigerian oil palm belt covers majorly nine states of the Niger Delta (Akwa Ibom, Abia, Rivers, Edo, Imo, Ondo, Bayelsa, Cross River and Delta). Within the oil palm belt in Nigeria, 80% of production comes from dispersed smallholders who harvest semi-wild plants and use manual processing techniques. The estimate for oil palm plantations in Nigeria ranges from 169,000 hectares to 360,000 hectares of plantations (PIND, 2011) [20]. Sadly, over the years, Nigeria can no longer be a dominant player in the oil palm production and sales business. The literature suggest many ingrained factors. One is the discovery of crude oil in 1958 and the other is the effect of the civil war (1967-70) (Akhaine, 2017) [4]. The discovery of crude in commercial quantity and the consequent Dutch disease that petro-dollars bred undermined any conscious inclination towards the potential of the oil palm industry. Others have cited the bureaucratic failures of the colonial masters of placing undue priority over crude oil production to palm oil. As pointed out by Bassey (2016) [9] the origin of poor penetration of large oil plantations estates of 5% is attributed to the deliberate policy of British colonial government that discouraged the establishment of Plantations in Southern Nigeria and a rising encouragement of such in Southeast Asia. As a result of these deliberate neglect, local control of palm oil trade eroded under colonial administration and Nigeria is estimated to have lost more than 20 billion dollars annually (PWC, 2019) [29]. In the beginning periods of oil palm production in Nigeria, the oil palm industry was rudimently fragmented with local small scale farmers accounting for over 80 percent production and a paltry 20 percent production being accounted for by established plantations. As a result capital investment for accelerated technological production dipped. With these attendant challenges, it was no longer news that the country loose its dominant production stance to fifth world's largest producer of palm oil and sixth largest exporter of palm oil in Africa and even meeting the current domestic consumption demands becomes a mirage.



Source**:** Authors

Fig 2: Trends in climate factors in Nigeria 1980-2022

Literature Review

Russell and Paterson (2021) [31] explored the longitudinal trends of future climate change on oil palm production in Africa. He employed mechanistic niche model (CLIMEX) that allows for ecological research by incorporating modelling of the potential distributions of plant species under various climate scenarios to assess a rising climate fluctuation on oil palm growth in the years prior to 2021. His study revealed an increasing trend in suitable climate that runs from east to west for oil palm production with Uganda being the worse hit in reduced climate change. He therefore make a case for oil palm production migration towards the east in Africa

For Aneni, Aisagbonhi and Iloba (2012), the impact of climate change on pest of oil palm has not been adequately given attention. They investigated such impact for the Nigerian sub region using data obtained from the main station of the Nigerian Institute for Oil Palm Research (NIFOR) from 1952 to 2006. Their findings showed that insect pests of the Oil palm benefited considerably to variability impacts of climate change in Nigeria between the period. In specific terms, they showed that as temperature increased, insect pests increase correspondingly. This increases the vulnerability of the oil palm to pest attack and lower oil palm production as a result of increased pest infestation. They therefore recommended up scaling climate and weather data information to ensure that farmers get information in ways they can use to make on-farm decisions and transition to an energy efficient and low carbon economy as remedy to the climate change-pest effect on oil palm output.

Koyenikan and Anozie (2017) [23] believes that truly climate change impacted on oil palm production. However, they strongly believe that individual farmers adaptation to such climatic fluctuations could minimize climate change impact. In their study, they used a multistage process involving random and snow ball techniques were used to draw a total of 120 respondents from 14 communities in Edo state Nigeria to measure farmer-gender based adaptation to climate change. Their study dwelled on simple measures of dispersion (frequency, means, percentages and t-test) to measure farmers climate change adaptation to oil palm production. Their findings indicated significant difference between male and female adaptation needs. While 78.3% of male dominated the on farm adaptation process, 48.3% of female accounted for the off-farm adaptation processes. They suggested training needs to the Edo farmers on climate change adaptation to oil palm post-harvest practices. In a recent study by Ojemade, Okorji and Enete (2019) [26] showed that farmers are already having difficulty adapting to climate change in the region. In over 171 farmers sampled in the region, they found majorly high labor cost (0.759), land tenure (0.64), poor access to information (0.740), lack of training (0.767), lack of capital (0.820), limited availability of land (0.798) and lack of improved oil palm production technologies (0.438) as challenges impeding climate change adaptation to oil palm production within the area.

