Climate Change and Performance of the Agricultural Sector in Nigeria: A Disaggregated Approach

Ibeinmo Friday Cookey[1*], Donny Sigah Ayibazuomuno[2]

[1,2]*Department of Economics. Faculty of Social and Management Sciences, University of Africa, Toru- Orua, Bayelsa State, Nigeria*

**Corresponding Author*

Abstract: **- The paper investigated the effect of climate change on agricultural sector performance in Nigeria between 1981 and 2018. Agricultural sector output was disaggregated into crop, livestock, forestry, and fishery. The selected climate change variables are temperature, rainfall, and greenhouse gas emission. Data were collected from the CBN Statistical Bulletin and the Climate Change Knowledge Portal published by the World Bank. The pre-estimation (unit root and bond co integration) tests revealed the time series are integrated of order 0 and 1 and that a long run relationship only exists among the selected variables in the crop and fishery output models. The study found out that, while temperature had negative impact on crop and fishery production, it had positive results on livestock and forestry production. Secondly, while rainfall had positive results on crop and fishery production, it was found to have negative impact on livestock output. Food security is threatened by climate change in Nigeria. Hence, ministries and agencies of the government must work to achieve some remarkable feat in reduction of climate change in Nigeria. Specifically, government active participation in the crusade to save the environment by policies formulation and affirmative action by supporting agencies like Nigeria Meteorological Agencies, NEMA, and National Orientation agency in their drive for safer environment is highly recommended.**

Keywords: **Temperature, Rainfall, Total Greenhouse Emission, Crop, Livestock, Forestry, Fishery**

I. INTRODUCTION

The agricultural sector maintains a multiplier effect on any nation's industrial fabrics and socio-economic because of the universal identity of the sector (Ogen, 2007). It has the prospects to be the economic and industrial starting post from which the country's development can be launched (Stewart 2000). This sector remains the ultimate source of living for most rural communities in developing countries in general. In Africa, agriculture generates employment for more than 60 per cent of the population and contributes about 30% of Gross Domestic Product (Kandlinkar and Risbey, 2000). Rain-fed farming have the power to influence agricultural production in sub-Saharan Africa, covering about 97% of total farmland and discloses agricultural production to excessive seasonal rainfall changes (Alvaro, Tingju, Katrin, Richard and Claudia 2009). In Nigeria, agriculture is the utmost producer of food and employer of labour employing about 60-70 per cent of the population (Manyong, Ikpi, Olayemi, Yusuf, Omonoma, Okoruwa, and Idachaba, 2005). It is a significant sector of the economy and supplies the raw materials used in the processing industries as well as a source of foreign exchange earnings for the country (Mohammed-Lawal and Atte 2006).

Since agriculture in Nigeria is primarily rain-fed, it is apparent that any variation in climate is expected to affect its productivity along with other socio-economic activities in the country. The impact could, however, be ascertained with regards to effects on crop growth, soil water availability, incident of pest and diseases, soil erosion, sea level increases and reduces soil fertility (Adejuwon, 2004). The subject of climate change has become scarier not only to the socio-economic and sustainable development agricultural occupation of any country but to the entirety of human existence (Adejuwon, 2004). As further explained by the United Nations Framework Convention on Climate Change (UNFCCC), the effect of climate change indicates that the local climate variability which humans have previously witnessed and acclimatized to is changing and this change is noticed in a somewhat great speed.

The pain climate change inflict on agricultural exhibition does not only include the area of crop farming but also includes livestock as well as the total agricultural sector. African farmers also rely on livestock for income, animal products and food (Nin, Ehui, and Benin, 2007). Climate change can control livestock both directly and indirectly (Manning and Nobrew, 2001). The direct effects of climate variables such as air, temperature, humidity, wind speed and other climate factors affect animal performance like growth, wool production, milk production, and reproduction. Climate can also determine the amount and standard of feed stuffs like forage, pasture and grain as well as the harshness and dissemination of livestock diseases and parasite (Niggol and Mendelsohn 2008). Hence, the totality of the agricultural sector is considered by investigating agricultural productivity.

Rainfall is considered the most significant factor of climate change in Nigeria and water resources prospects in the country (Adejuwon 2004). The northeast region of Nigeria is more and more becoming a dry environment at a speedy rate per year prompted by fast reduction in the quantity of surface water, flora and fauna resources on land (Obioha, 2008). The increasing decrease in rainfall resulted to a decrease in the natural regeneration rate of land resources (Fasona and Omojola, 2005). This makes people to utilize more previously undisturbed lands leading to depletion of the forest cover and increase on sand dunes/Aeolian deposits in the northern axis of Nigeria. Climate change is the most threatening problem that world is facing today. It has been suggested that it is more frightening than global terrorism (King 2004). The southern part of Nigeria, known for excessive rainfall is currently faced irregular rainfall and temperature is slowly increasing in the Guinea savannah zone of the country.

