*IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)*
*e-ISSN: 2319-2402, p- ISSN: 2319-2399.Volume 19, Issue 1 Ser. 2 (January 2025), PP 01-09*
*www.iosrjournals.org*

# Climate Change And Agricultural Productivity In Nigeria

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***Abstract:***
*The study examined the effect of climate change on agricultural productivity in Nigeria. The study used annual frequency data from 1990 to 2020 sourced from World Bank World Development Indicator (WDI) and United State Department of Agriculture database. The autoregressive distributed lag (ARDL) estimator was used to estimate the static and dynamic models. Also, the study examined stability of the series using KPSS method and cointegration was tested by means of bound test. Estimation using the bound test method disclosed the variables have common long run trend. Growth in $CO_2$ emissions does not threaten agricultural productivity by causing a decline in agricultural output level, but rather, its impact was positive and significant, increasing productivity by as much as 0.5359 percent in the long run. Agricultural land use and average rainfall, the result showed, enhanced agricultural productivity, but only the impact of agricultural land use. In the long run, fertilizer consumption was found to have a negative and significant impact on agricultural productivity. Though $CO_2$ emissions had fluctuated over time, the study recommend adopting climate-adapting practices like using push-pull technology.*
***Keywords**: Climate Change, Agricultural Productivity, $CO_2$ emissions, Fertilizer Consumption, Agriculture Land Use, ARDL and KPSS method*

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Date of Submission: 13-01-2025 Date of Acceptance: 23-01-2025

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## I. Introduction

In the last few decades, the world has experienced substantial changes in climate. These changes in climate have been traced to continued greenhouse gas (GHG) emissions which results majorly from the activities of corporations and firms spread across the globe. Despite evidences that the developed and developing countries differ in the volume of greenhouse gas emission as it is argued that the emissions are more pronounced in the developed world than the developing countries due to the nature of industrial activities carried out in the developed countries (Raza, Sui, Jermsittiparsert, Żukiewicz-Sobczak and Sobczak, 2021); but the effect of such greenhouse gases are majorly felt in developing countries (IPCC, 2014), especially Africa where over 70 percent of her population engage in agricultural activities (Adedoyin, Alola and Bekun, 2020).

With the threat of climate change, it's been reported that pass-through variable change in the form of drought, flood and wildfire have been reported to directly impact agriculture as it alters farming activities, product yield, increase agricultural losses, and threaten food security. For instance, changes in temperature and precipitation patterns can modify the growing season and impact crop production. According to studies, agriculture yields have already decreased as a result of climate change, with a 1°C rise in temperature causing a 5% loss in wheat productivity and 3.8% decrease in maize production reported in India (Lobell et al., 2011). Increased vulnerability to pests and illnesses can result from heat stress in crops and livestock, which can also reduce productivity (Wheeler et al., 2018). Changes in precipitation patterns can result in soil erosion, floods, and droughts, all of which can harm crops and lower yields (FAO, 2020).

In Nigeria, studies exist on the impact of climate change on agricultural productivity. As reported by Akintoye et al. (2019), temperature and rainfall variability significantly impacted crop yield in Nigeria, with higher temperatures leading to reduced crop yield and increased rainfall variability leading to reduced maize yield. Additionally, Falowo et al. (2019) found that smallholder farmers in Nigeria who had access to extension services and credit facilities were more likely to adopt adaptation strategies such as crop diversification and the use of drought-tolerant crops. Akindele and Olubanjo (2018) observed that the impacts of climate change on livestock productivity in Nigeria were complex and varied by species and region, with heat stress reducing milk yield in dairy cattle and increased temperature leading to reduced weight gain in beef cattle. Likewise, Olaniyan et al. (2020) emphasized the need for policy interventions to support adaptation and mitigation efforts in agriculture, including sustainable agricultural practices, climate-resilient infrastructure, and financial and technical support to farmers. These studies suggest that climate change is a significant challenge for agriculture in Nigeria and that strong policy interventions are needed to address its impact.

Despite the effort of these studies, gap still exist on the nexus between climate change and agriculture productivity in Nigeria, which is likely to cause bias any policy intervention being planned out. This is because the effect of climate change on agriculture could also be indirect, as both climate change and agriculture productivity are linked through inputs in agriculture production, which previous studies failed to give adequate attention to. Furthermore, the changes in factor inputs (labour, land and capital) brought about by climate change is likely to affect agricultural productivity (Ozdemir, 2022).

It is on this backdrop that this study this study will (i) re-examine the effect of carbon dioxide emissions on agricultural sector output in Nigeria; (ii) determine the impact of agricultural land use on agricultural sector output in Nigeria; (iii) investigate the effect of fertilizer consumption on agricultural sector output in Nigeria; and examine the impact of rainfall on agricultural sector output in Nigeria.

