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Climate Change and Its Effects on Agricultural Outputs in Nigeria

K. J. Akomolafe[1*], O. B. Awoyemi[1] and A. Babatunde[1]

[1]Afe Babalola University, Ado Ekiti, Ekiti State, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study was carried out to examine the effects of climate change on agricultural productivity in Nigeria. Changes in annual rainfall, temperature, and CO_2 emission were used as proxies for climate change. Autoregressive Distributed Lag (ARDL) Bound test approach to co-integration was used for the analysis. The result shows that climate change is insignificant in influencing agricultural productivity in the short run. It is recommended that the proposed agricultural policy should be keenly implemented by taking Nigerian Meteorological Agency (NIMET) prediction into consideration.

Keywords: Climate change; rainfall; temperature; agriculture.

1. INTRODUCTION

With population of 187 millions, Nigeria is the most populous country in Africa, and the seventh in the world [1]. In terms of projection, the country will be fourth most populous country in the world by 2050 with population of 398 millions. Ironically, the country depends on imports to

**Corresponding author: E-mail: akjohn2@yahoo.com, akjohn@abuad.edu.ng;*

meet her agricultural products and food needs. According to Rondon and Nzeka [2], the total food and agricultural products imported no the country in 2010 was $3.7 billion, and rose to $4.0 billion in 2011. With annual population growth rate of 3%, the country faces food insecurity. According to Von Grebmer, Bernstein, Nabarro, Prasai, Amin, Yohannes, Thompson [3], Nigeria ranks among 100 countries that are most vulnerable to hunger and under nutrition.

Nigeria has 75 percent of its land suitable for agriculture, but only 40% is cultivated [4]. Over 60% of the population is involved in agriculture [2]. Despite these, the country still faces food shortage. As shown in Table 1, the total domestic demand exceeds domestic supplies for most of the crops. For instance, the total domestic demand for rice annually is 6.3 million tons, while the total annual domestic production is 2.3 million. This means that 4 million tons demand gap must be met by imports. The more pathetic situation is that most of the imports are met through illegal means. For wheat, the total domestic demand exceeds domestic supply by 4.64 million, which must also be met through imports. In the case of chicken, the annual domestic supply is 140 million birds while annual domestic demand is estimated to be 200 million, leaving a gap of 60 million, which is also met though imports.

The over-reliance on imports has had negative effects on the economy. For instance, the increasing demand for foreign currencies, brought about by demand for imports, has led to continued depreciation of exchange rate. This has had multiplier effects on inflation and balance of payment position of the country. Apart from this, it has negatively affected manufacturing sector competitiveness. Manufacturing companies that depend on agricultural products for their raw materials face unfair competition with their foreign competitors in term of prices, meeting demand etc. The resultant effect is increasing unemployment and insecurity in the country. The Nigerian Bureau of Statistics [5] disclosed that unemployment in the first quarter of 2015 increased to 7.5% from 6.4% of the last quarter of 2014. According to Odo [6], the underlying causes of the present security challenges in Nigeria are hunger, unemployment, illiteracy, social inequality, and poor leadership.

There are various reasons for the state of agriculture production in the country. One of these is the over reliance on the oil sector. Prior to the discovery of oil in Nigeria, the country's main domestic product was agriculture. The sector provided the country with employment and foreign exchange earnings. However, since the oil boom era, there has been a steady decline in the market share of the economy that was held by agriculture. In the 1960's, the contribution of agriculture to the gross national product was 60 percent. In the 1970's, this declined to 49 percent and by 1980's, it had declined to 22% (National Bureau of Statistics, 2012). Apart from this, the practice of agriculture in Nigeria is at subsistent level. This is despite the fact that the sector employs over 60% of the entire population. Most famers plant only for their personal consumption. This is because of problems of infrastructure and land use policy which make commercial agriculture difficult.