Across Nigeria, daily temperature average which varies by location and period of the year from 250C in the southern coast to 400C in the north is projected to an average temperature rise of 1–2°C by 2050 (Ngene, 2012).Also, Nigeria has been identify by IPCC (2007b) as a climate change "*hot spot*" likely to see major movement in weather especially temperature, rainfall, storms, and sea levels throughout in the 21st century (Aaron, 2011). Meanwhile, the Simon, Alex, Charlie, and Philip, (2016) model on effect of climate change on financial assets revealed that the expected 'climate value at risk' (VaR) of global financial assets today is 1.8% along a business-as-usual (BAU) emissions path, translating to $2.5 trillion. That means, climate change will remove about $2.5 trillion or 1.8% of world's financial assets if global mean surface temperature rises above its pre-industrial level of 20C by 2100,and Nigerian is not isolated.

Additionally, the northern zone faces the scare of desert encroachment (Federal Ministry of Environment, 2004). Climate change determines food and water resources that are critical for livelihood in Africa where much of the inhabitants especially the poor, rely on local supply system that are conscious of climate variation. Disruptions of existing food and water systems will have devastating undertone for development and livelihood. All these in addition to the problems climate change already constitute for poverty eradication (De Wit and Stankiewicz, 2006). According to Obioha (2009), the sustainability of the environment to supply all life support systems and the materials for accomplishing all developmental yearnings of humans and animal is reliant on the appropriateness of the climate that is undergoing constant changes. The effect of these changes is terrifying to food security in Nigeria.

Therefore, this study examines the effect of climate change on the performance of the agricultural sector in Nigeria. In specific term, this study examines the:

i. Effect of climate change (average rainfall, temperature and total greenhouse emission) on crop production;
ii. Effect of climate change (average rainfall, temperature and total greenhouse emission) on livestock production;
iii. Effect of climate change (average rainfall, temperature and total greenhouse emission) on forestry production; and
iv. Effect of climate change (average rainfall, temperature and total greenhouse emission) on fishery production.

The hypotheses formulated to guide the focus of this study are as follows:

i. H_0: Climate change (average rainfall, temperature and total greenhouse emission) has no significant effect on crop production;
ii. H_0: Climate change (average rainfall, temperature and total greenhouse emission) has no significant effect on livestock production;
iii. H_0: Climate change (average rainfall, temperature and total greenhouse emission) has no significant effect on forestry production; and
iv. H_0: Climate change (average rainfall, temperature and total greenhouse emission) has no significant effect on fishery production.

II. LITERATURE REVIEW

2.1 Climate Change Defined

According to Intergovernmental Panel on Climate Change (IPCC) (2007b), climate change is the variance in the position of climate that can be caused by variations in the mean and or the variability of its effects that persist for a longer period usually decades or longer. Also, United Nations Framework Convention on Climate Change (UNFCCC) (2007), ascribes climate change directly or indirectly to human actions (anthropogenic factors) that changes the composition of the global atmosphere and are in addition to natural climate variability observed over a comparable period of time. Climate is the statistics of weather, usually over a 30-year interval. It is ascertained by assessing the shapes of divergence in temperature, humidity, atmospheric pressure, wind, precipitation, atmospheric particle counts and other meteorological variables in a given region for a long period of time (Carey, 2009). Climate can be dissimilar from whether in that weather only reports the short term conditions of these variables mentioned above in a given period of time.

2.2 A Review of Theoretical Literature

The literature suggests that various models can be employed to assess the effects of climate change on agriculture. Each model has advantages and shortcomings, and presents divergent levels of difficulty and absoluteness as regards the particular areas considered in its analysis. These distinctions are discussed below for each models class.

The effects of climate change were analyzed by several scholars with consideration given only to the changes in the production of certain crops (specifically maize, rice, cotton and soybean), using the so-called 'crop simulation models'. These models confined the analysis to crop physiology, and simulate and compare crop productivity for different climatic conditions (Eitzinger, Stastna, Zalud, and Dubrovski, 2003; Torriani, Calanca, Schmid, Beniston, and Fuhrer, 2007). Crop models are considered 'agriculture oriented' because the analysis of these models are focused on the biological and ecological consequences of climate change on crops and soil. In these models, farmers' behavior is not captured and the management practice is considered fixed. Moreover, they are crop and site specific, and they were carefully adjusted only for the major grains and for a limited number of places (Mendelsohn and Dinar, 2009).

