ANALYSIS OF THE IMPACT OF CLIMATE CHANGE ON THE GROWTH OF NIGERIAN ECONOMY (A CASE OF AGRICULTURAL SECTOR IN NIGERIA)

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Abstract

Climate change remains one of the focal areas of world leaders for both its global importance, and most especially, its threat to the existence of world's habitants. The study examined the challenges of climate change in Nigeria and its implication on agriculture and food security over a period from 1980-2022.Time series data and econometric techniques were used to analyze the data. Specifically, descriptive statistics, co-integration, bound test and regression analysis with the option of ordinary least square were employed. The results showed that, there is variability in Nigeria rainfall and temperature. It also showed that climate change has significant effect on agricultural productivity. Other factors such as price and labour input have a significance effect on agricultural productivity. The result also showed that rainfall is more significant than temperature as a determinant of agricultural output in Nigeria. It is therefore recommended that the need for adequate provision of irrigation and drainage infrastructure which could be regarded as crucial for climate change adaptation should be provided by all agencies and persons concerned to boost agricultural productivity in Nigeria.

Introduction

Nigeria has ambition of diversifying her economy from crude petroleum dependency to agricultural based economy. The country is also battling with problem of food insecurity with a growing population that is increasing geometrically while food production is being done arithmetically and thus Nigeria mostly depends on importation of food. The Global food security index which evaluates a country's ability to feed its people on the basis of the key determinants of food security, affordability, availability and quality in 2011, however ranked Nigeria as the 80th food insecure nation out of 105 countries studied. About 65% of Nigerians are food insecure (that is, do not have sufficient access to the amount and variety of food for a healthy and productive life); 64% of its population is reported as living below the international poverty line of $1.25 per day (UNICEF, 2010), About 40% of children under the age of five are stunted; 9% are wasting and 25% are underweight, owning to widespread deficiencies in Vitamin A, Iron and Iodine and general poor food lifestyle (Abubakar, 2010).

Further evidence of food insecurity and high rate of hunger in Nigeria is revealed by high rate of children undernourished (27% percent) in 2003-2009, under 5 mortality rate per 1,000 live births was 155, 151, 147, 143in 2007, 2008, 2009 and 2010 respectively (UNICEF, 2010). Owing to nutritional deficiencies and illnesses particularly malaria, diarrhoea, acute respiratory infections and vaccines preventable disease (Bryce, 2005). Between 2005 and 2007, about 6% of Nigerians were undernourished and net receipts of cereals as food aid dramatically rose to 3,500 tons between 2004 and 2006

The agricultural sector has a multiplier effect on any nation's socio-economic and industrial fabric because of the multi-functional nature of the sector. It has the potential to be the industrial and economic springboard from which the country's development can take off. Insecure land tenure, scarcity of fund and credit facilities, labour scarcity despite overall high unemployment and stagnant technology has crippled its further development. But now government is trying her best to tackle most of the problems which has some positive impact in solving these problems. This sector mostly depends on nature which involves rising temperature, changing sea level and rainfall system leading to poor performance in Agricultural sector. Nigeria has been identified as one of the sub-Saharan African states that are vulnerable to changing climatic conditions (Ughaelu, 2017). Some researchers such as Ayinde, O. E., Muchie, M.& Olatunji, G. B., (2011) Ughaelu (2017) and Ikem (2018) have found noted that recurring environmental disasters in parts of Nigeria have worsened food productivity and human suffering in the past decade. In 2012, severe flooding that has not been recorded in the country in the past four decades occurred in many parts

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of Nigeria leading to heavy losses in human lives, crops and livestock as well as human displacement (Ogbuchi, 2020).

Agriculture still remains the main stay of the world economy. This is because it has a large share of national output and employs a majority of the labour force, most especially in most developing countries of the world. Agriculture employs 65% of Africa labour force, out of which 75% are women. It also accounts for 32% of GDP growth in sub-Sahara Africa (World Bank 2012). Apart from its contribution to GDP and employment, agriculture also provides food for human consumption, plants and animals.

Nigeria has not been immune or isolated from the effects of the uncertainties of weather conditions and climatic extremities imposed by global warming and climatic change. The most practical effect noticeable by the entire Nigerian populace is the vagaries of seasons and flooding. From the 2012 climatology observations, the rains started very early in most parts of Nigeria, even at awkward months of February and March, in say southwest Nigeria (World Bank 2012). The Nigeria Meteorological Agency (NIMET, 2008) assessed the Nigerian climate from the period of 1941 to 2000 and identified some changes, Building Nigeria Response to Climate Change (BNRCC, 2011). The report showed that some regions, notably northeast, northwest and southeast experienced late onset of rains between the period of 1941 to 1970, but from 1971 up on until 2000, many other parts of the country had begun experiencing late onset of rains. Also, climate scenarios used for projecting future climate showed that changing climate will keep increasing.

Aim and Objectives

The aim of the study is to examine the impact of climate change on agriculture and food security in Nigeria. The objectives are to:

- Examine the relationship between climate change and Agriculture and food security in Nigeria.
- Know the different components of Agriculture and food security contingent on climate change.