Table 1. Gaps in Nigeria demand and supply across key crops

Crop	Demand (Tons)	Supply (Tons)
Rice	6.3 million	2.3 millions
Wheat	4.7 million	0.06 million
Maize	7.5million	7million
Soya Beans	0.75 million	0.6 million
Chicken	200 million birds	140 million birds
Fish	2.7 million	0.8 million
Milk/Diary	2 million	0.6 million
Tomato	2.2 million	0.8 million
Yams	39 million	37 million
Oil Palm	8 million	4.5 million
Cocoa	3.6 million	0.25 million
Cotton	0.7 million	0.2 million
Sorghum	7 million	6.2 million

Source: Federal Ministry of Agriculture and Rural Development (FMARD, 2016 Report)

Another important factor responsible for the dismal performance of agriculture in the countries is climate change. According to Ethan [7], there has been a long-term temperature increase in most parts of Nigeria, with the only exception in Jos. According to Adefolalu [8], Nigeria is already being plagued with diverse ecological problems brought about by climate change. Apata, Ogunyinka, Sanusi, and Ogunwande [9] claimed that many farmers abandon farming for non-farming activities as a result of problem declining crop yields brought about by unfavorable environmental condition.

Climate change may cause unstable temperature and rainfall pattern, and this could affect the planting and harvesting planning. According to Food and Agricultural Organization [10], about 25% of cereals, 37% of root and tubers, and 53% of fruits are lost in developing countries as a result of unstable climatic conditions. Also, the excessive rise in temperature affects the development process and yields of agricultural products [11]. Olesen and Bindi [12] argued that extreme meteorological events, such as spells of high temperature, heavy storms, or droughts, can severely disrupt crop production, and reduces the effectiveness and duration of pesticide control. Climate change is a threat to rural farmers in developing countries, especially those living in the tropics and sub-tropics [13].

Given the current recession in the country, the current administration has decided to diversify the economy, with agriculture as the focal sector. This is detailed in policy paper tagged;

The Agriculture Promotion Policy [14]. Some of the policy objectives are to (i) grow the integrated agriculture sector by twice the rate of growth in GDP between 2016 and 2020. (ii) Integrate agricultural commodity value chains into the broader supply chain of Nigerian and global industry (iii) promote the responsible use of land, water and other natural resources to create a vibrant agricultural sector offering employment and livelihood for a growing population (iv) facilitate the government's capacity to meet its obligations to Nigerians on food security, food safety and quality nutrition [14]. However, with weather prediction for 2017 by NIMET [15], achieving these objectives remains a concern. It is therefore pertinent that there is a need to examine the relationship between climate change and agricultural productivity in the country. This is the focus of this paper. The next section presents some stylized facts on climate change in Nigeria.

1.1 Climate Change in Nigeria

In Nigeria, the body saddled with the responsibility of weather forecast and advice is the Nigerian Meteorological Agency (NIMET). Over the years, its predictions have been near accuracy. For instance in 2012, they warned in their 2012 seasonal rainfall prediction about the flood that affected many parts of the country later that year [15], The flood in 2012 was very devastating. In fact, over 2.6 trillion naira was reputedly lost to 2012 flood disaster (National Emergency Management Agency (NEMA), [16]. At the beginning of each year, NIMET predicts and make available to the public seasonal rainfall across the country for stakeholders in aviation sector, agriculture sector, etc to plan their activities for the year.

1.2 NIMET 2016 Forecast Evaluation

According to [17], there was 87%% accuracy in their 2016 forecast of length of season and seasonal amount of annual rainfall. However, there were little errors in the predictions for some cities. As shown in Table 2, the predicted length of days for annual rainfall in Gusau was below the actual by 54 days. This would have a significant effect on agricultural planting and harvesting planning in the area. A similar situation exists in the case of Makurdi and Ado Ekiti, where the predicted length of days of rain was far lower than actual length of days. In the case of Ikeja and Zaria, the predicted length of days was far higher than the actual length of days. The case of Ikeja was highly significant with a difference of about 91 days. This indeed would have significantly disrupted planning process in the area.

In the case of forecasted rainfall amounts as shown in Table 3, there were cities where the predicted amounts did not match the actual amount of rain fall. For instance in Ilorin, the predicted amount of rainfall was below the actual by 1298mm. A similar exists in the case of Asaba, Kaduna, Nguru, and Minna. However, the forecasted rainfall amount exceeded the actual in Jos. Incidentally; all these areas are known for agriculture. This means the wrong prediction would impact negatively on agriculture productivity in the areas.

1.3 Temperature Evaluation 2016

As shown in Table 4, there was 77% accuracy in the performance of predicted day temperature in January, while that of the night was 84% accurate in the same month. A similar result was observed in February and April forecasts. In March, the predicted night and day temperature prediction were above 80% in performances.