## II. Literature Review

Empirical discourse exists on the nexus between climate change and agriculture productivity. For example, Adzawla, Sawaneh and Yusuf (2019) used panel of sub-Saharan Africa countries for the period from 1970 to 2012 to examine the greenhouse gases emission and economic growth nexus. The study focused on testing the Environmental Kuznets hypothesis in the sub-Saharan Africa countries. The aggregate panel data was analyzed using the Vector Autoregressive (VAR) model and the ordinary least square regression method. A quadratic model was specified and global greenhouse gases (GHGs) emission which was proxied by using carbon dioxide emissions, methane, and nitrogen dioxide emissions. They show significant relationship between gross domestic product and GHGs. Specifically, the result indicated increase in GDP initially raises carbon dioxide emission, but carbon dioxide emission declines with higher levels of GDP. They reported a U-shape and inverted N-shape response of GDP to changes in methane and nitrous oxide emissions, implying that the emission level of methane and nitrous oxide reduces at the initial growth of GDP and the level of emission of both gases increases with higher levels of economic growth.

In the same vein, a panel approach to the relationship between environmental quality and agricultural productivity was adopted by Salahuddin, Gow and Vink (2020). The study which was carried out in sub-Saharan Africa used dataset of 24 sub-Saharan Africa countries covering the period from 1984 to 2016. Environmental quality was measured using three indicators comprising per capita carbon dioxide emission, adjusted national savings and energy intensity. The environment and agricultural productivity nexus were estimated using the Mean Group, Augmented Mean Group, Common Effect Mean Group and Common Correlated Effect Pooled Mean Group. They conclude that deteriorating environmental quality induces low agricultural productivity as their results showed a negative and significant relationship between per capita carbon dioxide emission and agricultural productivity. They show that increasing level of national savings induces higher level of agricultural productivity.

Liu, Wang, Yang, Rahman and Sriboonchitta (2020) in their work tried to identify the determinants of agricultural productivity growth in 15 south and southeast Asian countries. Their study covered the period from 2002 to 2016 and in explaining the determinants of agricultural productivity growth, they used the system generalized method of moments (SYS-GMM) and first-difference generalized method of moments (FD-GMM). Agricultural output was represented using net agriculture production value added and other variables which could determine agricultural productivity such as agricultural land, agriculture labour, capital input, fertilizer, agricultural import and export, urbanization and development flow were considered. From the panel dynamic results, level of economic development, human capital, agricultural import, level of urbanization and development flow were identified as determinants of agricultural productivity change. While development flow, human capital and level of urbanization influenced agricultural productivity growth positively, agricultural import and level of economic development negatively affect agricultural productivity.

Ahmad and Heng (2012) in assessing the determinants of agricultural productivity growth in Pakistan used the autoregressive distributed lag (ARDL) model to analyze annual data from 1965 to 2009. Their study used five variables which include agricultural total factor productivity, agricultural credit, human capital, area under crops and fertilizer. They established cointegrating relationship between agriculture total factor productivity, agricultural credit, human capital, area under crops and fertilizer using the bound test and proceeded to estimating the long run and error correction model. Three out of the four variables considered were found to be determinants of agricultural productivity growth. The three variables were human capital, fertilizer and agriculture credit. Though all three variables had positive and significant impact on agricultural productivity growth, however, fertilizer enhances agricultural productivity growth the highest in Pakistan. Area under crops had negative and insignificant impact on agricultural productivity.

Using data of the BRICS countries of Brazil, Russia, South Africa, China and India from 1990 to 2014, Balsalobre-Lorente, Driha, Bekun and Osundina (2019) investigated if agricultural activities, mobile use, energy use and trade openness induce carbon emissions. The method employed by them in assessing the drivers of environment degradation include the fully modified ordinary least square (FMOLS), dynamic ordinary least square (DOLS) and the panel causality test methods. From the regression result, it was shown that agriculture activities negatively affect the environment. Trade openness and electricity consumption was found to increase carbon emission in the BRICS countries. It was reported that increase mobile use reduces the emission of pollutants in the sampled areas.

## III. Methodology

**Theoretical Underpinning**

The neoclassical growth model, created by Solow (1956), serves as the foundation for this study's analysis of long-term output (productivity of agriculture in this context). The model places a strong emphasis on capital accumulation, which fuels technical change and results in output growth via expanding labour and physical capital. The neoclassical model, however, is unable to account for the drivers of technological advancement and total factor productivity. The endogenous growth model, which takes into account the choices made by economic agents like individuals, businesses, and governments, was created to address this problem.