Similarly Chukwuma Olive and Evangel (2021) [15] extended the interest of farmers' adaptation strategy to climate change on oil palm production to include South-South Nigeria. They study incorporated both primary and secondary research design to carry out their analysis. Respondents were randomly sampled from three states of Imo, Ondo and Delta. To investigate the farmer's choice adaptation strategy, they applied Multinomial logit regression model that takes care of choice probabilities across the various options of climate change adaptation strategies. Their study indicated that about 23.39% of the famers adapted to new varieties of Oil Palm seedlings to cope with declining palm oil-climatic conditions while 50.29 % of the farmers did not respond to climate change effects. More generally, the determinant for such effect in palm oil-climate change adaptation depends largely on household size, Farm size, the likelihood of farmers using improved technologies, purchase of water for irrigation and crop diversification. They thus agitate for farmers' education as a way of feeding adaptation strategies on the mind of the farmers in Southern Nigeria.

Ogunbode, Aliku, Ogungbile, Olatubi, Adeniyi and Akintunde (2022) [4] argued that oil palm production may improve soil quality under certain climate conditions. In a study to assess the impact of oil palm processing activities on selected soil properties in Iwo, Nigeria, using stability index. Three soil samples - upstream, mid-section, and downstream were selected in an oil palm mill dumpsite and compared against a control. Findings suggest that soil texture was superior at the mid-section sample and reduced by 57.0% upstream and downstream 76.2%. There thus concluded that oil palm mill processing activities improved the on-site soil organic matter and its physical conditions.

Abubakar, Ishak and Makmom (2021) [1] undertaken a review of all such impact and adaptation to climate change on oil palm production in Malaysia from 2000 to 2021. They identified certain anthropogenic activities and the agroecological practices in oil palm plantation, including excessive use of fertilizers, bush fire due to land clearing, and cultivation on peatland that have accelerated the effects of climate change noticeable in extreme events such as drought, flooding, heatwave, as well as infestation of pest and diseases. Such practices exacerbated a range of impacts on the oil palm production in Malaysia within the period under review. They suggested several adaptation stratergies to mitigate the climate impacts including hybrid resistant varieties of oil palm inputs that are tolerant to heat; sustainable soil usage and management, adequate track management in plantation sites, reduced dependence on fertilizers, herbicides, and pesticides and zero burning among others. They thus recommended that sustainable national policy on climate change, conservation of the existing carbon stock, effective management of tropical rainforest biodiversity, afforestation for carbon sequestration, and reduction in greenhouse gas (GHG) emission will, moving forward act to deter the negative impact of climate change on oil palm in Malaysia.

Abubakar, Ishak, Uddin, Samad, Mukhtar and Danhassan (2021) [2] selected some climate factors in Peninsular Malaysia such as temperature and rainfall to measure their effect on oil palm production from 1975 to 2020. Utilizing multiple regression technique on the transformed data, they found that annual mean rainfall had risen for the area at the rate of 0.0153 unit with minimum of 156.3 mm and a maximum of 311.04 mm indicting a high difference in the highest and lowest amount of rainfall in the area different from about 1,500 mm–2000 mm of rainfall per period naturally required for oil palm yield. Equally, average annual temperature also increased at the rate 0.0357℃ per year. With these increases, oil palm yield also increased at a statistically significant the rate of 0.2581 per year.

Sarkar, Begum and Pereira (2020) [32] investigated the impact of climate factors fluctuations on oil palm output in Malaysia from 1980 to 2010. In their study, they decided to streamline the climate factor to only temperature and rather gauged the system with area of oil palm plantation. Employing multiple regression analysis on the logged data, they showed that a one percent rise in temperature in Malaysia dipped oil palm output by nearly 29 percent. However, the larger the area of oil palm cultivation, oil palm output increased by almost 100 percent. They recommended cost-effective mitigation options as adaptation strategy to mitigate huge climate impact on oil palm production for Malaysia.

Zainal, Shamsudin, Mohamed and Adam (2012) [38] compared the impact of climate change variability on oil palm yield for three region-Peninsular, Sabah and Sarawak of Malaysia. Average climate data sample from 1980 to 2010 were investigated using the Ricardian model. Results from the OLS estimation showed that a spark in temperature and rainfall in Malaysia will dipped oil palm yield in Peninsular for RM 40.55; in Sabah for RM48.69 and in Sarawak for RM 37.61 respectively. They suggested that mitigating this effect will require development of plant species resistant to high temperature and low water level.

Oktarina, Nurkhoiry and Pradiko (2020) [27] considered the effect of climate change on changing oil palm prices in Indonesia from 1980 to 2018. Data comprising of climate variability and oil palm yield was fused into a system of equations that linked supply to demand. Utilizing a system of simultaneous equation and simulations on the variables, they found intriguing evidences of ecosystem disruption that affect household welfare in oil palm business by climate variability particularly from rainfall. This has the effect of also fluctuating the oil palm prices and ultimately farmers welfare.