Despite the variation between the predicted and actual results in both temperature and rainfall as noted above, the predictions were still generally above 70% accurate. This means that stakeholders can rely on it.

1.4 NIMET 2017 Forecast

According to NIMET [17], the country was expected to experience earliest onset of rainfall in February in coastal region of the Niger Delta, especially Bayelsa State, while the earliest cessation date was expected to be in October 4th in Katsina., while the late cessation is expected to be around December 25. This means that the country may experience early heavy rain but dire season towards the end. Incidentally, coastal areas that are likely to experience longer rains are the areas that are already not good for agriculture as a result of environmental pollution brought about by oil activities. The expected average rainfall for the year is between 400mm and 3100mm. They also predicted that the most of the state in the northern part of the country would experience annual rainfall that is below or above normal. They predicted that the country would experience high level of temperature especially around the northern parts of the country which may cause sickness like hyperthermia.

1.5 Actual Weather Experienced 2017

According to NIMET [18], the recorded amounts of rainfall in April in the country were either below normal or above normal, with most states in the northern part of the country recoding light rain, and low amounts of rainfall were also recorded in most states in the southern part of the country. Averagely, there was increase in temperature across the country. The highest temperature in the month was 41.0°C which recorded in Sokoto State, while the minimum temperature for the month was 18.3°C, and was recorded in Jos. The temperature experienced across the country in the same month was warmer than-normal around north-east, north-west and north-central states, and colder than-normal across most states in south-south, south-west, and south-south zones of the country. A similar experience was recorded in May with most parts of the country experiencing below-normal or above normal amounts of temperature. The highest temperature for the month was 41.30C, and was recorded in Nguru, while the minimum

Table 2. Cities where forecast length of season were inaccurate

S/N	City	Predicted length of season (days)	Actual length of season (days)	Remarks
1	Gusau	124	179	Actual higher than forecast
2	Makurdi	203	248	Actual higher than forecast
3	Ado Ekiti	250	281	Actual higher than forecast
4	Ikeja	261	170	Actual lower than forecast
5	Zaria	152	103	Actual lower than forecast

Source: NIMET [17]

Table 3. Cities where forecasted rainfall amount were inaccurate

S/N	City	Predicted Rainfall (mm)	Actual Rainfall (mm)	
1.	Ilorin	1192.0	2490.2	More rainfall than predicted
2.	Asaba	1769.0	2516.7	
3.	Kaduna	1177.0	1781.0	
4.	Nguru	396.0	837.5	
5.	Minna	1136.0	1547.4	
6.	Jos	1270.0	998.0	Less rainfall than predicted

Source: NIMET [17]

Table 4. 2016 temperature evaluations

Temperature forecast	Forecast performance Day (%)	Forecast Performance Night %
January Day/Night	77	84
February Day /Night	73	79
March Day/Night	82	82
April Day /Night	82	73

Source: NIMET [17]

temperature was 18.10C, which was recorded in Jos. Also, most cities in the north recorded amounts of rainfall below 25mm, while most cities in the south recoded amounts of rainfall below 52 mm. In June, the country recorded a significant increase in the amounts of rainfall across the country. The highest rainfall amount was 441.2 mm, which was recorded in Awka. In the same month, the highest mean temperature recorded dropped to 36.70C as against 41.30C in the previous month. In July, the country recorded moderate rainfall and temperature. The highest temperature recorded in the month was 34.8°C, while the highest amount of rainfall was 210.8 mm. The experience in July is a usual dry season in Nigeria each year when rains cease.

1.6 Implication for Agriculture

Given the predicted early cessation of rainfall this year means that planting season will be short. Though the early rainfall led to early food harvest in the market in the country, the short planting period means that there may be possibility of scarcity of food towards the end the year. This is could be so given the situation in the country where there are no storage facilities. Also, the increase in temperature may lead to water stress and outbreak of heat-related diseases among livestock. Fish production farmers may suffer losses due to wash off of ponds in areas with high run off especially during the peak of the rainy season [17].