The AK model was further created to overcome the Solow model's problem with diminishing marginal returns to capital accumulation (Rebalo, 1991). By indigenizing the growth rate and setting equal to 1, it makes output growth reliant on the sophistication and rate of technological advancement. Although the Solow model doesn't take these into account the environment's importance in determining output despite economic literature associating output with the stock of natural resources and the quality of the environment, hence green model. The green model considers natural capital to be a subpar substitute or addition to other resources, incorporating it as a factor of production (Hallgatte et al., 2012). The theory therefore emphasizes the significance of maintaining output (agriculture productivity) while safeguarding the environment because investment in physical, human, or technological change cannot make up for the damage to the environment caused by human activity.

**Model Specification**

The model for this study followed the work of Salahuddin, Gow and Vink (2020) in examining the impact of climate change on agricultural productivity in Nigeria. This study made adjustment to the model adopted by Salahuddin, Gow and Vink (2020) by including variables that tend to determine agricultural productivity.
The model for this study is expressed functionally as:

$$agp_t = f(co2_t, F_t') \qquad (1)$$

Where;
$agp_t$ = Agricultural productivity;
$co2_t$ = carbon dioxide emission, used as proxy of climate change.

$F_t'$ = $(k \times 1)$ vector of check variables which determine agricultural productivity such as fertilizer consumption (FCOM), agricultural land (ALU) and average rainfall (RAF). Fertilizer consumption was proxy using kilograms per hectare of arable land, and agricultural land by percentage of land area.
In econometric specification; equation (1) becomes:

$$lnAGP_t = \theta_0 + \vartheta_1 lnCO2_t + \vartheta_2 lnALU_t + \vartheta_3 lnFCOM_t + \vartheta_4 lnRAF_t + \varepsilon_t \qquad (2)$$

The expectation from economic theory is that $\vartheta_1 < 0$; and $\vartheta_2 - \vartheta_4 > 0$.

**Data and Estimation Strategy**

The study used the dataset of Nigeria sourced from the World Bank World Development Indicator (WDI) and United State Department of Agriculture database. The data used are secondary data and spanned from 1990 to 2020.

The approach of data analysis was in three folds. The first is the pre-estimation tests where the statistical properties of the data were examined. In this phase, tests of unit root using Kwiatkowski, Phillips, Schmidt and Shin (KPSS) (1992) procedure was adopted. Also, cointegration by means of Pesaran, Shin and Smith (2001) bound test was dutifully followed. The second is the estimation phase where the specified model was estimated using the autoregressive distributed lag (ARDL) method. The third phase of the data analysis process is the post estimation phase where certain diagnostic tests was carried out to ensure the residuals from the estimated regression model satisfy the assumptions of the Classical Linear Regression Model (CLRM). This is to ensure that decisions made and policy formulated based on the parameter estimates are not misleading due to inaccurate statistics such as t-statistics and standard error.

## IV. Result And Discussion

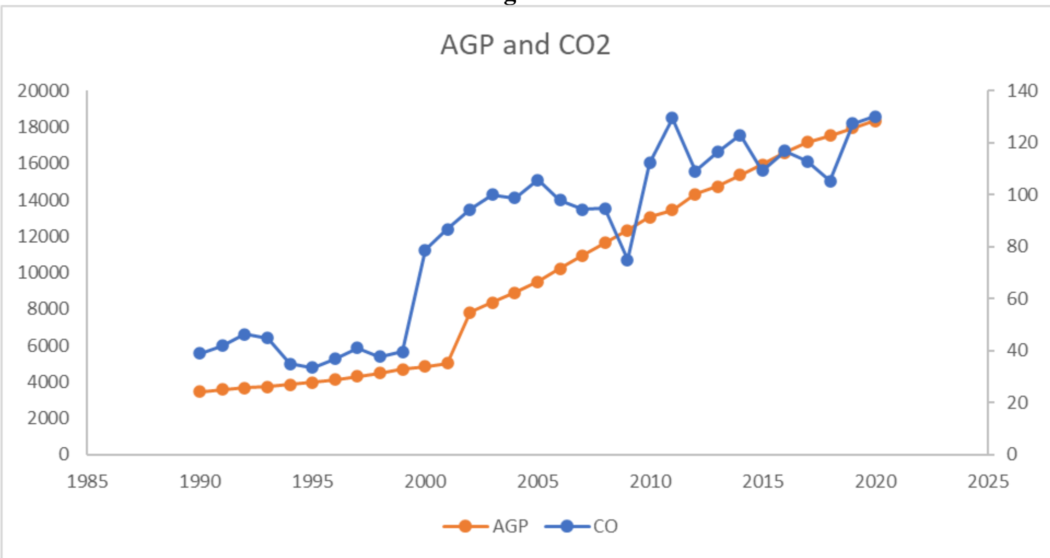
**Table 1: Descriptive Statistics**

| | AGP | CO2 | ALU | FCOM | RAF |
|---|---|---|---|---|---|
| Mean | 9807.989 | 84.3017 | 73.4165 | 9.5776 | 93.7400 |
| Median | 9516.992 | 94.7722 | 73.5646 | 8.2155 | 94.5600 |
| Maximum | 18348.18 | 130.1768 | 76.2542 | 20.9685 | 111.7800 |
| Minimum | 3464.716 | 33.4167 | 67.6197 | 4.1475 | 76.6000 |
| Std. Dev | 5300.031 | 33.9527 | 1.9549 | 5.2323 | 8.3573 |