Going by these conditions, the food security agenda of the government is threatened. Ani, Anyika and Mutambara (2022) [6] examined the changing climatic conditions on food and human security in Nigeria. Primary data collected from January 2018 to November 2019 across various towns in Nigeria including Abakaliki, Asaba, Barutin, Maiduguri, Gusau and Markurdi were sampled using 48 semi-structured questionnaires. Secondary data spanning from 2006 to 2019 were also collected to analyze the trend of variables of interest. Their results showed that climate variability negatively impacted on food and human security in Nigeria.

Specifically, from 2008 to 2018, there is a persistent increase in the trend of undernourishment thus soaring food insecurity in the country. Climate change-related events such as cases of rising flood and drought have significant impact on human lives. The rising drought has caused herders and their cattles to migrate in search for pastures and has often brought them in constant combat with local farmers hunters.

The method of study

To examine the effect of climate change on the oil palm productivity of Nigeria, a transcendental logarithmic (translog) functions is used. The translog functional form has been widely used, around the world in empirical research, since its introduction by Christensen, Jorgenson and Lau (1973) [14]. The choice of this specification is to allow for clarity in the combined effects of the structural component of climate change on oil palm products in the region. Thus, the model allow for greater flexibility in measuring environmental relationships compared to other traditional measurement techniques and have the ability to provide formulas for variables elasticities, in a more convenient manner.

The translog functional specification of the model is

$$In\,Y_t = \partial_0 + \partial_1 \sum_0^k In\,X_{it} + \frac{1}{2}\partial_2 \sum_0^k In\,X_{it}^2 + \partial_3 \sum_0^k In\,X_{it}X_{jt} + u_t \qquad 1.0$$

Where, Y_t = *Value added of agricultural production;* X_t = *independent regressors and* $X_i \neq X_j$*;*$_\partial$*= unknown parameters;* U_t = *error term;* ∂_1,$\partial_2$and∂_3 are unknown system parameters to be estimated.

The joint impact of climate change on the productivity performance of oil palm output in Nigeria will be determined by ∂_3. ∂_2 captures the effect of correlation of climate change factors with itself over time, brought about by environmental acclimatization in the zone.

According to Chilioke, Haile and Waschkeit, (2011) [13], crop production in Sub-Saharan Africa is directly affected by many aspects of climatic change, stemming primarily from average, change in rainfall amount and patterns, rising atmospheric concentration of CO_2, change in climatic variability and extreme events and sea water rise. In Nigeria, three most predominant climatic effects are, temperature increase, atmospheric concentration of CO_2 and change in rainfall. More recently, due to the degrading effect of oil exploration in South-South Nigeria, agricultural productivity is also affected by uncontrolled gas flaring, making the region susceptible to declining palm oil output. We therefore include gas flaring as an important variable in our climatic consideration of the region.

It was not difficult to determine the total parameters to be estimated in our climate change-oil palm output equations if we follow this simple specification;

$$P_{i,j} = \frac{n\,(n+3)}{2} \qquad 2.0$$

Where, $P_{i,j}$ is the parameter estimate for variable *i* or *j*; and *n* is the number of variables in the system. Expanding equation 1.0 to our desired purpose, we have;

$$InAgr_t = \partial_0 + \partial_1 InRain_t + \partial_2 InTemp_t + \partial_3 InCO_{2,t} + \partial_4 InGasf_t + \frac{1}{2}\partial_5 InRain_t^2 + \frac{1}{2}\partial_6 InTemp_t^2 + \frac{1}{2}\partial_7 InCO_{2,t}^2 + \frac{1}{2}\partial_8 InGasf_t^{\,2} + \partial_9 InRain_t InTemp_t + \partial_{10} InRain_t InCO_{2,t} + \partial_{11} InRain_t InGasf_t + \partial_{12} InTemp_t InCO_{2,t} + \partial_{13} InTemp_t InGasf_t + \partial_{14} InCO_{2,t} InGasf_t + u_t \qquad 3.0$$

One key concern with the estimation of translog functions has to do with the issue of collinearity of the interacting variables. At the moment, the literature provides two options in dealing with the issue. First, Pavelescu (2011) [28] and Gujarati (2004) [21] suggested estimating single variable equation for all variables in the system. However, as variables increases, the single equations become too numerous to content. Second, Umar, Girei and Yakubu (2017) [35] and Gujarati (2004) [21] have showed that the issue of increasing single equations can be handled by Maximum Likelihood Estimation (ML) and is applied in this study.