2. LITERATURE REVIEW

There have been various attempts to study the effects of climate change on agricultural productivity in the literature. Olesen and Bindi [12] examine the Consequences of climate change for European agricultural productivity, land use and policy. They conclude that there may be a positive relationship between climate change agriculture productivity through introduction of new crop species and varieties. Also, Chikezie, Ibekwe, Ohajianya, Orebiyi, Ehirim, Henri-Ukoha , Nwaiwu, Ajah, Essien, Anthony, and Oshaji [19] examined the effect of climate change on maize production, yam production, and cassava production in southeast, Nigeria, using Co-integration and Vector Error Correction Model techniques. The result shows that there is a positive relationship between yam productivity and rain days, humidity, and sunshine, but a negative relationship with temperature. However, maize production is negatively related with rain days and temperature but positively related with rainfall volume, humidity and sunshine. Also, a positive relationship exists between the productivity of cassava and rainfall volume, rain days, and sunshine, but a negative relationship with temperature and humidity.

Apata [20] examined the effects of global climate change on agriculture sector in Nigeria. The study was done using both primary data consisting of 850 questionnaires and secondary data which was divided into 10 years periods, and production, consumption and storage of grains under different climate scenarios were calculated over a 10-year scenery. The results showed that unfavourable climatic environment negatively impacts grain productions, but climate change adaptations have significant impact on farm productivity. Also, Kazi and Abu (2014) examined the impact of climate change on agricultural productivity in 23 regions of Bangladesh through fixed effect regression. The result shows a significant positive relationship between rice production and temperature during wet season, but insignificant after controlling for the year specific heterogeneity. Also, fluctuation of rainfall in dry and wet seasons has a positive impact on agricultural productivity, but fluctuation of humidity in the wet season has a negative impact on rice productivity.

Tingem, Rivington, Bellocchi, Azam-Ali, and Colls [21] assessed the potential effects of greenhouse gas climate change and CO_2 emission on crop yields in Cameroon. They found out that maize and sorghum yields are expected to decrease by 14.6 and 39.9% respectively due to climatic change. In addition, Gbetibouo and Hassan [22] examined the economic impact of climate change on field crops in South Africa. The result shows that field crops were sensitive to marginal changes in temperature. Also, rise in temperature has positive effects on net revenue of the farmers. Mamun, Ghosh, and Islam [23] examined the effects of climate change on rice yields in Bangladesh. They found out that increase in temperature and relative humidity and decrease in rainfall have both positive and negative effects on the yield. Mulatu, Eshete, and Gatiso [24] examined the Impact of CO_2 emissions on agricultural productivity and household welfare in Ethiopia using Computable General Equilibrium Analysis. The result shows that CO_2 emissions negatively affect traded and non-traded agricultural product. Also, CO_2 emissions reduces the welfare of all segments of rural-poor households.

3. DATA AND METHOD

The data used for this study are secondary data from 1975 to 2015. They were obtained from Food and Agricultural Organization Statistics, World Bank data bank and National Bureau of Statistics. All the series were transformed into their natural-log form. The log-log specification helps to analyze the elasticity of the dependent variables with respect to any of the regressors. The empirical model is specified as follows:

$$LAGRIC_t = \delta_1 + \delta_2 LTEMP_t + \delta_3 LRAIN_t + \delta_4 LCO2_t + \delta_5 LGDP_t + \delta_6 LLAND_t + \varepsilon_t$$

Where; *AGRIC is Total* Agricultural Output, TEMP is Temperature, RAIN is rainfall, CO_2 is CO_2 emission, and was used as proxy for pollution, GDP is gross domestic product which was used as proxy for the size of domestic market in the country, LAND is the arable land measured in hectares, and ε is the error term which is assumed to be normally distributed. Changes in temperature, rainfall, and CO_2 emission were used as the proxy for climate change, while LAND and GDP were used as control variables.

The analysis was carried out to examine the effects of climate change on agricultural output. In order to achieve the objective, ARDL approach to co-integration was used. This was because all the series were not integrated of the same order, and none was integrated of the second order. Also, the dependent variable (log of Agricultural output) was integrated of order (1) . With all these conditions satisfied, we used the ARDL bounds testing approach to co-integration developed by Pesaran and Shin [25]. The ARDL requires the estimation of the following unrestricted error correction model (UECM)