| | | | | | |
|---|---|---|---|---|---|
| Skewness | 0.1884 | -0.3606 | -0.7778 | 0.8977 | -0.2661 |
| Kurtosis | 1.5297 | 1.5826 | 3.7033 | 2.5619 | 2.7821 |
| Jarque-Bera | 2.9756 | 3.2667 | 3.7652 | 4.4120 | 0.4271 |
| Prob. | 0.2258 | 0.1952 | 0.1521 | 0.1101 | 0.8076 |
| Obs. | 31 | 31 | 31 | 31 | 31 |

Source: Authors' compilation (2023)

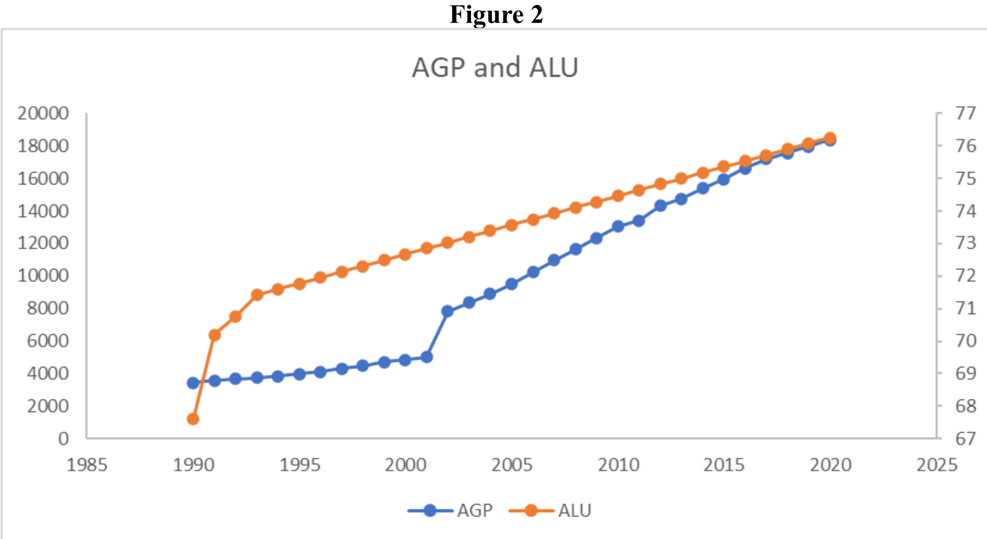
**Figure 1**




*World Bank World Development Indicator (WDI)*

The Agricultural Productivity (AGP) had a steady increase from 1990 to 2020 despite the fluctuations in Carbon dioxide emission (proxy for climate change). The carbon dioxide emission had a huge jump from 74.88 metric tons in 2009 to 129.56 metric tons in 2011. It also noted an increase in emission from 105 metric tons in 2018 to 130 metric tons in 2020.

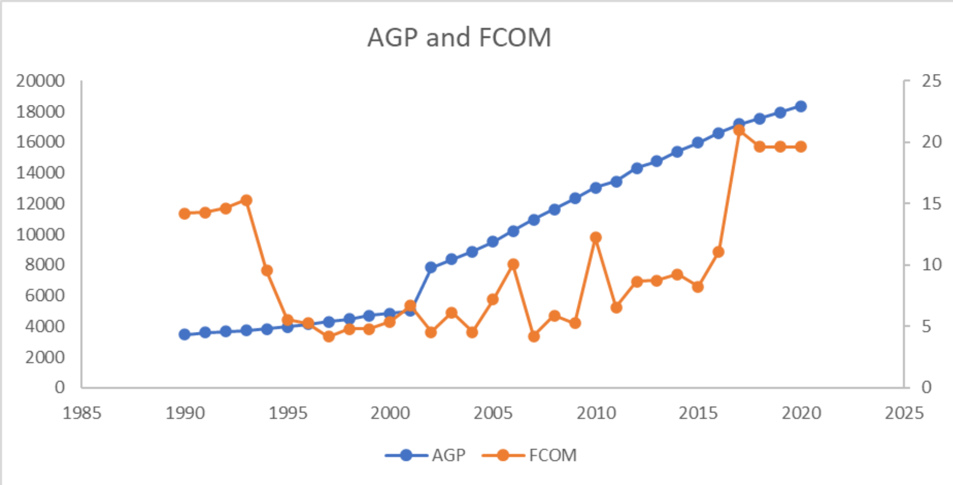
**Figure 2**




*World Bank World Development Indicator (WDI)*

Agricultural Productivity had a steady increase from 1990 to 2020 in relation to Arable Land (ALU). APG surpassed ALU from 2012 to 2020.