In the production function approach, the economic dimension is of less significance and is seen in a bias and simplified manner (Bosello and Zang, 2005), even though these models produce very vital information for larger model frameworks that consider economy, later discussed. Some studies explicitly investigated the economic impact of climate change through the estimation of the economic production function (Adams, 1989; Rosenzweig and Parry, 1994 cited in Nastis, S.A.; Michailidis, A.and Chatzitheodoridis, F. (2012). However, other research accessed the economic effects of climate change by implementing the results of agronomic analyses or of empirical yields models in mathematical programming models (Finger and Schmid, 2007). The main weakness of the production–function model is that it is crop and site specific. It endorses the so-called 'dumb-farmer' hypothesis, which excludes from analysis the plausible adoption by farmers of blueprints for coping with the effects of climate change, for example, strategies that replace crops that are most sensitive with others that are less so (Rosenzweig and Parry 1994 cited in Nastis, S.A.; Michailidis, A.and Chatzitheodoridis, F. (2012). To overcome this limitation, Mendelsohn, Nordhaus and Shaw (1994) cited in Nastis, S.A.; Michailidis, A.and Chatzitheodoridis, F. (2012) proposed the Ricardian model. The principal characteristic of the Ricardian model is that it treats adaptation to climate change as a 'black box'. In fact, it estimated the relationship between the outcomes of farms and climate normal using cross-sectional data and including, among regressors, appropriate control variables. As such, it implicitly considers farmer adaptation strategies without the need to implement such strategies as explicit exploratory variables (Mendelsohn and Dinar, 2009). However, this part could also represent a weakness in the model if the aim of the analysis were to estimate the effect of farmer adaptation strategies on climate change. Due to this weakness, models have been proposed that use mathematical programming to consider specifically farmer adaptation strategies (Adams et al., 1990 cited in Nastis, S.A.; Michailidis, A.and Chatzitheodoridis, F. (2012) especially concerning irrigation (Medellín-Azuara , Harou and Howitt (2010). However, these applications often suffer the limitation of considering hypothesized and simulated strategies that can be derived by incorrect simulation of the farmers' goal function.

Some other theories have tried to explain the impact of climate change on the environment and production. First is the theory of climate change reviewed in this study is known as Anthropogenic Global Warming (AGW) (IPPC, 2013). It insists that human emissions of green-house gases, principally carbon dioxide (CO_2), methane, and nitrous oxide, are causing a catastrophic rise in global temperature. The mechanism whereby this happens is called the enhanced green- house effect. Another theory of climate change is called Global Bio-thermostat which argues that negative feedbacks from biological and chemical processes entirely or almost entirely offset whatever positive feedbacks might be caused by rising CO_2. These processes act as a "Global Bio-thermostat" keeping temperatures in equilibrium. The scientific literature contains evidence of at least eight of such feedbacks which includes Carbon Sequestration, Carbonyl Sulfide, Diffuse Light, Iodo compounds, not counting cloud formation, dimethyl sulfide and other Aerosols. Another theory of climate change is called Human Forcing's spearheaded by IPCC (2007b), it holds that mankind's greatest control on climate is not its greenhouse gas emissions, but its transformation of Earth's surface by clearing forests, irrigating deserts, and building cities. According to Pielke (2009), although, the natural causes of climate variations and changes are obviously important, the human influences are significant and involve a diverse range of first-order climate forcings, including but not limited to, the human input of carbon dioxide (CO2). Short descriptions of some of these "human forcings" other than green-house gases follow. According to Gray (2009), the lead proponent of "Ocean Currents Theory" which contends that global temperature variations over the past century and a half, and particularly the past 30 years, were because of the slow-down of the ocean's Thermohaline Circulation (THC). Ocean water is constantly transferred from the surface mixed layer to the interior ocean through a process called ventilation. The ocean fully ventilates itself every 1000 to 2000 years through a polar region (Atlantic and Antarctic) deep ocean subsidence of cold-saline water and a compensating upwelling of warmer less saline water in the tropics. This deep ocean circulation, called the Meridional Overturning Circulation (MOC), has two segments, the primary Atlantic Thermohaline Circulation (THC) and the secondary Surrounding Antarctica Subsidence (SAS). Paleo-proxy data and meteorological observations show there have been decadal to multi-century scale variations in the strength of the THC over the past thousand years, when the THC circulation is stronger than normal the earth-system experiences a somewhat higher level of evaporation-precipitation (~2 percent). When the THC is weaker than normal, as it is about half the time, global rainfall and surface evaporation are reduced about 2 percent.

2.2 Empirical Review

On the global context, externalities are specified in terms of difference between polluting and victim countries. However, Mendelsohn and Dinar (1999) cited in Nastis, S.A.; Michailidis, A.and Chatzitheodoridis, F. (2012) have study the impacts of climate change on agriculture in India and Brazil.They employed three different methods for the analysis namely; the Ricardian method, Agro-economic model and agro-ecological zone analysis. Environmental factors like farm performance, land value or net income and traditional economic inputs which are land and labour, and support system like infra- structure were used as explanatory variables in the model. Unlike most studies, this analysis pointed out the significance of adaptation. They argue that farmers will adapt to new conditions due to climate change by making production decisions which best suit their own interest. Crop choice is one of the examples of farmers' adaptation to warmer weather in the study. Wheat, corn and rice are three crops for example used since the regions in which they grow depend on the temperature. As temperature gets warmer wheat farmers' switch from production of wheat to corn for enhanced profit making. Later, if temperature gets warmer again enough to lose profits, farmers adapt to warmer weather thus switch to rice from corn. The results of the Ricardian method; agro-economic model, and agro-ecological zone analysis showed that a rise in temperature will decrease crop production especially the crops grown in cool areas such as wheat. However, the authors argued that the result of the Ricardian method suggest that farmers' ability to adjust to new conditions will mitigate the impact of climate change in the long run while the agro-economic model and agro-ecological zone analysis would be more suitable for short run analysis since the adaptations is not included in the models.