Literature Review

Studies have shown that extreme climatic conditions that manifest as desertification, high rainfall and flooding have very adverse consequences for food production (Tirado *et al.*, 2010; Wossen *et al.*, 2018; Uwazie, 2020). The reason for food security and human security crises currently faced in Nigeria is not far-fetched; climate has identified by researchers as the subtle causative factor for these (Uwazie, 2020). Persist fall of rainfall gradient in parts of northern Nigeria have increasingly rendered the affected areas unfit for crop and animal production through the use of natural resources (Wossen *et al.*, 2018). Also, persistent flooding of coastlines and southernmost part of the Nigeria has led to crop damages, loss of soil fertility, soil toxicity and disruption of soil ecosystem (Wossen *et al.*, 2018). The World Bank and the Food and Agricultural organization has through their various publications warned that climate change will continue to pose serious danger to sustainable food production in Nigeria (World Bank, 2016; FAO, 2017).

The study of climate change on agricultural and food price dynamics in economic literature has been framed within so many competing theories providing alternative to explanation to output, quantity supply, quantity demand and price for nation. Namely: the Cobweb theory of adaptive expectations (Cochrance, 1958; Ezekiel, 1938; Nerlove, 1958), the rational expectation model (Muth, 1961), the production function, and the agronomic-economic models.

The Cobweb Model says that prices are formed by endogenous factors, namely, forecasting errors. For example, in response to high prices of a particular crop farmers increase their production which leads to lower price for this crop in the next period. Responding to these lower prices, farmers reduce their production of this crop in the second period, only to see the rising prices in the third period as a result of this supply reduction, and so on (Barre, 2011). The second model assumes that economic agents rationally use all the available information and price dynamics are caused by exogenous factors, especially climatic change (i.e. weather shocks). These two approaches also differ in the solutions they propose for tackling price volatility on agricultural product and food security. If the last year's price was high, this year's planting will be more ambitious than that of the last years and hence this year's output will increase. As much as last year's price determines this year's output, this year's climate condition will affect directly this year's output. In this case we reduce the climate change to be the level of " Rainfall and degree of temperature".

Some empirical studies have demonstrated that climatic variability affects agricultural productivity adversely (Jung and Kunstman; Kralovec, 2020). Muringai *et al.* (2020) studied the impact of declining water resources, higher temperature an increasing CO_2 emission on food production. Their findings like those of most other researchers established a significant link changing climatic condition and poor crop performance. Climate change as seen in most scientific literature affects the very first phase of food supply chain which is production. Hence, its effects inevitably affect every other element in a food supply chain. The supply chain of the fishery sector as noted by Muringai *et al.* (2020) is also affected by climate variability. According to Muringai *et al.* (2020), climate change-induced drought has negatively affected the fishery sector especially in environments where fishery is dependent on natural water resources. Anyika (2020) also, noted that shrinking water resources in the Lake Chad area of Nigeria brought about by climate change has drastically affected the hitherto flourishing and lucrative fishing activities in the area, thereby cutting the fish supply chain that originates from the zone and rendering many fishermen jobless. A related by Oyinloye *et al.* (2018) it was noted climate change has very dangerous consequences for aquatic life. According to the researchers, rising water temperature brought about by climate change results in low volume of oxygen in water which destabilizes the fish habitat and may cause death in fish, low productivity or contamination of fish with harmful bacteria. Researchers are generally of the view that increasing desertification leads to loss of water bodies and aquatic animals.

Another impact of climate change on food security as noted by Ogbuchi (2020) is that it brings about changes in environmental condition which can force people to move out of their original habitation where they engage in food production and other economic activities, thus making them susceptible to food insecurity. The link between forced migration and food insecurity has been established in so many other studies such as Ogbo *et al.* (2019), Oyinloye *et al.* (2018) and Ngo and Otekunrin *et al.* (2019). From the findings of these studies, forced migration limits access to food thereby exposing the victims to under-nutrition.

Methodology

The assumption is that crop production follows the Cobweb Theory, where the present year's planting will depend on the last years produce price. We treat the supply of crop output and the production to be the same, what is planted and harvested (production) is also what is supplied as output. The decision before planting about the size of area of planting and the variety of the crops to plant can be influenced largely by price obtained in the last trading season. Thus, the relationship between output and price as:

$Y_t = f(P_{t-1})$................ (1)

Where: "Y" is crop output measured in tons and "P" is the price per ton.

If the last year's price was high, this year's planting will be more ambitious than that of the last years and hence this year's output will increase. As much as last year's price determine this year's output, this year's climate condition will affect directly this year's output. In this case we reduce the climate change to be the level of " Rainfall and degree of temperature".

We combine this relationship respectively as;

$Y_t = f(P_{t-1}, R_t, T_t)$ .... (2)

Where "p" is the price per metric tons, "R" is the annual rainfall in millimeters and "T" is the degree of temperature and small t is the time period from 1980-2022. The explanatory variables are as defined respectively above.

Production function is specified and the yields of different species of crop are examined under different climatic conditions (Reinsborough, 2003), a production function represents the relationship between the output and the combination of factors or inputs, used to obtain it.