Translog specification of climate change on oil palm production allows us to determine the cumulative effect of change in a particular climate factor on oil palm output using the marginal product analysis thus;

$$\frac{\partial Oil\ Palm}{\partial Clim_{i,j}} = \alpha_i + \sum_{j=1}^{n} \beta_{i,j}\, In\, Clim_{i,j} \qquad 4.0$$

Stationarity test

We employ the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test and the DF-GLS test to assess the stationarity of the variables. The KPSS test statistic is obtained by regressing the residuals of a regression on the independent variables of the original regression and is given as:

$$KPSS = \frac{1}{T^2}.\frac{\sum_{t=1}^{T} S_t^2}{\varpi_\infty^2} \qquad 5.0$$

Where,$S_t = \sum_{s=1}^{t} \hat{e}_s$ is a partial sum
ϖ_∞^2 is the HAC estimator of the variance of $\hat{e}_t$

The use of this test is predicted by its ability to mitigate low power statistic and size distortion problems inherent in other stationarity test procedures. In the KPSS, the null hypothesis is that the variable in question is stationary and the decision criteria is to accept the null only if the absolute value of the calculated statistic is below the critical value at the accepted level of significance (Ekong and Ekong, 2017) [17].

The DF-GLS test also possess good size and power properties (Elliot. Rothenberg and Stock, 1996; Aziakpono and Wilson, 2013) [18, 8]. The t statistic is generated from the parameters gotten from the following equation;

$$\Delta y_t^d = \vartheta y_{t-1}^d + \delta_1 \Delta y_{t-1}^d + \ldots. + \delta_p \Delta y_{t-p}^d + \mu_t \qquad 6.0$$

Where,y_t^d is the detrended data series; Δ is the difference operator; $\vartheta, \delta_1, \delta_p$ are parameters to be estimated and μ_t is the error term.

Results and discussion

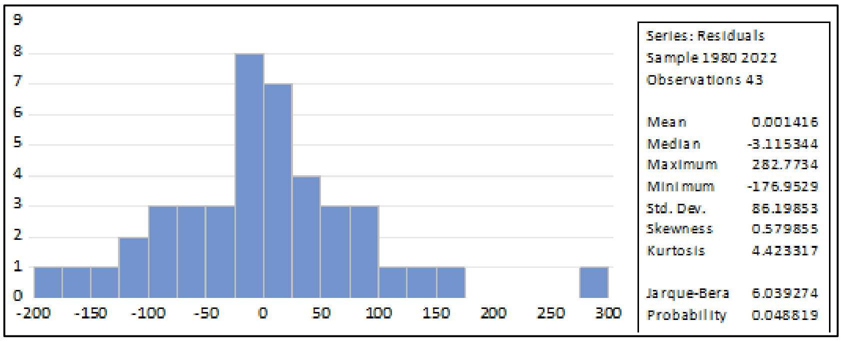
The descriptive properties of the variables in the study is presented in Table 1.0. Table 1.0 shows that oil palm and rainfall possess statistically acceptable peaks of 3.0 or above. Gas flared and carbon (IV) oxide exhibited more flatter curves. Also, gas flared and temperature skewed more to the left of the distribution whereas the distribution of carbon (IV) oxide, oil palm and rainfall exhibited positive concentration. Fairly stable distribution of the probabilities of the Jarque-Bera output (except for oil palm and rainfall) shows that the variables were largely normally distributed. However, to maintain such freeness of speech, we conducted a formal normality test for the variables and report the results in Figure 3.0.

Table 1: Descriptive properties of the variables

	$oil\,palm$	tem	$rain$	CO_2	$gasf$
Mean	791.1860	27.24140	124.9372	93.84742	6387716.
Median	760.0000	27.28000	103.8000	91.67100	6190329.
Maximum	1400.000	27.86000	436.6000	127.0290	9529930.
Minimum	500.0000	26.39000	2.200000	68.08100	2549647.
Std Dev.	232.2714	0.319401	106.8312	16.52683	2298529.
Skewness	0.977769	-0.321974	1.033682	0.149451	-0.165917
Kurtosis	3.422967	2.930389	3.667925	1.924338	1.668747
Jarque-Bera	7.172097	0.751633	8.456876	2.233117	3.372539
Probability	0.027708	0.686728	0.014575	0.327405	0.185209
Observations	43	43	43	43	43

Source**:** Authors

Figure 3.0 shows that all our variables were multivariate normal at one percent level of significance but not at five percent level of significance. None normally distributed population sample may affect model specification form, may indicates important variable(s) omission (Khatun, 2021) [22]. Also, a none-normally distributed sample presents a spurious mean representation different from the true population mean and hence unreliable fitted values needed for comparism.