Mathauda, Mavi, Bhangoo, and Daliwal (2001) investigated the effects of temperature change on rice yield in the Punjab region in India by employing the Ceres Rice simulation model between 1970-1990. They stratified the weather scenarios by 5 different conditions that are normal weather, slight warm (0.5 increase), and extreme warm condition (2˚C increase) in the simulation model. The model predicted that temperature increase decreases rice yield by 3.2% in slight warm, 8.2% in greater warm, and 8.4% in extreme warm condition compared to normal condition scenario. The result also showed that a rise in temperature negatively affects not only rice production but also other rice attributions such as biomass, crop duration and straw yield.

Torvanger, Twena, and Romstad (2004) studied the climate change in Norway for the period 1958-2001. The study used time series data with biophysical statistical model to examine the dynamic linkages between yields of potatoes, barley, oats, wheat and climate change variables such as temperature and precipitation. The study established that there is a positive impact on yields from temperature in 18% of the crops. The effect is found to be most powerful for potatoes. Regionally, the study revealed that temperature is likely to be a major important limiting factor for crop growth in Northern Norway than other regions. The effect of precipitation is seen to be negative in about 20% of the cases.

Basak, Ali, Islam and Rashid (2010) analysed climate change influence on rice production in Bangladesh by using simulation model. The model specifically focused on Boro rice production that amounts to 58% of the total rice production during 2008 in Bangladesh to estimate to estimate the effects of future cli- mate change, soil and hydrologic characteristics of the locations, typical crop management practices, and traditional controlled in the simulation model called DASAT (Decision Support System for Agro technology Transfer). The simulation results show that rice production changes in different locations for different climatic conditions and hydrological properties of soil although same Boro rice was used in all areas. The model also indicates that rice production decreased drastically from 2.6% to 13.6% and from 0.11% to 28.7% when the highest temperature was increased by 2˚C and 4˚C. Although the simulation model shows that a reduction in minimum temperature also reduces the rice yield. It suggests that increases in temperature causes more damage in production. The model also discovered some positive effects of CO_2 concentration on rice yield but the impact was little compared to that of temperature change.

In Nigeria, Agboola and Ojeleye (2007), studied the impact of climate change in Ibadan Nigeria. The study adopted both primary and secondary sources of data. For the secondary source of data, time series data covering 30 years were obtained on climatic variables and the analysis was done with bivariate Chi-square and ANOVA supported by graphical illustrations. The study showed that farmers have experienced reduced crop yield on food crop production due to reduction in rainfall and relative humidity as well as increase temperature.

Terfa (2012) studied "climate change and food supply in Nigeria" the study adopted the use of generalized error correction model using time series data sourced from CBN statistical bulletin and world bank country data from 1970 to 2009 on variables like food output, temperature and rainfall. The study revealed that both temperature and rainfall had an insignificant influence on food supply and the increase in temperature leads to decrease in food supply while increase in rain- fall leads to increase in food supply.

Eregha, Babatolu, and Akinnubi (2014) did a study titled "Climate Change and Crop Production in Nigeria: An Error Correction Modeling Approach" the work used time series data sourced from Food and Agricultural Organization Database, 2012 Central Bank Statistical Bulletin 2011 and data from World Development Indicator Database 2012. The technique of analysis was done with the Error Correction technique. The data coverage was 1970-2009. The study used variables like crop output, temperature and rainfall as well as carbon emission. The study found that temperature and had a significantly negative influence on crop production, while rain was found to have a significantly positive effect while carbon emission was found to have a significantly negative impact on crop production in Nigeria.

2.3. Gap in Literature

A careful study of literature available shows that most models of climate change estimated only looks at temperature and rainfall. While one of the studies included carbon emission, none of the studies included total greenhouse gas (GHG) emission. This paper acknowledged that atmospheric particulates are not only made up of carbon emission but other particulates like nitrous oxide. Hence the gap in other literature is filled by including total greenhouse gas (GHG) emission as an indicator of climate change. Moreover, most of the studies assumed that only crop production is affected by climate change. This assumption may not be true as other aspects of agricultural production are not immune to the impact of climate change. Livestock, fishery, and forestry are not unaffected by climate change too. Hence, this study therefore estimated four models to show the relative impact of climate change on the different categories of farming activities so far identified.