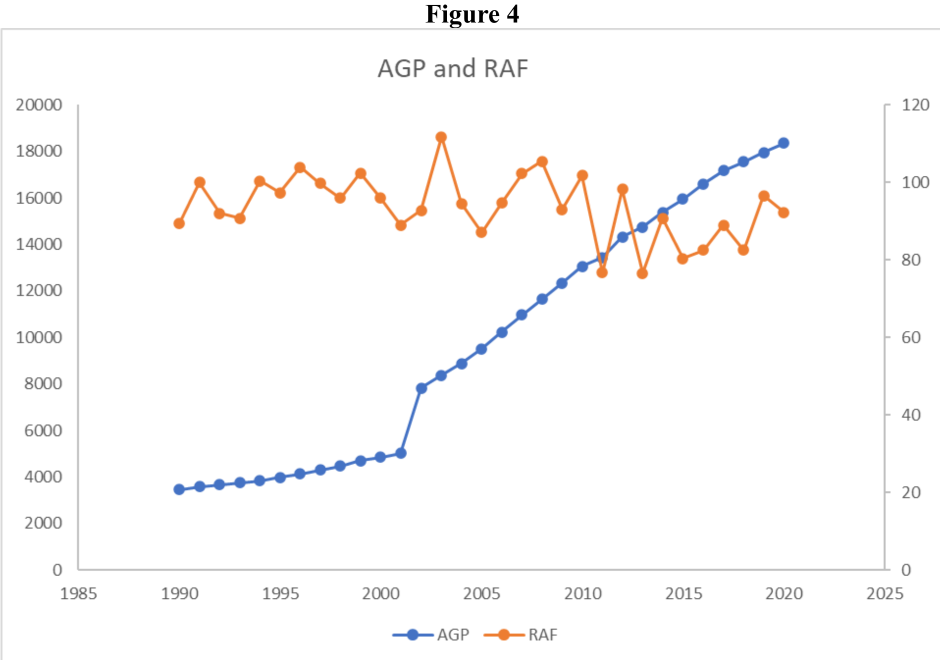
**Figure 3**




*World Bank World Development Indicator (WDI)*

Agricultural Productivity had a steady increase from 1990 to 2020 despite fluctuations in Fertilizer Consumption (FCOM). The figure observed a huge increase in fertilizer consumption, the figure jumped from 8.22 kilograms in 2015 to 20.97 kilograms in 2017, and a slight decrease to 19.6 kilograms in 2020.

**Figure 4**




*World Bank World Development Indicator (WDI)*

Agricultural Productivity had a steady increase from 1990 to 2020 despite fluctuations in Annual Rainfall (RAF). APG surpassed RAF from 2012 to 2020.

**Table 1 and Figures 1-4** showed agricultural productivity averaged N9807.989 billion and productivity in the agricultural sector increased to a peak of N18,348.18 billion from N3,464.716 billion. Within the 31 years, Nigeria emits 84.3017 metric tons of carbon dioxide ($CO_2$) every year. From 1990 to 2020, the volume of $CO_2$ emitted in Nigeria grew from 33.4167 metric tons to 130.1768 metric tons. Every year, a total of 73.4165 percent of land area is used for agriculture and the proportion of land area used for agriculture has only grown marginally, from 67.6197 percent to 76.2542 percent within the period studied. On the average, 9.5776 kilograms of fertilizer is consumed per hectare of arable land in Nigeria, with the quantity of fertilized consumed fluctuating between 4.1475 kilograms to 20.9685 kilograms. Rainfall in Nigeria average 93.74 millimeters and the amount of rainfall has increased from 76.60 millimeters to 111.78 millimeters within 30 years of the study period. The study observed, based on the standard deviation statistics, that there have been steady improvements in agricultural productivity over the years. However, it was observed there were fluctuations in the behavior of carbon emissions, fertilizer consumption and average rainfall. While the study learned that carbon emissions has been fluctuating, the skewness value revealed disturbing information about agriculture land use and rainfall as both observations has dwindle over the period studied.

**Unit Root**

The test for presence of unit root in series is now an integral part of model estimation, as doing so gives insight into the integration properties of the series. Also, engaging in such test is critical in the selection of the framework that is appropriate in understanding the connection that might exists among modelled variables. The study relied on the Kwiatkowski, et al., (1992, KPSS) framework for unit root testing and the summary of the test is presented in Table 2.