$Q = f(L, K)$ .... (3)

Where: "Q" is the quantity of products, "L" is the quantity of labour force and "K" is the quantity of capital.

There can be other inputs; "K" and "L" are just examples. The Cobb-Douglas production function is a particular form of the production function. It is widely used because it has many alternative characteristics as we will see below.

The basic form of the Cobb-Douglas production function is as follows

$Q(L, K) = AL^{\beta}K^{\alpha}$ .... (4)

Where: "Q" is Total Output, "L" is Labour input, "K" is capital input, "A" is a positive constant and β and α are constants between 0 and 1.

Model Specification

The model according to the theories above as follows:

$Q = f(R_1, T_2, P, L \text{ and } C)$......... (5)

Where: "Q" is Agricultural output, "R_1 is the annual rainfall (mm), "T_2 is the annual temperature (C^o), "P" is indices of average world price in the last period of Nigeria's major Agricultural commodities in Naira per ton, "L" is the Labour input and "C" is the capital input.

Using Cobb Douglas production function, we take the natural logarithm of variable as:

$Q_t = (\beta_0, R_1^{\beta1}, T_2^{\beta2}, P^{\beta3}, L^{\beta4}C^{\beta5})$............ (6)

$LnQ_t = C + \mu_i + V_t + \beta_1 LnR_t + \beta_2 LnT_t + \beta_3 LnP_{t-1} + \beta_4 LnL_t + \beta_5 LnC + ə_t$ ...... (7)

Where C is the regression constant, μis the individual cross section effect, V is the time period effects, and ə is the random error term of the model. The error term and the time period effects are assumed to be random and independent and normally distributed, their sum will be random, independent and normally distributed. Let their sum be V.

The Empirical Model is given as:

$$Q_t = \beta_0 + \beta_1 R + \beta_2 T_t + \beta_3 P_{t-1} + \beta_4 L_t + \beta_5 C_t + \mu_t \text{................} (8)$$

The model has five explanatory variables that are expected to impact relatively on the crop output in Nigeria. The crop output is what has been announce and reported in the national bureau of statistics appendices of Nigeria and various central bank bulletins.

Where Q_t is Agricultural output, "R" is annual rainfall (mm), "T" is annual Temperature (C^0), P_{t-1} as indices of average world price in the last period of Nigeria's major Agricultural commodities in Naira per ton, "L" is Labour force and "C" is Capital input.

β_0 as intercept, β_1 β_2 as parameters $_{t-1}$ represent Lag period. Where μ_t is a white noise error term with mean equal to Zero, a constant and finite variance and non-serial correlation of the disturbance error term.

Data Presentation and Discussion

Descriptive Analysis

This section describes the trends and patterns in the variables included in the study. The variables include agricultural growth, rainfall, temperature, labour, capital, and agricultural price. The descriptive tools employed include mean, standard deviation, minimum, and maximum.

Summary Statistics of the Variables

Variables	Obs.	Mean	Std. Dev.	Minimum	Maximum
AGG	42	5.605568	8.654222	-4.382437	55.57805
RAIN	42	1052.011	795.4214	168.4	2151.03
TEMP	42	14.43738	0.1740207	14.08	14.67
LAB	42	4.35E+07	1.36E+07	2.28E+07	7.06E+07
CAP	42	5.36E+10	3.63E+10	1.23E+10	1.49E+11
PRICE	42	5481.845	4375.854	56	11851.47

Source: Author's Computation, 2023

AGG is Agricultural Growth; RAIN is Annual Rainfall; TEMP is Temperature; LAB is Labour Inputs; CAP is Capital Inputs; PRICE is Last year price of Agricultural Output.

The table above shows that agricultural growth has an average value of 5.60% with a standard deviation of 8.65%, which indicates that agricultural growth values deviate from its mean value over the years being considered. The minimum value of agricultural growth is -4.38%, while the maximum value of agricultural growth is 55.57%. Annual rainfall has an average value of 1052.011 millimeters with a standard deviation of 795.42 millimeters, indicating that there is minimal difference in rainfall value over the years within the considered period. The minimum value of annual rainfall is 168.4 millimeters, while the maximum value of annual rainfall is 2151.02 millimeters. Annual temperature has an average value of 14.44 degrees with a standard deviation of 0.17 degrees, indicating that there is relatively low difference in temperature value over the years. The minimum value of temperature is 14.08 degrees, while the maximum value of temperature is 14.67 degrees. Labor has an average value of 43.5 million with a standard deviation of 13.6 million, which suggests that there is a wide difference in the value of labor over the years within the period considered. The minimum value of labor is 22.8 million, while the maximum value of labor is 70.6 million. Capital has an average value of ε 53.6 billion with a standard deviation of ε 36.3 billion, indicating that the value of capital deviate widely over the years within the period considered. The minimum value of capital is ε 12.3 billion, while the maximum value of capital is ε 149 billion. Last year price of agricultural output has an average value of ε 5481.84 with a standard deviation of ε 4375.854, which suggests that there is wide difference in the price of agricultural output over the years. The minimum value of price of agricultural output is ε 56, while the maximum value is ε 11851.47

Pairwise Correlation Analysis

This sub-section is on the presentation and discussion of the results of the correlation analysis showing the correlation coefficient and its respective p-value for each of the variables employed in this study. These results are presented in Table below, which shows the coefficients of correlation for each pair of variables and their p-values beneath the coefficients, in parentheses. The p-values are to reveal the significant relationships.