Source**:** Authors

Fig 3: Normality test results

The correlation results for oil palm production and climatic factors in Nigeria are reported on Table 2.0. The result shows that oil palm production and climatic factors in Nigeria exhibited various levels (both negative and positive) of strength and association capable of further investigation. To examine the correlative strength further, we applied the transcendental logarithmic (translog) functions on the variables. However, this is preceded by the unit root test.

Table 2: Correlation matrix of the variables

$oil\,palm$	1				
tem	0.694569	1			
$rain$	0.153598	0.102654	1		
CO_2	0.814182	0.513318	0.245307	1	
$gasf$	-0.519024	-0.487795	-0.101049	-0.265143	1
Variables	$oil\,palm$	tem	$rain$	CO_2	$gasf$

Source**:** Authors

We test for the stationarity properties of the variables using Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test and the DF-GLS test with constant and trend and reported the results in Tale 3.0. As Table 3.0 indicated, all our variables were stationary at various levels of statonarity not exceeding first difference. With this outcome, we can be sure that the effects of climate factors on oil palm production in Nigeria are not just useless but important.

Table 3: Unit root test

	KPSS	DF-GLS
Oil Palm	0.189938***	-1.018319
Δ Oil Palm		-5.997961***
Rainfall	0.152199***	-4.474373***
CO_2	0.681946***	-2.939190*
Δ CO_2		-5.886728***
Temp	0.100138***	-5.268544***
Gas Flared	0.323961***	-1.690955*

Source**:** Authors

Note: Δ denotes the difference operator

***, * denotes significance at 1and 10 percent respectively

The result of the translog estimates is presented on Table 4.0. Table 4.0 shows that taken by themselves, rainfall, carbon (IV) oxide and gas flaring exerted positive impacted on oil palm production. Their effects will run ascendingly from gas flaring to rainfall and carbon (IV) oxide but not statistically significance. Within the same parameter, temperature dampened oil palm production in Nigeria within the same period.

Over time, deepening pressure from rainfall, carbon (IV) oxide and temperature will also deepen oil palm production significantly. For instance, a one percent improved rainfall overtime improves oil palm production by nearly 4 percent although not statistically significant. Equally, any slight improvement in carbon (IV) oxide by 1 percent will increase oil palm production by at least 54 percent and statistically significant. Through the process of fertilization effect, deepening CO_2 generates rising photosynthesis level for oil palm growth. Thus, as noted by Scientific American (2018), higher concentration of CO_2 in our atmosphere aid photosynthesis, which in turn contributes to increased plant growth. In the same vain, a unit improvement in atmospheric temperature as time passes improves oil palm productivity by at least 6.5 basis point units. In this case, rising temperatures triggers the needed heat palm-food production which in turn promote palm shoot growth, including leaf expansion and stem elongation and thickening for higher yield (Dyer, 2023). The effect of increasing gas flaring in time will be negative to oil palm production. Increasing gas flaring by 1 percent overtime will dipped oil palm production by nearly 27 percent and statistically significant.

Table 4: Estimated Results

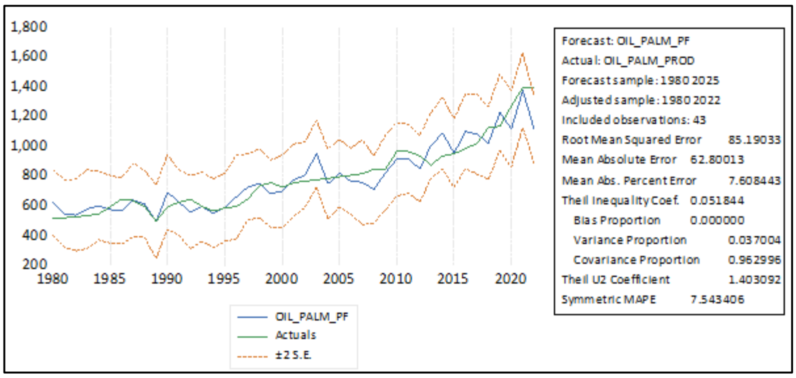
Dependent Variable: Oil Palm		
Variables	**Coefficient**	**t-Stats**
tem	-8.652325	-1.353120
CO_2	15.64505	0.832266
$rain$	5.307280	0.227783
$gasf$	0.000685	0.583352
tem^2	6.555344	1.387758
${CO_2}^2$	0.543946***	2.649190
$rain^2$	0.040076	0.151365
$gasf^2$	-2.6911**	-2.057883
tem_CO_2	-6.870138	-0.975201
tem_rain	-0.175011	-0.201024
tem_gasf	-1.3205	-0.312431
CO_2_rain	-0.007181	-0.568914
CO_2_gasf	-1.6506**	-2.052495
$rain\_gasf$	-6.2209***	-4.068122
$Adjusted\ R^2$ 0.8005 R^2 0.8623		
$LIML\ min.eigenvalue$ 1.0182 $D.W$ 1.5127		