**Table 2: Unit Roots Result**

| Variable | KPSS | | | I(d) |
|---|---|---|---|---|
| | Level | 1st Diff | 5% Critical Value | |
| $lnAGP_t$ | 0.7039 | 0.1531*** | 0.4630 | I(1) |
| $lnCO2_t$ | 0.6167 | 0.0698*** | 0.4630 | I(1) |
| $lnALU_t$ | 0.7458 | 0.4063** | 0.4630 | I(1) |
| $lnFCOM_t$ | 0.2538*** | - | 0.4630 | I(0) |
| $lnRAF_t$ | 0.4244** | - | 0.4630 | I(0) |

Note: *, **, and *** denote significance at 10%, 5% and 1%, respectively
**Source:** Authors' compilation (2023)

The test result indicates that agricultural productivity, $CO_2$ emissions and agriculture land use contain unit root in their level form. When the KPSS regression model was estimated, it was noticed that, its critical values for agricultural productivity, $CO_2$ emissions, and agriculture land use, reported in column II, exceeds the critical value of 0.4630. The study then differenced the series, further subjecting them to test of unit root. The outcome revealed the differenced series (for agricultural productivity, $CO_2$ emissions, and agriculture land use) to be stationary. In level form, fertilizer consumption and rainfall reverted to its mean of zero and are deemed stationary in its observed form. Hence, the decision summarized in column IV, shows the series are I(1) and I(0). This outcome provides the impetus for applying Pesaran, Shin and Smith (2001) bound test and the ARDL estimator.

**Cointegration**

The motivation for cointegrating testing is the presence of non-stationary variables in the model explaining how climate change relates with agricultural productivity. Asteriou and Hall (2015) suggest conducting cointegration test when modelling non-stationary series, due to its permanent, rather than transitory, properties. The confirmation of cointegrating relationship attest to a non-spurious relationship, as the errors from combining the series whose mean do not revert to zero, individual, will be transitory. The bound test specification of Pesaran, et al., (2001) was dutifully followed, with Table 3 reporting the result.

**Table 3: Bound Test Result**

| Estimated Model | | F-statistics |
|---|---|---|
| $F_{AGP}(agp/lnco2, lnalu, lnfcom, lnraf)$ | | 9.534653*** |
| K = 4 | | |
| Critical Value | I(0) | I(1) |
| 1% | 3.29 | 4.37 |
| 5% | 2.56 | 3.49 |
| 2.5% | 2.88 | 3.87 |
| 10% | 2.2 | 3.09 |

**Note:** No level relationship is the null hypothesis; *K* is what informs on the regressors used; *, ** and *** informs on 10%, 5% and 1% significance, respectively.
**Source:** Author's computation (2023)

The decision on cointegrating relationship among combined series are documented in Pesaran, et al., (2001). The conventional approach is comparing the F-statistics with 3.49, the 5% critical value. Cointegration is confirmed in the instance where the former exceeds the latter. Otherwise, the null hypothesis is jettisoned. The result appears to align with the process of validating cointegrating relationship as the F-statistics of 9.534653 is over and above 3.49. By this, the study reasonably concludes that there is cointegration among agricultural productivity, $CO_2$ emissions, agriculture land use, and average rainfall. By implication, including the series with non-stationary features will not bias the estimates.

**Table 4: ARDL Long and Short Run Results**

| Dependent Variable: $lnAGP_t$ | | | | |
|---|---|---|---|---|
| **Panel A: Long Run Results** | | | | |
| $Variable$ | $Coefficient$ | $Std.Error$ | $t-Stats$ | $Prob.$ |
| $lnCO2_t$ | 0.5359*** | 0.0879 | 6.0956 | 0.0000 |
| $lnALU_t$ | 19.1174*** | 2.6000 | 7.3526 | 0.0000 |
| $lnFCOM_t$ | -0.1056** | 0.0504 | -2.0936 | 0.0499 |
| $lnRAF_t$ | 0.1001 | 0.1898 | 0.5276 | 0.6038 |
| C | -75.7003 | 11.1171 | -6.8093 | 0.0000 |
| **Panel B: Short Run Results** | | | | |
| $Variable$ | $Coefficient$ | $Std.Error$ | $t-Stats$ | $Prob.$ |
| $D(lnCO2_t)$ | 0.0600 | 0.0460 | 1.3040 | 0.2078 |
| $D(lnCO2_{t-1})$ | -0.2743*** | 0.0579 | -4.7384 | 0.0001 |
| $D(lnALU_t)$ | 20.4223*** | 3.9837 | 5.1264 | 0.0001 |
| $D(lnALU_{t-1})$ | 4.1369*** | 1.8771 | 2.2038 | 0.0401 |
| $ECM_{t-1}$ | -0.6444*** | 0.0758 | -8.5007 | 0.0000 |
| $R^2 = 0.7138$ | | Adjusted $R^2 = 0.6661$ | | |

Note: *, ** and *** denote significance at 10%, 5% and 1% level.
**Source:** Author's computation (2023)

One of the strengths of the ARDL method is its ability to concurrently produce the long- and short-run results as it is a single equation model. This can be seen in Table 4 as the long run model result is summarized in Part A and the short-run result in Part B, with a single intercept.