$$\Delta lAGRIC = \delta + \delta_{Agric} LAGRIC_{t-1} + \delta_{Tem} LTEMP_{t-1} + \delta_{Rain} LRAIN_{t-1} + \delta_{co2} LCO2_{t-1} + \delta_{gdp} LGDP_{t-1} + \delta_{Land} LLAND_{t-1} + \sum_{i=1}^{k} \theta_i \Delta LAGRIC_{t-i} + \sum_{j=1}^{q} \theta_j \Delta LTEM_{t-j} + \sum_{r=1}^{\gamma} \theta_r \Delta LRAIN_{t-r} + \sum_{i=f}^{n} \theta_f \Delta LCO2_{t-f} + \sum_{b=1}^{h} \theta_b \Delta LGDP_{t-b} + \sum_{v=1}^{m} \theta_v \Delta LLAND_{t-v} + \mu_i$$

$$\Delta LTEMP = \delta + \delta_{Agric} LAGRIC_{t-1} + \delta_{Tem} LTEMP_{t-1} + \delta_{Rain} LRAIN_{t-1} + \delta_{co2} LCO2_{t-1} + \delta_{gdp} LGDP_{t-1} + \delta_{Land} LLAND_{t-1} + \sum_{i=1}^{k} \theta_i \Delta LAGRIC_{t-i} + \sum_{j=1}^{q} \theta_j \Delta LTEM_{t-j} + \sum_{r=1}^{\gamma} \theta_r \Delta LRAIN_{t-r} + \sum_{i=f}^{n} \theta_f \Delta LCO2_{t-f} + \sum_{b=1}^{h} \theta_b \Delta LGDP_{t-b} + \sum_{v=1}^{m} \theta_v \Delta LLAND_{t-v} + \mu_i$$

$$\Delta lRAIN = \delta + \delta_{Agric} LAGRIC_{t-1} + \delta_{Tem} LTEMP_{t-1} + \delta_{Rain} LRAIN_{t-1} + \delta_{co2} LCO2_{t-1} + \delta_{gdp} LGDP_{t-1} + \delta_{Land} LLAND_{t-1} + \sum_{i=1}^{k} \theta_i \Delta LAGRIC_{t-i} + \sum_{j=1}^{q} \theta_j \Delta LTEM_{t-j} + \sum_{r=1}^{\gamma} \theta_r \Delta LRAIN_{t-r} + \sum_{i=f}^{n} \theta_f \Delta LCO2_{t-f} + \sum_{b=1}^{h} \theta_b \Delta LGDP_{t-b} + \sum_{v=1}^{m} \theta_v \Delta LLAND_{t-v} + \mu_i$$

$$\Delta lCO2 = \delta + \delta_{Agric} LAGRIC_{t-1} + \delta_{Tem} LTEMP_{t-1} + \delta_{Rain} LRAIN_{t-1} + \delta_{co2} LCO2_{t-1} + \delta_{gdp} LGDP_{t-1} + \delta_{Land} LLAND_{t-1} + \sum_{i=1}^{k} \theta_i \Delta LAGRIC_{t-i} + \sum_{j=1}^{q} \theta_j \Delta LTEM_{t-j} + \sum_{r=1}^{\gamma} \theta_r \Delta LRAIN_{t-r} + \sum_{i=f}^{n} \theta_f \Delta LCO2_{t-f} + \sum_{b=1}^{h} \theta_b \Delta LGDP_{t-b} + \sum_{v=1}^{m} \theta_v \Delta LLAND_{t-v} + \mu_i$$

$$\Delta lGDP = \delta + \delta_{Agric}LAGRIC_{t-1} + \delta_{Tem}LTEMP_{t-1} + \delta_{Rain}LRAIN_{t-1} + \delta_{co2}LCO2_{t-1} + \delta_{gdp}LGDP_{t-1} + \delta_{Land}LLAND_{t-1} + \sum_{i=1}^{k}\theta_i\Delta LAGRIC_{t-i} + \sum_{j=1}^{q}\theta_j\Delta LTEM_{t-j} + \sum_{r=1}^{\gamma}\theta_r\Delta LRAIN_{t-r} + \sum_{i=f}^{n}\theta_f\Delta LCO2_{t-f} + \sum_{b=1}^{h}\theta_b\Delta LGDP_{t-b} + \sum_{v=1}^{m}\theta_v\Delta LLAND_{t-v} + \mu_i$$

$$\Delta lLAND = \delta + \delta_{Agric}LAGRIC_{t-1} + \delta_{Tem}LTEMP_{t-1} + \delta_{Rain}LRAIN_{t-1} + \delta_{co2}LCO2_{t-1} + \delta_{gdp}LGDP_{t-1} + \delta_{Land}LLAND_{t-1} + \sum_{i=1}^{k}\theta_i\Delta LAGRIC_{t-i} + \sum_{j=1}^{q}\theta_j\Delta LTEM_{t-j} + \sum_{r=1}^{\gamma}\theta_r\Delta LRAIN_{t-r} + \sum_{i=f}^{n}\theta_f\Delta LCO2_{t-f} + \sum_{b=1}^{h}\theta_b\Delta LGDP_{t-b} + \sum_{v=1}^{m}\theta_v\Delta LLAND_{t-v} + \mu_i$$