Pairwise Correlation Analysis

Variables	AGG	RAIN	TEMP	LAB	CAP	PRICE
AGG	1.0000					
RAIN	0.0527	1.0000				
	(0.7402)					
TEMP	0.164	0.7409	1.0000			
	(0.2993)	(0.0000)				
LAB	-0.0191	0.8929	0.7967	1.0000		
	(0.9046)	(0.0000)	(0.0000)			
CAP	-0.1559	0.5504	0.2032	0.4554	1.0000	
	(0.324)	(0.0002)	(0.1969)	(0.0024)		
PRICE	0.0075	0.8367	0.8459	0.9467	0.4185	1.0000
	(0.9624)	(0.0000)	(0.0000)	(0.0000)	(0.0058)	

Source: Author's Computation, 2023

Note: AGG is Agricultural Growth; RAIN is Annual Rainfall; TEMP Temperature; LAB is Labour; CAP is Capital; PRICE is Last year price of Agricultural Output.

Starting with the first column, it could be seen that the correlation coefficient of agricultural growth with annual rainfall is 0.0527, implying that they are positively related but not statistically significant with p-value of 0.7402, the coefficient of agricultural growth with temperature is 0.1640, which indicates that they are positively related but not statistically significant with p-value of 0.2993, the correlation coefficient between agricultural growth and labor is -0.0191, which indicates that they are negatively related but not statistically significant with p-value of 0.9046, the correlation coefficient between agricultural growth and capital is -0.1559, indicating that they are negatively related but not statistically significant with p-value of 0.3240, the correlation coefficient between agricultural growth and price of agricultural output is 0.0075, which implies that they are positively related but not statistically significant with p-value of 0.9624. It implies that there are no significant relationships between agricultural growth and all the variables.

In the second column, annual rainfall has a correlation coefficient of 0.0527 with annual temperature, implying that they are positively related and statistically significant with p-value of 0.0000, annual rainfall has a correlation coefficient of 0.8929 with labour inputs, which suggests that they are positively related and statistically significant with a p-value of 0.0000, annual rainfall has a correlation coefficient of 0.5504 with capital inputs, indicating that they are positively related and statistically significant with a p-value of 0.0002, and annual rainfall has a correlation coefficient of 0.8367 with price of agricultural output, indicating that they are positively related and statistically significant with a p-value of 0.0000. This implies that annual rainfall has significant relationships with annual temperature, labour inputs, capital inputs, and price of agricultural output.

In the third column, annual temperature has a correlation coefficient of 0.7967 with labour inputs, which implies that they are positively related and statistically significant with p-value of 0.0000, annual temperature has a correlation coefficient of 0.2032, indicating that it is positively related with capital inputs but not statistically significant with a p-value of 0.1969, annual temperature has a correlation coefficient of 0.8459 with price of agricultural output, which implies that they are positively related and statistically significant with p-value of 0.0000. The implication of this is tat annual temperature has significant relationship with labour inputs and price of agricultural output bit insignificant relationship with capital inputs.

In the fourth column, labour inputs has a correlation coefficient of 0.4554 with capital inputs, which suggests that they are positively related and statistically significant with p-value of 0.0024, labour inputs has a correlation coefficient of 0.9467 with price of agricultural output, implying that they are positively related and statistically significant with p-value of 0.0000. This implies that labour inputs has significant relationship with capital inputs and price of agricultural output. In the fifth column, capital inputs have a correlation coefficient of 0.4185 with price of agricultural output, which implies that they are positively related and statistically significant with p-value of 0.0058. This implies that there is a significant relationship between capital inputs and price of agricultural output.

Generally, the correlation coefficients between agricultural growth and the independent variables were found to fall below 0.8, which is the rule of thumb for determining problem of multicollinearity. However, the relationship between some of the independent variables are greater than 0.8. This necessitates transforming the affected variables using log. This will be help to manage the multicollinearity among the independent variables that will be included in the model estimation in later section.

Augmented Dickey-Fuller Unit Root Test

Results of the Augmented Dickey-Fuller Unit Root Test (ADF-URT)

Variables	Unit Root at Level		Unit Root at First Difference		
	Test statistic	p-value	Test Statistic	p-value	I(d)
AGG	-4.531	0.000***	-	-	I(0)
RAIN	-0.838	0.808	-6.215	0.000***	I(1)
TEMP	-1.496	0.535	-7.829	0.000***	I(1)
LAB	1.522	0.998	-3.585	0.006***	I(1)
CAP	-1.887	0.338	-4.177	0.000***	I(1)
PRICE	-0.701	0.847	-5.492	0.000***	I(1)

Source: Author's calculation (2023)

AGG is Agricultural Growth; RAIN is Annual Rainfall; TEMP is Temperature; LAB is Labour Inputs; CAP is Capital Inputs; PRICE is Last year price of Agricultural Output.