III. RESEARCH METHOD

This paper is situated on the Ricardian model which treats adaptation to climate change as a 'black box'. The model estimates the relationship between the outcomes of farms and climate.

3.1 Data

Secondary data was used in this paper. The data collected includes data on contribution of agricultural subsectors (namely crop, livestock, forestry, and fishery production) to the RGDP of the Nigerian economy and climate change (proxied by temperature and rainfall). Data was collected from the CBN Statistical Bulletin and the World Bank Climate Change Portal.

3.2 Pre-estimation Tests

3.2.1 Unit Root Test

Testing for the existence of unit roots is a key preoccupation in the study of time series models and co integration. A random process $Y_{(t)}$ is known as a unit root if its first difference, $Y_{(t)} - Y_{(t-1)}$ is stationary. Thus, a random process with a unit root is itself non-stationary. The presence of a unit root implies that the time series under consideration is non-stationary while the absence of a unit root means that the random process is stationary. The most commonly accepted method of testing for unit roots is by use of the Augmented Dickey-Fuller (ADF)test.

To check for whether the linear combinations of the series are stationary, we conducted a unit root test using the Augmented Dickey Fuller test. The ADF test implies running regression equation (3.1):

$$\Delta u_{it} = \pi u_{it-1} + \Sigma^{m}_{i=1} \gamma_i \Delta u_{it-1} + \varepsilon_{it} \qquad 3.1$$

Where t is the time or trend variable, ε_{it} is a pure white noise error term and $\Delta u_{it-1} = \Delta u_{it-1} - \Delta u_{it-2;}$ and the number of lagged difference terms to include is often determined empirically to the extent that ε_{it} are serially uncorrelated. The null hypothesis is that $\delta = 0$; that is, there is a unit root- the time series is non-stationary while the alternative hypothesis is that δ is less than zero; that is, the time series is stationary. If the null hypothesis is rejected, that is δ is statistically significant, it means that u_{it} is a stationary time with zero mean.

3.2.2 Cointegration Test

Pesaran and Shin (1998) suggest obtaining the long-run parameters from an ARDL model:

- OLS estimators of the short-run parameters are √T-consistent and asymptotically normal.
- The corresponding estimators of the long-run parameters are super-consistent provided the regressors are I (1), and asymptotically normally distributed irrespective of the order of integration.

Pesaran, Shin, and Smith (2001) tabulate asymptotic critical values that span a band from all regressors being purely I (0) to all regressors being purely I (1).Narayan (2005) computes corresponding small-sample critical values for various sample sizes.

3.3 Estimation Technique

$ARDL(p, q, ..., q)$ model:

$$y_t = c_0 + c_1 t + \sum_{i=1}^{p} \phi_i y_{t-1} + \sum_{i=1}^{q} \beta'_i x_{t-1} + u_t \qquad 3.2$$

t = max (p, q), T, for simplicity assuming that the lagorder q is the same for all variables in the K × 1 vector x_t.

- The variables in $(y_t, x'_t)'$ are allowed to be purely I (0), purely I (1), or cointegrated.
- The optimal lag orders p and q (possibly different across regressors) can be obtained my minimizing a model selection criterion, e.g. the Akaike information criterion (AIC) or the Bayesian information criterion (BIC).

The econometric form of the models estimated are thus:

$$\Delta[Log(CROP)] = \alpha + \beta T + \gamma_1 Log(CROP_{t-1}) + \gamma_2 Log(TEMPR_{t-1}) + \gamma_3 Log(RAINF_{t-1}) + \gamma_2 Log(TGEMI_{t-1}) + \sum_{i=1}^{K} \lambda_i \Delta Log(CROP_{t-i}) + \sum_{j=0}^{L} \lambda_j \Delta Log(TEMPR_{t-j}) + \sum_{l=0}^{M} \lambda_l \Delta Log(RAINF_{t-l}) + \sum_{r=0}^{N} \lambda_l \Delta Log(TGEMI_{t-r}) + \varepsilon_t \qquad 3.3$$

$$\Delta[Log(LIVESTK)] = \alpha + \beta T + \gamma_1 Log(LIVESTK_{t-1}) + \gamma_2 Log(TEMPR_{t-1}) + \gamma_3 Log(RAINF_{t-1}) + \gamma_2 Log(TGEMI_{t-1}) + \sum_{i=1}^{K} \lambda_i \Delta Log(LIVESTK_{t-i}) + \sum_{j=0}^{L} \lambda_j \Delta Log(TEMPR_{t-j}) + \sum_{l=0}^{M} \lambda_l \Delta Log(RAINF_{t-l}) + \sum_{r=0}^{N} \lambda_l \Delta Log(TGEMI_{t-r}) + \varepsilon_t \qquad 3.4$$