***Source*:** Authors

Interestingly, our result also shows the combined effect of climatic factors and oil palm production. As seen in Table 4.0, the correlative effects of all the climatic factors on oil palm production in Nigeria were oil-palm-dipping. Infact, the combined effect of rainfall and temperature produces approximately 18 percent decline on oil palm production; the combined effect of ccarbon(IV)oxide and temperature produces approximately 6.9 basis point decline on oil palm production; the combined effect of gas flared and temperature produces approximately 1.3 basis point reduction on oil palm production; the combined effect of rainfall and ccarbon(IV)oxide produces approximately 0.7 percent decline on oil palm production; a 0.1 percent combined effect of gas flared and ccarbon(IV)oxide produces approximately 17 percent decline on oil palm production; a 0.1 percent combined effect of gas flared and rainfall produces approximately 62 percent decline on oil palm production. According to the World Bank (2022), gas flaring emits black carbon that accelerates ice and snow melting, to which most of the world's flooding and rising water levels could be associated. In other areas, gas flaring is associated to acid rain (Agugwo, 2013; Atuma and Ojeh, 2013). Through its sulphuric content, acid rain damages plants and vegetation including oil palm plantations thereby dipping output.

Our results were obtained not in error as over 80 percent of the variations in oil palm production in Nigeria between 1980 and 2022 were those due to climate factors fluctuations within the period. There was also no serial correlation in our system.

Based on our outcome of the climatic factors/oil palm production nexus, we used in-sample data to predict future behavior of oil palm production in Nigeria in the face of continuous climate change. Our oil palm forecast result reported in Figure 4.0 shows that overtime, fluctuations in oil palm production may be massive and more declining over increasing climatic correlations with a very high degree of covariance in production.



***Source*:** Authors, based on sample data

Fig 4: Forecast of oil palm production

We report the elasticity response of oil palm output to different climate factors in Nigeria in Table 5.0. A calculation of marginal impact from the analysis of translog function allows us to investigate the value added of climate change to production output of palm oil. Table 5.0 shows that oil palm output response more to fluctuations in temperature, carbon(IX)oxide and gas flaring in absolute term and much less likely to fluctuations in rainfall. In terms of policy, our study indicates that any change in temperature, carbon (IX)oxide and gas flaring are likely to generate much larger variations in oil palm output than what rainfall variations could bring.

Table 5: Oil Palm Marginal response to climate change

Rainfall	6. 74 93
Temperature	-110.5104
Carbon(IX)oxide	75.5924
Gas flared	-50.1048

***Source*:** Authors

Discussion

Our analysis revealed that climatic factors exerted noticeable effects on oil palm production in Nigeria. Taken by themselves, some climatic factors such as rainfall, carbon (IV) oxide and gas flared impacted positively on oil palm production. We are also interested on the impact of flared gas on oil palm production. Generally, our report showed that if left unchecked, any slight increase in flared gas can have detrimental impact on oil palm production that are statistically significant. Extensively, the correlative effect from flared gas also weakens other climatic factors to continue weakening oil palm growth. In terms of policy, we propose effective gas utilization to curb excess gas flaring. In specific term, such policy will consider "activity ranging" for gas and oil related activities whose gas flaring are usually an output from oil palm plantations taking into account the strong correlative strength of flared gas.

Again, we are also interested on the weakening correlative impacts of all the climatic factors on oil palm production. Our results thus confirms that clearly, correlative effects of climatic factors on oil palm production in Nigeria thus matters. If the gap between production and consumption in oil palm output is to be slowed and eventually closed, then policy substitution in greener economy is to intensify. Such conservatory policies includes a broad and ambitious package of policies and investments that would transform our economy away from fossil fuels domination, with focus on efficient energy renewable sources and ensure that all has clean air and water. A new Greener economy would also invest in projects to capture climate-damaging gases already in the atmosphere and that green technology is pursued in global partnership.