The table above shows that all the variables employed in the study were either stationary at level or at first difference. The results of the Augmented Dickey Fuller (ADF) unit root test, indicate that the variables are mix I(0) and I(1), which is a valid condition for the Auto-regressive Distributive lag (ARDL) estimation. More specifically, agricultural growth (AGG) follows a I(0) series, implying that it is a stationary at levels, while annual rainfall, annual temperature, labour inputs, capital inputs, and price of agricultural output follows I(1), implying that they are first difference variables. The outcome presented in the table indicated that none of the variables is I(2) series. Thus, we can safely begin the ARDL data estimation, having established that the variables are a mix of *I(0)* and *I(1)*. The study proceeds to determining the optimal lag length suitable for the ARDL estimation test.

Optimal Lag Length Selection

Vector Autoregressive, VAR, was used to determine the optimal lag length for the ARDL co integration test which was based on the AIC criterion as shown in table below. The lag selection will be conducted for the model specified in the methodology chapter of this study. Below is the outcome of the tests.

Lag Selection Result

VAR Lag Order Selection Criteria		
Lag	Chi^2	p-value
2	29.46	0.771
1	41.52	0.243

Source: Author's calculation (2023)

Likelihood Ratio Tests for Smaller Lag Lengths compare models with different lag lengths to find the optimal lag length. The results show that the likelihood ratio test for lag length 2 and 1 are not significant ($p > 0.05$), suggesting that adding an additional lag (lag 3) does not significantly improve the model fit. Overall, the results suggest that lag length 1 is the most appropriate choice for your VAR model.

Auto-Regressive Distributive Lag (ARDL) Bound Test

The ARDL bounds test procedure to cointegration has a null hypothesis of no long run relationship among variables. Rejection of such hypothesis indicates there is long run equilibrium relationship among the variables. Failure to reject this hypothesis indicates otherwise. The test carried out for the ARDL Co-Integration Approach is presented below.

ARDL Cointegration Approach

ARDL Bounds Test		
K	5	
F-statistic	8.387	
Critical Bound Value		
Significance	I(0) Bound	I(1) Bound
10%	2.26	3.35
5%	2.62	3.79
2.5%	2.96	4.18
1%	3.41	4.68

Source: Author's calculation (2023)

The bound test results shows f-statistics for model to test if long run relationship exist between the dependent variable (agricultural growth) and independent variables (annual rainfall, annual temperature, labour inputs, capital inputs, and price of agricultural output). The f-statistic value of 8.387 is greater than the lower bound I(0) and upper bound I(1) at 1% and 5% level of significance. That implies that the result is inconclusive, meaning that either of the short run relationship or the long run relationship between agricultural growth and the explanatory variables is valid. Therefore, the study proceeds to conducting short run and long run relationship estimation to ascertain the influence of climate change on agricultural growth in Nigeria.

Auto-Regressive Distributive Lag (ARDL) Model Estimation

The regression analysis conducted in this study employed the short run error correction model and long run cointegrating form following the autoregressive distributive lag (ARDL) methodology. The ARDL approach will be employed to estimate the specified model to examine the effect of climate change on agricultural growth in Nigeria.

ARDL Long Run Parameter Estimates Results

Variables	Coefficients	Std. Err.	T-Stat	P-value
AGG(-1)	-1.440	0.196	-7.34	0.000
RAIN	10.969	3.123	3.51	0.001
TEMP	4.594	15.558	0.30	0.770
LOGLAB	-40.239	14.462	-2.78	0.009
LOGCAP	-8.027	2.758	-2.91	0.007
PRICE	0.0014	0.0011	1.30	0.203
Post-Estimation Test			Statistic	P-value
Breusch-Godfrey Serial correlation Test			0.748	0.6881
Breusch-Pagan test for heteroskedasticity			1.547	0.2127
Normality Test			3.865	0.1341
Ramsey RESET			15.11	0.1008

Source: Author's Computation, (2023).

*Note: ** imply the significance of the variables at $p<0.05$ significance levels, respectively. AGG is Agricultural Growth; RAIN is Annual Rainfall; TEMP is Temperature; LAB is Labour Inputs; CAP is Capital Inputs; PRICE is Last year price of Agricultural Output*

The table above presents the estimated ARDL long-run relationship between agricultural growth and climate change with respect to the independent variables considered in the study. The findings revealed that the lag of agricultural growth, annual rainfall, labour inputs, and capital inputs have negative effect on agricultural growth, while annual temperature, and last year price of agricultural output have positive effect on agricultural growth in Nigeria in the long run. However, the findings indicated that the lag of agricultural growth, annual rainfall, and capital inputs are statistically significant in explaining agricultural growth, given their respective p-values. Precisely, the coefficient of these variables are statistically significant at 1% level of significance. On the other hand, annual temperature, labour inputs, and last year price of agriculture does not have effect on agricultural output in the long run.