The analysis was done in two stages: The first stage involved testing for unit root and determining the order of integration of the various series, while the second stage involved bounds testing and ARDL estimation.

4. THE RESULTS

4.1 Unit Root Test

We conducted the tests for unit root using the Augmented Dickey Fuller (ADF) method using with Schwartz information criterion (AIC) lag length criterion. We can reject the null hypothesis of a unit root by comparing the ADF statistic with the critical values. Another way is to examine the significance of the T-statistics using the probability value, The results show that all the variables, except LTEMP, are integrated of order I(1). The Temperature is integrated of order zero or I(0) . Since, none of the variables is I(2), and the dependent variable (LAGRIC) is I(1), the bounds testing approach can be used to check for co-integration in the model.

4.2 ARDL Bounds Test for Co-integration

Since the dependent variable(LAGRIC) is I(1), and one of the series(LTEM) is I(0), and none of the series is I(2), Johansen co-integration test is no longer valid. We proceed to ARDL otherwise known as Bond test. The first step is choosing the optimal lag. As shown in Table 6, all other lag length criteria indicate optimal lag of 1, except the AIC. Hence, the optimal lag was chosen to be 1.

4.3 ARDL Co-integration Test

Table 7 presents the results of the bounds test procedure for long-run co-integration. The table shows the calculated F-statistics for the joint significance of the coefficients of the lagged levels of the variables. This was done by estimating the equation F-statistics using the OLS-ARDL method. According to Narayan [26], the existing critical values in Pesaran, Shin and Smith [27] cannot be applied for small sample size as they are based on large size. Hence, Nasaran (2006) provided a set of critical values for small sample sizes ranging from 30 to 80 observations. This is shown in Table 7. it can be seen that the calculated F-statistics exceed the upper bound critical value of 3.910 at 5 percent significance level. This implies that the null hypothesis of no long-run co-integration relationship between the variables is rejected. It can be concluded that there is a long-run co-integration relationship between the variables.

Table 5. ADF Test Unit Root Test

Variables	Intercept and Trend					Remark
	Level		First Difference		LAG Length AIC	
	T-Stat	Prob.	T-Stat	Prob.		
LAGRIC	-1.091221	0.9174	-7.308224***	0.0000	9	I(1)
LRAIN	-2.871843	0.1823	-5.896793***	0.0001	9	I(1)
LTEMP	-5.212837***	0.0007			9	I(0)
LCO_2	-2.129962	0.5140	-6.322613***	0.0000	9	I(1)
LGDP	-1.720216	0.9995	-4.847307***	0.0003	9	I(1)
LLAND	-0.856744	0.7912	-5.253470***	0.0001	9	I(1)

****indicates stationary at 1%, **indicates stationary at 5% *indicates stationary at 10%*

4.4 Long Run Analysis

Following the existence of long-run co-integration relationship among the variables, the study estimates the long-run coefficients of the ARDL. The result is presented in Table 8. The results are consistent with the expected results. It shows that pollution emission(LCO_2) is negatively related with agricultural production in the long run. A 1% increase in C02 will decrease agricultural output by 0.14%. Also, there is a positive relationship between arable land available and agricultural output in the long run. This means the more available arable land is in the country, the more is the productivity of agriculture. Also, economic growth, used as proxy for market size, positively influenced agricultural output in the long run. A 1% increase in growth of the economy, will lead to 0.4% increase in agricultural output. There is also a positive relationship between rainfall and agricultural output in the long run. The temperature also has a positive relationship with agricultural output in the long run. This shows that climatic condition in the country is favourable to agricultural output in the long run. This implies that the global climate change has not had its effect in Nigeria. However, rainfall is not significant in influencing agricultural production in the long run, though it has expected sign.