Table 4 shows that growth in carbon dioxide emissions significantly affects the level of agricultural productivity in Nigeria positively at 5 percent level of significance. The estimated carbon emission coefficient of 0.5359 indicates that a 1 percent increase in $CO_2$ emissions will lead to an increase in agricultural productivity by 0.5359 percent in the long run. The obtained result is not consistent with economic theory which argues that climate change in the form of rising sea levels and/or higher frequency of extreme weather conditions will affect agrarian activities negatively, through disruption of the farming cycle and activities. The implication of this is that carbon emissions in Nigeria is low and, on the decline, (as shown in Table 1) and this could explain why its effect on agricultural productivity is not contractionary. This result failed to uphold the finding suggested by Salahuddin, Gow and Vink (2020) that deteriorating environmental quality induced low agricultural productivity.

The results exposed agricultural use of land as the significant driver of increased agricultural productivity. As the proportion of land area used for agriculture increases by 1 percent, agricultural productivity is bound to increase by 19.1174 percent over the long run. The result showed that use of land area for agricultural activities has contributed to improving productivity in the agricultural sector in Nigeria for the period studied. The result of a positive relationship between agricultural land use and agricultural productivity is consistent with economic theory. Fertilizer consumed per hectare of arable land appeared with negative sign, indicating that increased consumption of fertilizer reduces agricultural productivity. By the result, 1 percent increase in the kilogram of fertilizer consumed per hectare of arable land caused agricultural productivity to contract by 0.1056 percent, which is opposite to expectation that fertilizer consumption improves yields and agricultural productivity. This finding which varies from expectation is insignificant. Another driver of agricultural productivity observed from the estimation is rainfall. Estimation indicate agricultural productivity is expected to inflate by 0.1001 percent as average rainfall increase by 1 percent, but the positive impact of rainfall on agricultural productivity was insignificant.

The error correction model was also estimated to verify the short-run dynamics of the modeled variables. The coefficient of determination was 0.7138, suggesting that 71 percent of the fluctuation observed in agricultural productivity are explained by $CO_2$ emissions, agriculture land use, fertilizer consumption and average rainfall. In the short run, increased emissions of $CO_2$ in the current period boost agricultural productivity, as it caused an insignificant increase of about 0.0600 percent in agricultural output, when $CO_2$ emissions in the current period rises by 1 percent. The study observed declining effect of carbon dioxide emissions on agricultural productivity in the short run. Agricultural productivity significantly declines by 0.2743 percent following increase in carbon dioxide emissions. These decline in agricultural productivity caused by increased carbon dioxide emissions was observed after 1 year. The stimulating effects of agricultural land use was also observed in the short run. Though agriculture land use improves agricultural productivity, its impact after a year is lesser compared to its contemporaneous effect. The error correction coefficient of -0.6444, which validate the cointegrating relationship, implies that the estimated short run model adjusts back to long run from short run at the speed of 64 percent when there are short run disturbances. The implication of this is that, long run agricultural productivity will be achieved in approximately two years.

**Diagnostic Test**

The result of the post-estimation tests which was conducted to provide backing for the result, indicating the assumptions of the regression model are upheld, are presented in Table 5.

**Table 5: Diagnostic Test Results**

| Tests | CLRM Problem | $\chi^2$ Value | $\chi^2$ Prob. | Decision |
|---|---|---|---|---|
| Breusch-Godfrey LM | Serial Correlation | 2.6909 | 0.2604 | Serial independence |
| ARCH | Heteroscedasticity | 0.7710 | 0.3799 | Constant Variance |
| Ramsey RESET | Specification error | 2.9489 | 0.1031 | Correctly specified |
| Jarque-Bera | Normality | 5.4204 | 0.0665 | Normal residuals |
| CUSUM | Stability | - | - | Stable Model |
| CUSUM of Squares | Stability | - | - | Stable Model |

Note: CLRM stands for classical linear regression model
Source: Authors' compilation (2023)

Table 5 summarily shows presence of constant variance and serial independence of the errors due to a higher probability value of ARCH and Breusch-Godfrey LM Chi-square statistics. Normality is the errors was also verified and the linear functional specification used to explain how climate change relates with agricultural productivity in Nigeria is with specification error. The study confirmed stability of the coefficients and absence of structural instability as the cumulative sum (CUSUM) and CUSUM of squares plots are within the 5% critical bound.