Conclusion

In this study, we have taken a critical look at the correlative impact of climate factors fluctuation in Nigeria and the generated shocks to oil palm production. At the individual capabilities most climatic factors exerted growth inhibiting reflex on oil palm output over the review period. We also found out that deepening climatic factors impact may also deepens palm oil output over time. However, when the effect of the climatic factors correlative responses were investigated, the outcome weakens palm oil output. Our results were obtained not in error as over 80 percent of the variations in oil palm production in Nigeria between 1980 and 2022 were those due to climate factors fluctuations within the period. It was necessary at this point to affirm that the correlative impact of climate factors is important in determining oil palm output in the Nigerian sub-region. Specifically, we proposed climate factors correlation reduction policies such as "activity ranging" for gas and oil related activities aimed at mitigating the impact of climatic factors correlation for the sub-region in years following this study. We are hopeful that mitigating climatic factors correlation will peaked oil palm output and close the output gap seen in the sub-region.

References

1. Abubakar A, Ishak MY, Makmom AA. Impacts of and adaptation to climate change on the oil palm in Malaysia: a systematic review, Environmental Science and Pollution Research. 2021; 28:54339-54361.
2. Abubakar A, Ishak MYB, Uddin MK, Samad MYA, Mukhtar S, Danhassan SS. Effects of Some Weather Parameters on Oil Palm Production in the Peninsular Malaysia, 2021. www.preprints.org, 28.01.2023.
3. Agugwo AO. Negative Effects of Gas Flaring: The Nigerian Experience, Journal of Environment Pollution and Human Health. 2013; 1(1):6-8.
4. Akhaine SO. Background Review: The state, people and oil palm production in Nigeria: understanding the policy nexus, 2017. Retrieved on https://www.tropenbos.org/resources/publications/, 04.01.2023.
5. Aneni TI, Aisagbonhi CI, Iloba BN. Influence of Climate Variability on Oil Palm Pests in NIFOR, Nigeria, African Scientist. 2011; 12(2):1-13.
6. Ani KJ, Anyika VO, Mutambara E. The impact of climate change on food and human security in Nigeria, International Journal of Climate Change Strategies and Management. 2022; 14(2):148-167.
7. Atuma MI, Ojeh VN. Effect of Gas Flaring on Soil and Cassava Productivity in Ebedei, Ukwuani Local Government Area, Delta State, Nigeria, Journal of Environmental Protection. 20013; 4(10):1054-1066.
8. Aziakpono MJ, Wilson MK. Interest Rate Pass-through and Monetary Policy Regimes in South Africa, African Economic Research Consortium (AERC) Research Paper no, Nairobi, 2013, 259.
9. Bassey IO. Overview of Oil Palm Production in Nigeria; Comparative Social and Environmental Impacts; The Case of Ekong Anaku Community in Cross River State, Nigeria, Institute of Social Sciences, Erasmus University of Rotterdam. 2016; 3(15):1-10.
10. Bello OB, Ganiyu OT, Wahab MKA, Afolabi MS, Oluleye F, Ig SA, *et al*. Evidence of Climate Change Impacts on Agriculture and Food Security in Nigeria, International Journal of Agriculture and Forestry. 2012; 2(2):49-55.
11. Brown E, MF Jacobson. Cruel Oil: How Palm Oil Harms Health, Rainforest and Wildlife. Center for Science in the Public Interest, 2005. www.cspinet.org, 004.01.2023.
12. Chikezie C, Ibekwe UC, Ohajianya DO, Orebiyi JS, Ehirim NC, Henri-Ukoha A, *et al*. Effect of Climate Change on Food Crop Production in Southeast, Nigeria: A Co-integration Model Approach, International Journal of Weather, Climate Change and Conservation Research. 2015; 2(1):47-56.
13. Chilioke OB, Haile M, Waschkeit C. Implication of Climate Change on Crop Yeild and Food Accessibility in Sub-Saharan Africa, Interdisciplinary Term Paper of the Centre for Development Research, University of Bonn, 2011.
14. Christensen LR, Jorgenson DW, Lau LJ. Transcendental Logarithmic Production Frontiers. The Review of Economics and Statistics. 1973; 55:28-45.
15. Chukwuma OA, Olive OO, Evangel AC. Choice of Adaptation Strategies for Climate Change: The Case of Oil Palm Farmers in Southern Nigeria, International Journal of Agricultural Economics. 2021; 6(1):39-46.
16. Dyer MH. Does Weather affects Plant Growth? Effect of Temperature on Plants, Gardening Know How, 2023. availableonline at https://www.gardeningknowhow.com/plant-problems/environmental/temperature-on-plants.htm, 23.01.2023
17. Ekong UM, Ekong CU. Consumption dynamics, Interest

rate behavior and the Euler Equation: Time series evidence for Nigeria, International Journal of European Studies. 2017; 1(2):46-55.