4.5 Short-Run Dynamics

The result of the short run model is presented in Table 9. The result shows that CO_2 emission also negatively impact agricultural production in the short run. Rainfall has a negative short run relationship with agricultural production. A 1% increase in rainfall will lead to a decrease of 0.04% in agricultural production. However, temperature has a positive relationship with agricultural production in the short run. The result also shows that the ECT has the expected sign, and indicates that the speed of adjustment from short-run deviation back to the long-run equilibrium relationship is low at 8%. All the explanatory variables were not however significant in influencing agricultural production in the short run. This reflects the reality in Nigeria. The amount of rainfall and sunshine experienced in this country has not translated to increased productivity in agriculture.

Table 6. Lag order selection criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	173.4951	NA	5.98e-12	-8.815530	-8.556964	-8.723534
1	356.3622	298.3622*	2.70e-15*	-16.54538	-14.73542*	-15.90141*
2	393.0707	48.30066	3.01e-15	-16.58267*	-13.22131	-15.38672

** indicates lag order selected by the criterion*
LR: sequential modified LR test statistic (each test at 5% level), FPE: Final prediction error
AIC: Akaike information criterion, SC: Schwarz information criterion, HQ: Hannan-Quinn information criterion

Table 7. Results of Bounds Test for Long Run Co-integration

Dependent variable	F-statistic	P-Value	Critical value			
			1%	**5%**	**10%**	**Remark**
LAGRIC	4.844272**	0.0019	4.068 - 5.250	2.962 – 3.910	2.496 - 3.3468	Co-integration

, ** and * denotes statistically significant at 10, 5 and 1 percent respectively. Critical value of bounds were obtained from Narayan(2006). The conclusions are based on the 5 percent critical values.*

Table 8. Results of the long run result

Dependent Variable: LAgric				
Regressor	**Coefficient**	**Standard Error**	**T-Statistics**	**Prob value**
Constant	-44.49429	3.844377	**-11.57387*****	0.0000
LCO_2	-0.154137	0.089312	**-1.725840***	0.0935
LLAND	1.338848	0.137129	**9.763430*****	0.0000
LNGDP	0.436243	0.066917	**6.519152*****	0.0000
LRAIN	0.158218	0.260232	0.607988	0.5472
LTEM	3.414243	1.176945	**2.900936*****	0.0065

, ** and * denote statistically significant at 10, 5 and 1 percent respectively*

The R^2 is validated at around 0.43%, showing that about 43.73% variation in the dependent variable is explained in the model. The F-statistics for the joint significance of the coefficients of the explanatory variables is significant at 1 percent. The DW shows no first order autocorrelation.

4.6 Model Diagnostic Tests

Table 10 presents the model diagnostic statistics and their probability values. As can be observed in both Breusch-Godfrey Serial Correlation Lagrange Multiplier (LM) test and Breusch-Pagan-Godfrey Heteroskedasticity test, the model passes the diagnostic tests against issues like serial correlation, and heteroscedasticity. Jarque-Bera statistics in Fig. 1 also shows that the residuals from the regression are normally distributed. The plotted CUSUM line in Fig. 2 is within the 5 percent critical lines, indicating that the model is stable.