$$\Delta[Log(FORESTRY)] = \alpha + \beta T + \gamma_1 Log(FORESTRY_{t-1}) + \gamma_2 Log(TEMPR_{t-1}) + \gamma_3 Log(RAINF_{t-1}) + \gamma_2 Log(TGEMI_{t-1}) + \sum_{i=1}^{K} \lambda_i \Delta Log(FORESTRY_{t-i}) + \sum_{j=0}^{L} \lambda_j \Delta Log(TEMPR_{t-j}) + \sum_{l=0}^{M} \lambda_l \Delta Log(RAINF_{t-l}) + \sum_{r=0}^{N} \lambda_l \Delta Log(TGEMI_{t-r}) + \varepsilon_t \quad 3.5$$

$$\Delta[Log(FISHING)] = \alpha + \beta T + \gamma_1 Log(FISHING_{t-1}) + \gamma_2 Log(TEMPR_{t-1}) + \gamma_3 Log(RAINF_{t-1}) + \gamma_2 Log(TGEMI_{t-1}) + \sum_{i=1}^{K} \lambda_i \Delta Log(FISHING_{t-i}) + \sum_{j=0}^{L} \lambda_j \Delta Log(TEMPR_{t-j}) + \sum_{l=0}^{M} \lambda_l \Delta Log(RAINF_{t-l}) + \sum_{r=0}^{N} \lambda_l \Delta Log(TGEMI_{t-r}) + \varepsilon_t \quad 3.6$$

Where CROP = Monetary Value of the Contribution of Crop to Agricultural Sector Output
LIVESTK = Monetary Value of the Contribution of Livestock to Agricultural Sector Output
FORESTY = Monetary Value of the Contribution of Forestry to Agricultural Sector Output
FISHING = Monetary Value of the Contribution of Fishery to Agricultural Sector Output
TEMPR = Average Annual Temperature
RAINFALL = Average Annual Rainfall
TGEMI = Total Greenhouse Emission

ε_t = Disturbance Term

γ_i 's = are coefficients for long run

λ_i 's = are coefficients for short run

3.4 Post-estimation Tests

Since the ARDL is a linear regression model, itis therefore required that the underlying assumptions of Classical Linear Regression Models (CLRM) be verified. These assumptions are highlighted as linearity, homoscedasticity, and serial correlation among others. The post-estimation tests for ARDL models include:

i. Linearity Test (using Ramsey Reset Test);
ii. Homoscedasticity Test (using Breusch-Pagan-Godfrey Test); and
iii. Serial Correlation test (using the LM test).

IV. RESULTS AND DISCUSSION

4.1 Pre-estimation Tests

4.1.1Stationarity Test

The result presented in table 4.1 shows that only two of the time series (i.e. temperature and rainfall) were stationary at levels. Moreover, the remaining time series became stationary after first difference. Since, it is obvious that the time series in the specified models is a mix of different order of integration i.e. I(0) and I(1).Based on the mixed order of integration, the study proceeded to conduct the ARDL Bound co integration (Pesaran, Shin &Smith, 2001).

Table 4.1: ADF Stationarity Test Results

Time Series	**ADF Test Statistics**	**5% Test Critical Values**	**Order of Integration**
Log(Tempr)	5.43*	3.54	I(0)
Log(Rainf)	4.56*	3.54	I(0)
Log(Crop)	5.79*	3.54	I(1)
Log(Livestk)	4.07*	3.54	I(1)
Log(Forestry)	6.56*	3.54	I(1)
Log(Fishing)	8.75*	3.55	I(1)
Log(Tgemi)	7.11*	3.54	I(1)

Source: Author's Computation

NB: The statistics presented in the table are in absolute terms

4.1.2 Cointegration Tests

The bound cointegration test result presented in table 4.2 confirms the existence of a long run relationship (since F-stat.> upper bound I(1) statistics at 5% critical value bounds) among the time series in the crop and fishery production models. Moreover, the result shows that of a long run relationship does not (since F-stat.<lower bound I(1) statistics at 5% critical value bounds) among the time series in the livestock and forestry production models.

Table 4.2: Bounds Cointegration Test Results

	Models			
	Crop	Livestock	Forestry	Fishery
Computed F-statistic	26.63	0.88	1.02	19.37
5% Lower Critical Bound [*I(0)*]	4.01	4.01	4.01	4.01
5% Upper Critical Bound [*I(1)*]	5.07	5.07	5.07	5.07
Decision	Long run	No Long run	No Long run	Long run