18. Elliot G, Rothenberg TJ, Stock JH. Efficient tests for an autoregressive unit root. Econometrica. 1996; 64:813-36.
19. Fischer G, Shah M, Velthuizen H. Climate Change and Agricultural Vulnerability, A special report, prepared by the International Institute for Applied Systems Analysis under United Nations Institutional Contract Agreement No. 1113 on Climate Change and Agricultural Vulnerability as a contribution to the World Summit on Sustainable Development, Johannesburg, 2002.
20. Foundation for Partnership Initiatives in the Niger Delta (PIND), A report on Palm Oil Value Chain Analysis in the Niger Delta, 2011. available online at https://ndpifoundation.org/wp-content/uploads/2018/09/Palm-Oil-Value-Chain-Analysis.pdf, 04.01.2023.
21. Gujarati DN. Basic Econometrics, 4th Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2004.
22. Khatun N. Applications of Normality test in statistical analysis, Open Journal of Statistics. 2021; 11:113-122.
23. Koyenikan MJ, Anozie O. Climate Change Adaptation Needs of Male and Female Oil Palm Entrepreneurs in Edo State, Nigeria, Journal of Agricultural Extension. 2017; 21(3):162-175.
24. National Bureau of Statistics of China. Press Release, 2022. available online at http://www.stats.gov.cn/english/PressRelease/, 02.01.2023.
25. Ogunbode TO, Aliku O, Ogungbile PO, Olatubi IV, Adeniyi VA, Akintunde EA. Environmental impact of oil palm processing on some properties of the on-site soil in a growing city in Nigeria, Frontiers in Environmental Science. 2022; 10:1-6.
26. Ojemade AC, Okorji EC, Enete AA. Difficulties in adaptation to climate change by oil palm farmers in Southern Nigeria, African Journal of Agricultural Research. 2019; 14(2):46-53.
27. Oktarina SD, Nurkhoiry R, Pradiko I. The effect of climate change to palm oil price dynamics: a supply and demand model, A paper presented on the International Conference on Agriculture, Environment and Food Security, IOP Conference Series, 2020, 1-9.
28. Pavelescu F. Some aspects of the Translog Production Function Estimation, 2011. https://ideas.repec.org/a/ine/journls, (Retrieved on 13th October 2018).
29. Price Water Coopers (PWC). X-raying the Nigerian palm oil sector, 2019. www.pwc.com/ng, 04/01/2023.
30. Rosenzweig C, Liverman D. Predicted effects of climate change on agriculture: A comparison of temperate and tropical regions. In Global climate change: Implications, challenges, and mitigation measures, ed. S. K. Majumdar, PA: The Pennsylvania Academy of Sciences, 1992, 342-361.
31. Russell R, Paterson M. Longitudinal trends of future climate change and oil palm growth: empirical evidence for tropical Africa, Environmental Science and Pollution Research. 2021; 28(17):21193-21203.
32. Sarkar MSK, Begum RA, Pereira JJ. Impacts of climate change on oil palm production in Malaysia, Environmental Science and Pollution Research. 2020; 27:9760–9770.
33. Scientific American. Ask the Experts: Does rising CO_2 benefit Plants?, 2018. Available online at https://www.scientificamerican.com/article/ask-the-experts-does-rising-co2-benefit-plants1/, 23.01.2023
34. Smit B, Ludlow L, Brklacich M. Implications of a global climatic warming for agriculture: A review and appraisal. Journal of Environmental Quality. 1988; 17(4):519-527.
35. Umar HS, Girei AA, Yakubu D. Comparison of Cobb-Douglas and Translog Frontier Models in the analysis of Technical Efficiency in dry-season Tomato Production. Agrosearch. 2017; 17(2):67-77.
36. United States Department of Agriculture (USDA) United States Department of Agriculture FY 2022 Budget Summary, 2022. Available online at https://www.usda.gov/sites/default/files/documents/2022-budget-summary.pdf, 01.01.2023.
37. World Bank. Global Gas flaring reduction partnership (GGFR), 2022. Available online at https://www.worldbank.org/en/programs/gasflaringreduction/gas-flaring-explained, 23.01.2023.
38. Zainal Z, Shamsudin MN, Mohamed ZA, Adam SU. Economic impact of climate change on the Malaysian palm oil production, Trends in Applied Sciences Research. 2012; 7(10):872-880.