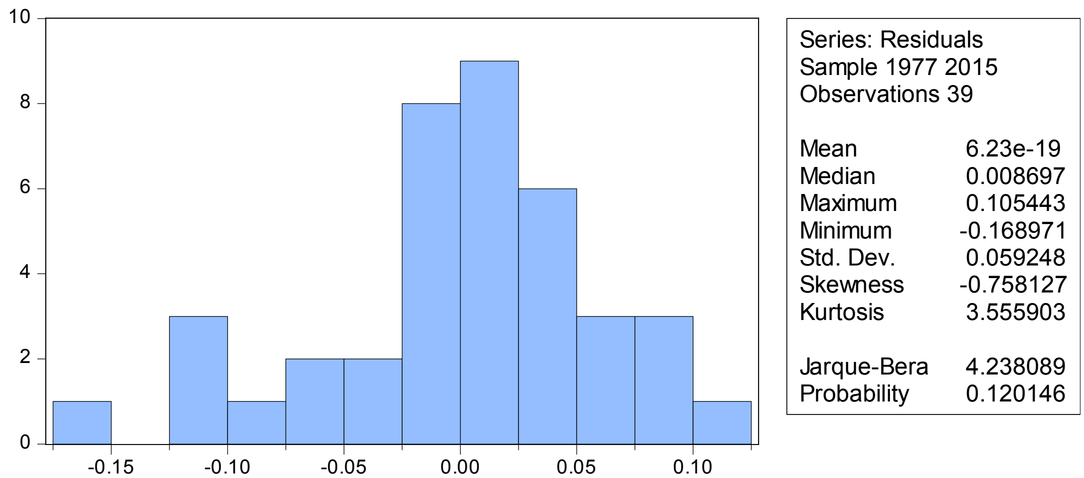

Fig. 1. Plot of Histogram Normality Test

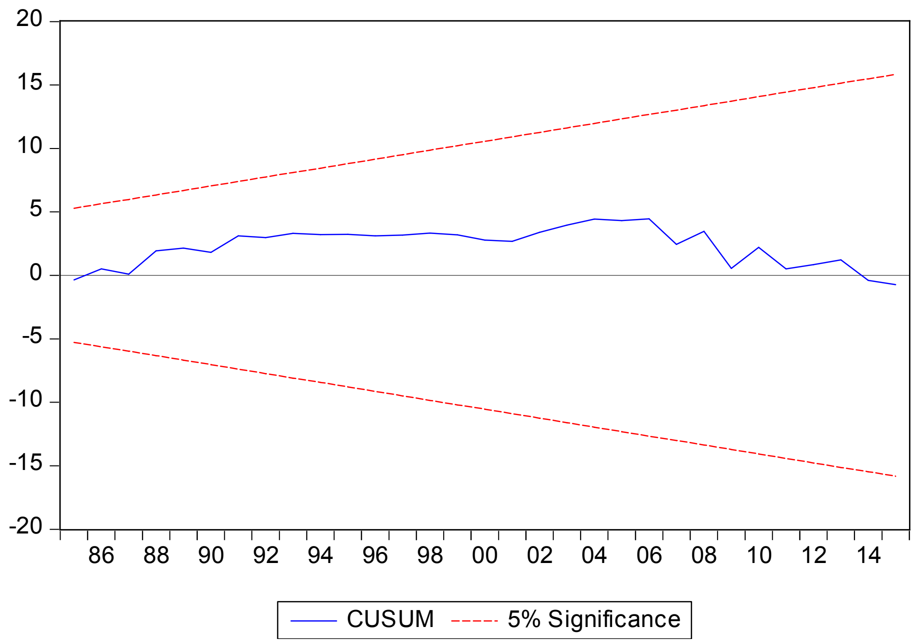

Fig. 2. Plot of cumulative sum of recursive residuals

Table 9. Results of the short run result

Dependent Variable: LAgric				
Regressor	**Coefficient**	**Standard Error**	**T-Statistics**	**Prob Value**
D(LTEM(-1))	0.367668	0.539907	0.680984	0.5009
D(LCO_2(-1))	-0.038850	0.058663	-0.662263	0.5127
D(LRAIN(-1))	-0.047931	0.095626	-0.501236	0.6197
D(LGDP(-1))	-0.024430	0.152970	-0.159704	0.8742
D(LLAND(-1))	0.178293	0.172994	1.030628	0.3107
ECT(-1)	-0.087460	0.096702	-0.904424	0.0027
F-statistic	0.704933			
Prob(F-statistic)	0.007833			
Durbin-Watson stat	2.055190			
R-squared	0.437320			

, ** and * denote statistically significant at 10, 5 and 1 percent respectively*

Table 10. Diagnostics checks

Test Statistics	**F statistics**
Breusch-Godfrey Serial Correlation LM Test	0.277722 (0.6021)
HeteroskedasticityTest: Breusch-Pagan-Godfrey	1.311032 (0.2781)

5. SUMMARY AND CONCLUSION

This study was carried out to examine the effects of climate change on agricultural productivity in Nigeria. Change in annual rainfalls, temperature, and CO_2 emission were used as proxies for climate change. The result shows that change in temperature and rainfall have positive relationship with agricultural productivity in the long run, but CO_2 exerts negative effects on agricultural productivity in long run. However, none of the explanatory variables was significant in influencing agricultural production in the short run. We therefore conclude that the amount of rainfall and sunshine experienced in this country has not translated to increased productivity in agriculture. It is therefore recommended that the proposed agricultural policy should be keenly implemented by taking NIMET prediction into consideration.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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