**Figure 5: CUSUM Plot**

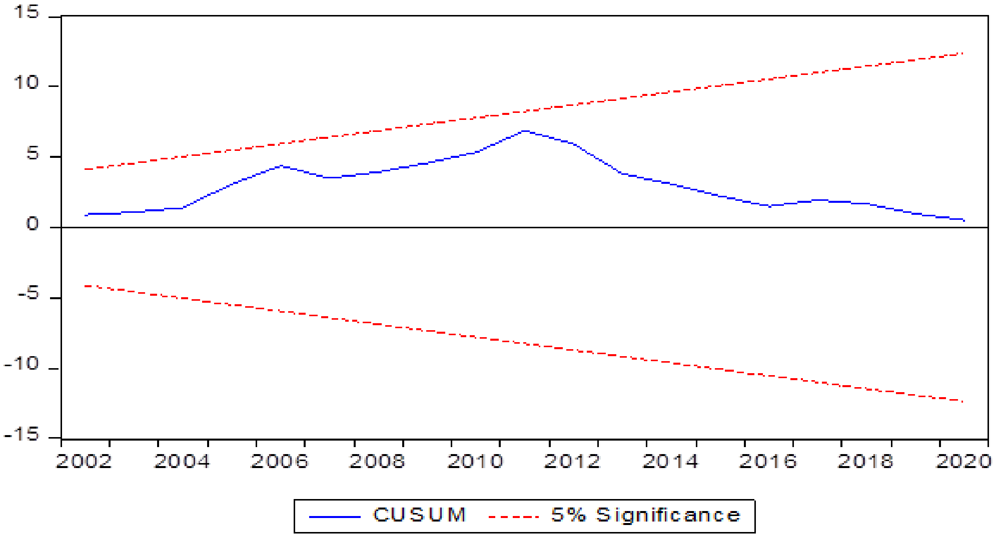
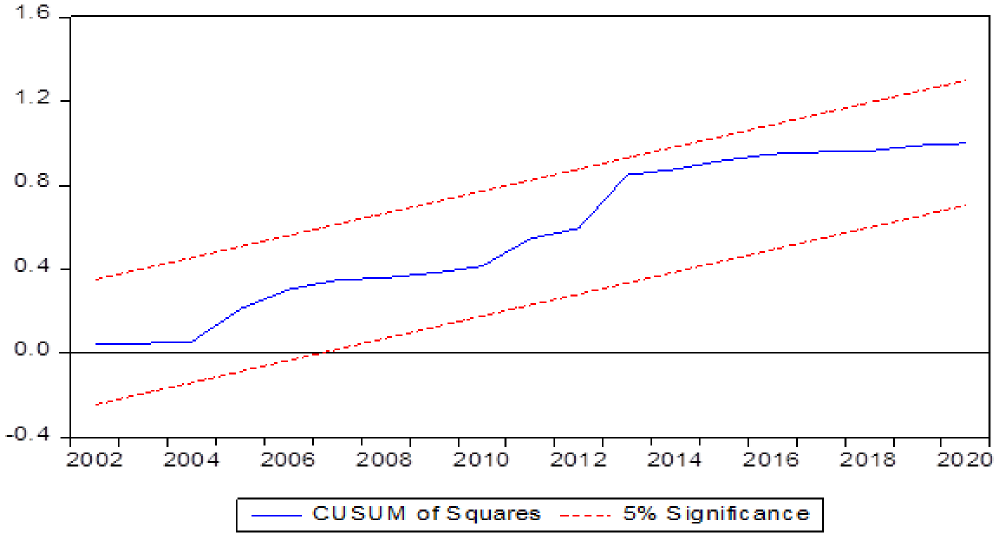



**Figure 6: CUSUM of Squares Plot**



## V. Conclusion And Recommendations

Agriculture is perceived as a critical backbone of the economy of Nigeria and the current push to diversify revenue from the oil sector to the non-oil sector like agriculture has reawakened the interest in agriculture and policy focus. The increased concern that $CO_2$ emissions every year is about 42 billion tons, according to the Inter-Governmental Panel on Climate Change (IPCC), and carbon emission exceeding 330 billion tons will cause the global temperature to increase by 1.5 degree Celsius and threaten food availability and droughts, motivated this study. This study examined the effect of climate change on agricultural productivity in Nigeria using the autoregressive distributed lag (ARDL) method and found that growth in $CO_2$ emissions does not threaten agricultural productivity by causing a decline in agricultural output level, but rather, its impact was positive and significant. Estimates revealed that agricultural land use is a significant driver of agricultural productivity. The study found that rainfall stimulates agricultural productivity, but not significantly. On the bases of these results, certain policy recommendations were made to enhance agricultural productivity. The use of land for agriculture should be scaled up by adopting home grown agricultural policy that mandates Nigerians to cultivate available lands. Climate adapting farming practices like the use of push-pull technology can be adopted.

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