Source: Author's Computation using Eviews 9

4.2 Model Estimation

Table 4.3: ARDLShort Run Models

Panel A: Short Run Dynamics				
Variable	**Crop** **Coeff. (p-value)**	**Livestock** **Coeff. (p-value)**	**Forestry** **Coeff. (p-value)**	**Fishery** **Coeff. (p-value)**
DLOG (TEMPR)	-1.168(0.266)	1.024**(0.029)	2.639***(0.004)	-1.203(0.585)
DLOG (TEMPR (-1))	-0.301(0.772)	-	-	-2.652(0.186)
DLOG (TEMPR (-2))	-2.178**(0.047)	-	-	-4.782**(0.021)
DLOG (TEMPR (-3))	-2.802***(0.006)	-	-	-
DLOG (RAINF)	-0.004(0.978)	-0.065(0.185)	-0.101(0.325)	-0.205(0.379)
DLOG (RAINF (-1))	0.298***(0.010)	0.075(0.118)	-	0.287(0.150)
DLOG (RAINF (-2))	0.192*(0.080)	-0.112**(0.037)	-	0.489**(0.024)
DLOG (RAINF (-3))	-	-	-	-
DLOG (TGEMI)	0.168(0.057)	-0.005(0.882)	-0.122(0.069)	-0.129(0.428)
DLOG (TGEMI (-1))	0.214**(0.025)	-	-	0.100(0.545)
DLOG (TGEMI (-2))	-0.093(0.313)	-	-	-0.108(0.538)
DLOG (TGEMI (-3))	-0.626***(0.000)	-	-	-0.342**(0.050)
CointEq(-1)	-0.445*** (0.00)	-	-	-1.454***(0.000)
Panel B: Long Run				
Variable	**Crop** **Coeff. (p-value)**	**Livestock** **Coeff. (p-value)**	**Forestry** **Coeff. (p-value)**	**Fishery** **Coeff. (p-value)**
LOG(TEMPR)	8.856**(0.045)	-	-	6.160***(0.009)
LOG(RAINF)	-1.579**(0.017)	-	-	-0.728**(0.012)
LOG(TGEMI)	1.308***(0.002)	-	-	0.101(0.303)
C	-29.744**(0.041)	-	-	-14.386(0.055)

Source: Author's Computation using Eviews 9

NB: ** and *** signifies statistical significance at 5%, and 1% respectively; and statistics in (…) are the probability statistics.

Table 4.3 above shows the estimated ARDL models. The short and long run models are presented in Panels A and B respectively. Only significant results are discussed here. In the short run, average temperate for a current year had positive impact on output from livestock and forestry subsectors. And the magnitude of the impact of average temperate for a current year was larger on output from forestry. Two-year period lag of average temperate impacted negatively on crop and fishery output. And the magnitude of the impact of two-year period lag of average temperate was larger on fishery output. Three-year period lag of average temperate has a negative impact on crop output alone. Secondly, in the short run, one-year lag of average rainfall had a positive and significant impact on crop output. While two-year lag of average rainfall had negative effect on livestock output on the one hand, it impacted positively on fishery output on the other hand. Thirdly, one-year lag of total greenhouse gas emission had a positive on crop output. Three-year period lag of total greenhouse gas emission had a negative impact on crop and fishery output. Lastly, the coefficient of the error correction terms in the crop and fishery output models appeared with the expected negative sign and are also statistically significant. This implies that, though at different speed, the short run disequilibrium in the system can be reconciled.

The long run models is presented in panel B of table 4.3. Based on the cointegration test, only crop and fishery output models had long run form. Firstly, temperature is expected to have a positive and impact on crop and fishery output. Secondly, annual average rainfall is expected to have a negative impact crop and fishery output. Lastly, total greenhouse gas emission is expected to have a positive impact on crop output in the long run.

4.3 Post Estimation Tests

Table 4.4: Post Estimation Diagnostic Test Results

	Models			
Post-estimation Tests	**Crop** Stat. (p-value)	**Livestock** Stat. (p-value)	**Forestry** Stat. (p-value)	**Fishery** Stat. (p-value)
Ramsey Reset Test	0.748 (0.466)	0.679(0.503)	0.482(0.633)	1.578(0.072)
Breusch-Pagan-Godfrey Test	0.942 (0.550)	2.423(0.061)	2.727(0.057)	0.491(0.924)
Breusch-Godfrey LM test	2.118 (0.157)	0.712 (0.500)	0.207(0.814)	0.864(0.444)

Source: Author's Computation Using Eviews

NB: Statistics in […] are the probability statistics.

The post estimation diagnostic test results for all the estimated models are presented in table 4.4 above.First,the null cannot be rejected since the p-values of the f-test statistics for the Ramsey Rest Test for all the models is greater than 0.05. We therefore conclude that all the models were well specified. Secondly,the null cannot be rejected since the p-values of the f-test statistics for the Breusch-Pagan-Godfrey testfor all the models is greater than 0.05. We therefore conclude that the specified model did not suffer from heteroscedasticity problem. The model satisfied the homoscedasticity assumption. Lastly, since the p-values of the test statistics for the LMtestfor all the models is greater than 0.05, the decision is to fail to reject the null hypothesis. We therefore conclude that the specified model did not suffer from serial autocorrelation problem. The model passed the serial correlation test.The estimated ARDL models passed all the tests and are fit for policy recommendation.