With regards to the magnitude of the coefficients, the long run estimates show that the lag of agricultural growth has a negative coefficient of -1.440 with an associated p-value of 0.000, indicating that it leads to reduction in agricultural growth. The implication of the negative coefficient is that a percent point increase in the value of agricultural growth in previous year will lead to decrease in agricultural growth in current year by 1.440 percent points. Accordingly, labour input has a negative coefficient of -40.239 with an associated p-value of 0.009, which implies that it brings about low agricultural growth. The implication of this is that a percent point increase in labour inputs will bring about decline in agricultural growth by 40.239 percent points. Also, capital inputs has a negative coefficient of -8.027 with an associated p-value of 0.007, indicating that there is tendency of reducing agricultural growth. The implication of this is that an increase in capital input will bring about decrease in agricultural growth by 8.027 percent points. On the other hand, annual rainfall has a positive coefficient of 10.969 with an associated p-value of 0.001, which suggests that annual rainfall contributes to agricultural growth positively. This outcome implies that a percent point increase in annual rainfall will bring about increase in agricultural growth by 10.969 percent points. Although annual temperature and last year price of agricultural output have positive effect on agricultural growth, their respective p-value, which are greater than 0.05 level of significance implies that they are not statistically significant in determining agricultural growth in Nigeria.

For result validation, several diagnostic tests and stability test were employed, including normality test. The model diagnostic checked for the assumption of the normality of residuals, serial correlation, and heteroscedasticity. Table 4.6 which reports the diagnostic tests revealed the absence of higher-order auto-correlation in the model through the Breusch-Godfrey serial correlation test which showed a p-value greater than 5% level of significance. The study confirm that the model residuals are free from non-normality since the p-value is greater than the 5% significance level. Therefore, the errors in the model are normally distributed. The p-value attached to the BreuschPagan-Godfrey (BPG) heteroscedasticity test is higher than 5% level of significance. This indicates that the errors are independent of the explanatory variables and they are homoskedastic, hence there is no heteroscedasticity problem. The table further further shows that the model is correctly specified through the Ramsey RESET model specification error test which revealed a p-value greater than 5% level of significance. These diagnostic tests are performed to determine the rejection of the null hypothesis by examining the test statistic value of each test and the p-value at a 5% level of significance.

ARDL Short Run Parameter Estimates Results

Variables	Coefficients	Std. Err.	T-Stat	P-value
D(RAIN)	-7.721	3.436	-2.25	0.032
D(TEMP)	11.417	17.741	0.64	0.525
D(LOGLAB)	80.971	119.874	0.68	0.505
D(LOGCAP)	12.593	6.193	2.03	0.048
D(PRICE)	0.0014	0.0015	0.91	0.369
Constant	1093.802	622.499	1.76	0.089
Model Result			Statistic	P-value
R-Squared			0.6917	-
Adj. R-Squared			0.5748	-
Durbin Watson			1.967	-
F-Statistic			8.434	0.0000

*Note: ** imply the significance of the variables at p<0.05 significance levels, respectively. AGG is Agricultural Growth; RAIN is Annual Rainfall; TEMP is Temperature; LAB is Labour Inputs; CAP is Capital Inputs; PRICE is Last year price of Agricultural Output*

The table above presents the short run results of the ARDL model, which indicates that rainfall and capital inputs are statistically significant in the short run based on their p-values that are less than 0.05 level of significance. On the other hand, annual temperature, labour inputs, and last year price of agricultural output do not have significant effect on agricultural growth in Nigeria in the short run.

The value of the R-Squared and adjusted R-Squared were estimated to be 0.6917 and 0.5748 respectively. This implies that implies the model of this study is strongly good fitted, as annual rainfall, annual temperature, labour inputs, capital inputs, and last year price of agriculture could explain 69.17 percent variation in agricultural growth in Nigeria. Hence, the explanatory power of the independent variables regarding the behaviour of agricultural growth is satisfactory. The F-statistics with a coefficient value of 8.434 (exact p-value =

0.000) implies that the overall significance of the short-run ARDL model. That implies that the independent variables are jointly significant in predicting agricultural growth.

In the result of the ARDL short-run model, annual rainfall has a negative coefficient of -7.721 with an associated p-value of 0.032, which implies that a percent point increase in annual rainfall in the short run will bring about decrease in agricultural growth by 7.721 percent points. On the other hand, capital inputs have a positive coefficient of 12.593 with an associated p-value of 0.048, which implies that a percent point increase in capital inputs in the short run will lead to increase in agricultural growth by 12.593 percent points.

Discussion of Findings

The study examines the effect of climate change on agricultural growth in Nigeria. Evidenced were provided to support the existence of both short-run and long-run relationships between climate change and agricultural growth in Nigeria. The result of the ARDL long-run estimates as shown in the preceding sections are discussed since this study was able to establish a long run co-integrating relationship.

From the aim of the study which is to ascertain how annual rainfall has affected agricultural growth over the years, the estimation result showed that annual rainfall has positive and significant effect on agricultural growth. This finding aligns with the a priori expectation of the study, which expected higher rainfall to bring about increased agricultural productivity and growth in Nigeria. The logical explanation for this outcome signifies a critical dependency between climatic conditions and the agricultural sector. Adequate and well-distributed rainfall is essential for supporting crop production, providing the necessary moisture required for plant growth and sustenance. When annual rainfall is abundant, it can lead to increased agricultural productivity, higher crop yields, and a boost in overall agricultural output. Favorable rainfall patterns can enable farmers to plant and harvest their crops effectively, leading to increased farm incomes and improved livelihoods in rural areas. The outcome supports the findings of Osita, Nnaemeka, Nwagwe, & Sabbas (2016); Njiforti, Duru, Mohammed, & Alehile (2022); and Nwaiwu (2021).

The findings of the study revealed that labour inputs have negative and significant effect on agricultural growth in Nigeria, the implication of this is that additional labour input will bring about decrease in growth of agriculture in Nigeria from the general perspective. This outcome does not corroborate with the expectation of the study, which expected labour inputs to have positive contribution to the agricultural sector. The logical explanation for the negative effect could be attributed to challenges faced by the agricultural sector in Nigeria, particularly inefficiencies in labor utilization, such as outdated farming practices and inadequate training. The limited availability of skilled laborers in the agricultural sector can hinder the adoption of modern agricultural technologies and techniques, which are essential for increasing productivity. The lack of skilled labor can result in suboptimal farm management practices, leading to lower yields and reduced agricultural growth. Additionally, inadequate access to credit and financial resources for farmers can limit their ability to invest in labor-intensive farming practices and modern agricultural machinery. This limitation can further exacerbate the negative effect of labor input on agricultural growth. Furthermore, factors like rural-urban migration and youth unemployment contribute to a shrinking agricultural labor force. The exodus of skilled laborers to urban areas leaves behind an aging and less efficient workforce in the agricultural sector, negatively impacting productivity and growth. This outcome does not align with the empirical findings of (Nwaiwu, 2021).

The findings also revealed that capital inputs has negative and significant effect on agricultural growth in Nigeria. This does not align with the a priori expectation of the study, expecting capital input to have positive effect on agricultural growth. However, the logical explanation of this finding could be over reliance on capital intensive method, neglecting other critical aspects of production, such as proper soil management, crop rotation, and pest control. This imbalance can lead to reduced productivity and inefficiency in the long run. Sometimes, the capital-intensive technologies used in agriculture may not be well-suited to the local conditions, soil types, or climate. This mismatch can lead to suboptimal results and lower productivity. Capital-intensive methods often come with high upfront costs for purchasing machinery, fertilizers, and other inputs. This can put financial strain on farmers, especially smallholders, leading to reduced investment in other crucial aspects of farming. Some capital-intensive practices, such as excessive use of chemical fertilizers and pesticides, can have adverse environmental effects, degrading soil quality and biodiversity. These impacts can negatively affect long-term agricultural productivity. Introducing capital-intensive technology may reduce the demand for labor, leading to unemployment and underutilization of local workforce skills, which can have broader social and economic consequences. The findings align with the findings of Yadav, Gupta, Gupta, & Ranjan, (2020) but against the empirical findings of Ogundan & Onyeaghala (2021).

Conclusion and Recommendations

Based on the findings of the study, it was concluded that climate change has significant effect on agricultural growth in Nigeria. More specifically, it was revealed that annual rainfall, labour inputs, and capital inputs are significant determinants of agricultural growth in Nigeria based on the long run estimation result. However, their effect differs in terms of magnitude and signs.

The overall implication of climate change effect on agricultural growth can be seen from the perspective of heavy reliance on rain-fed agriculture, making it particularly vulnerable to climate variability and extreme weather events, such as drought. s, floods, and heat waves. That implies that even though rainfall is a significant indicator for agricultural growth, excessive of it could lead to flood, which may damage farmland and the produce.

Recommendations

Based on the outcome of the study, the following are suggestions are made. Sufficient and well-distributed rainfall is crucial for crop production, enhancing soil moisture and promoting plant growth. Adequate water availability improves yields, crop quality, and overall agricultural productivity. Furthermore, it supports diversification, enabling farmers to cultivate multiple crops and increase farm income. To optimize the benefits, sustainable water management practices, watershed conservation, and climate-resilient agricultural techniques should be adopted to ensure long-term agricultural growth and food security.

In order to mitigate the negative effect of labor input on agricultural productivity, mechanization and adoption of modern agricultural technologies can optimize labor use, enhance productivity, and reduce physical strain on farmers, contributing to sustainable agricultural growth. In terms of managing capital inputs negativity on agricultural growth, overinvesting in costly machinery and equipment without proper planning should be looked into critically. Balanced investment in suitable technologies, aligned with the specific needs and scale of farming operations, is essential. Efficient resource management, guided by precision agriculture practices, can maximize capital usage and ensure optimal returns on investment, promoting long-term agricultural viability.

References

Anyika, V.O. (2020), "Insurgency, violent extremism and development in the lake Chad region, 1960-2015", MA Dissertation submitted to the Department of History and Diplomatic Studies, Ignatius Ajuru University of Education, Port Harcourt.

Ayinde O.E, (2010). Empirical Analysis of agricultural production and climate change: A Case Study of Nigeria. *Journal of Sustainable Development in Africa. (volume 12 No6, 2010).*

Ayinde, O. E., Muchie, M.& Olatunji, G. B., (2011) Effect of Climate Change on Agricultural Productivity in Nigeria: A Co-Integration Model Approach. *J Hum ecol, 35 (3):189-194 (2011).*

Berhanu, M. and Wolde, A.O. (2019), "Review on climate change impacts and its adaptation strategies on food security in Sub-Saharan Africa", Agricultural Social Economic Journal, Vol. 19 No. 3, pp. 145-154.

Chinedum Nwajiuba (2012). *Nigeria's Agriculture and Food Security Challenges* www.nigeriaclimatechange.org

FAO, IFAD, UNICEF, WFP and WHO (2017), "The state of food security and nutrition in the world 2017", Building Resilience for Peace and Food Security, FAO, Rome.

FAO, IFAD, UNICEF, WFP and WHO (2018), "The state of food security and nutrition in the world 2018", Building Climate Resilience for Food Security and Nutrition, FAO, Rome.

FAO, IFAD, UNICEF, WFP and WHO (2019), "The state of food security and nutrition in the world 2019", Safeguarding against Economic Slowdowns and Downturns, FAO, Rome.

Henderson-Sellers. A. Global Climatic change: the difficulties of Assessing impacts. Volume 29, issues2

Hgubgan, M. L. (2012) (14th edition) *Advanced Economic Theory.* VRINDA Publications (p) LTD

Idumah, F.O., Mangodo, C., Ighadaro, U.B. and Owombo, P.T. (2016), "Climate change and food production in Nigeria: implication for food security in Nigeria", Journal of Agricultural Science, Vol. 8 No. 2, pp. 74-83.

Ifeanyi-Obi, (2012). Perception and adaptation to climate change in Muyuka, subdivision, southwest region, Cameroon: A Gender Analysis.

Ijaiya,G.T. (2013). Social Science Research Reporting: *A manual for Beginners. Unilorin Press.*

Ikem, T.U. (2018), "Prospects of food self-reliance in Nigeria", Farming and Rural System Economics, Vol. 56 No. 1, pp. 112-120.

John. S. Stefan B. Reimund, R.& Helena, K. (2009). General Theoretical Framework (Sustainable Agriculture and Rural Development with Emphasis on Food Security within a Climate Change Setting). *University of Helsinki Department of Economics and management discussion papers no 30 Helsinki.*

Kralovec, S. (2020), "Food insecurity in Nigeria: an analysis of the impact of climate change, economic development, and conflict on food security", MA Thesis submitted to the Department of Global Political Studies, Malmo University.

Muringai, R.T., Naidoo, D., Mafongoya, P. and Lottering, S. (2020), "The impacts of climate change on the livelihood and food security of Small-Scale fishers in Lake Kariba, Zimbabwe", Journal of Asian and African Studies, Vol. 55 No. 2, pp. 298-313.

Neil Leery…et al (2014). Climate Change and Vulnerability: Earthscan Publishing for Sustainable Future London. Sterling, VA.

Ogbo, A., Ebele, N. and Ukpere, W. (2013), "Risk management and challenges of climate change in Nigeria", Journal of Human Ecology, Vol. 41 No. 3, pp. 221-235.

Ogbo, A., Ebele, N. and Ukpere, W. (2019), "Risk management and challenges of climate change in Nigeria", Journal of Human Ecology, Vol. 41 No. 3, pp. 221-235.

Ogbuchi, T.C. (2020), "Quantitative indicators of production of food crops", Journal of Tropical Agriculture, Vol. 32 No. 1, pp. 79-88.

Onuoha, F.C. and Ezirim, G.E. (2010), "Climate change and national security: exploring the conceptual and empirical connections in Nigeria", Journal of Sustainable Development in Africa, Vol. 12 No. 4, pp. 255-269.

Otekunrin, O.A., Otekunrin, O.A., Momoh, S. and Ayinde, I.A. (2019), "How far has Africa gone in achieving the zero hunger target? Evidence from Nigeria", Global Food Security, Vol. 22, pp. 1-12.

Oyinloye, O.D., Akinola, O.O., Akande, Y.O., Akinyele, A.A. and Mosimabale, M.M. (2018), "Food insecurity in Africa", Journal of Humanities and Social Science, Vol. 23 No. 9, pp. 68-75.

Tirado, M.C., Clarke, R., Jaykusc, L.A., McQuatters-Gollopd, A. and Frank, J.M. (2010), "Climate change and food safety: a review", Food Research International, Vol. 43 No. 7, pp. 1745-1765.

Tirado, M.C., Clarke, R., Jaykusc, L.A., McQuatters-Gollopd, A. and Frank, J.M. (2010),

"Climate change and food safety: a review", Food Research International, Vol. 43 No. 7, pp. 1745-1765.

World Bank (2016), "North East Nigeria recovery and peacebuilding assessment: Component Report", World Bank, Abuja.

World Bank, (2012) World bank annual development report 2012.

Wossen, T., Berger, T., Haile, M.G. and Troost, C. (2018), "Impacts of climate variability and food price volatility on household income and food security of farm households in east and west Africa", Agricultural Systems, Vol. 163, pp. 7-15.