V. CONCLUSION AND RECOMMENDATIONS

From the findings of this study, we can conclude that different indicators of climate change impacted selected agriculture sub-sectors differently in Nigeria. Crop and fishery output were adversely affected by increase in temperature as a climate change indicator; but livestock and forestry output was not affected negatively by increased temperature. Increased rainfall favoured crop and fishery production. Greenhouse gas emitted reduced both crop and fishery output after a long time. The study recommends that, for the agricultural sector to contribute significantly to the growth of the Nigerian economy, a holistic climate change policy with special focus on greenhouse gas emission should be implemented. Government active participation in the crusade to save the environment by policies formulation and affirmative action by supporting agencies like Nigeria Meteorological Agencies, NEMA, and National Orientation agency in their drive for safer environment is highly recommended.

REFERENCES

[1]. Aaron, S. (2011).Climate change adaptation and conflict in Nigeria. *Special Report United States Institute of Peace.* Available at: www.usip.org.

[2]. Adejuwon, S.A. (2004). *Impact of climate variability and climate change on crop yield in Nigeria*. Contributed Paper to Stakeholders Workshop on Assessment of Impact and Adaptation to Climate Change (AIACC): 2-8.

[3]. Agboola, T., & Ojeleye, D. (2007) Climate Change and Food Production in Ibadan. *Nigeria Afi. Crop Sciconfer Prod*, 8, 1423-1433.

[4]. Alvaro, C., Tingju, Z., Katrin, R., Richard, S.J.,& Claudia, R. (2009). Economy-wide Impact of Climate Change on Agriculture in Sub-Saharan Africa International Food Policy Research Institute (IFPRI). *Discussion Paper* 00873:1.

[5]. Ayinde, O.E., Muchie, M.,&Olatunji,G.B. (2011). Effect of Climate Change on Agricultural Productivity in Nigeria: A Co-integration Model Approach, *Journal of Human Ecology*, 35(3), 189-194

[6]. Basak, J.K., Ali, A., Islam, N., &Rashid, A. (2010). Assessment of the Effects of Climate Change on Boro Rice Production in Bangladesh Using DSSAT Model. *Journal of Civil Engineering*, 38, 95-108.

[7]. Bosello, F., &Zang, J. (2005). *Assessing Climate Change Impacts: Agriculture*. FEEM Nota di Lavoro 94.2005, Fondazione Eni Enrico Mattei.

[8]. Carey, C. (2009). The Impacts of Climate Change on the Annual Cycles of Birds. *Philosophical Transactions of the Royal Society B*, 364,3321-3330.

[9]. Chukwuezie, O.C., Nwakuba, N.R., Nwaigwe, K.N., & Asoegwu, S.N. (2016). The Impact ofClimate Change on Nigerian Agricultural Sector and Economy. *Paper presentation at the 37th Annual Conference and Annual General Meeting–"Minna 2016"*

[10]. De Wit, M.,&Stankeiwicz, J.(2006). Changes in surface water supply across Africa with predicted, climate change. *Science*, 311, 1917-1931.

[11]. Eitzinger, J., Stastna, M., Zalud, Z., Dubrovski, M. (2003). A simulation study of the effect of soil water balance and water stress on winter wheat production under different climate change scenarios. *Agric. Water Man.*, 61, 195–217.

[12]. Eregha, P.B., Babatolu, J.S.,& Akinnubi, R.T. (2014) Climate Change and Crop Production in Nigeria: An Error Correction Modelling Approach. *International Journal of Energy Economics and Policy*, 4, 297-311.
[13]. Fasona, M.J., &Omojola, S.A.(2005). *Climate Change Human Security and Communal Clashes in Nigeria*. An International Workshop Holmen Fjord Hotel, Asker, near Oslo, 21–23 June 2005.
[14]. Federal Ministry of Environment (2004). Abuja. From <www. nigeria.com.ngcichng.org./ccinfo.php> (Retrieved on May 20, 2004).
[15]. Finger, R., &Schmid, S. (2007). The impact of climate change on mean and variability of Swiss corn production. *Info Agrar Wirtchaft, Schriftenreihe* 2007/1. Available Online:(http://www.cer.ethz.ch/). Accessed on 25th May 2020.
[16]. Gray, W.M. (2009).*Climate Change: Driven by the Ocean, Not Human Activity*. 2nd Annual Heartland Institute Conference on Climate Change, New York, 8-10 March 2009.
[17]. Intergovernmental Panel on Climate Change (2007b).*Climate Change: Synthesis Report*. Cambridge: Cambridge University Press.
[18]. Intergovernmental Panel on Climate Change (2013). *Climate Change; The Physical Science Basis,Summary for policy makers, Observed Changes in the Climate System P 15, IN IPCC AR5, WG1*. IPCC. https://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WGIAR5_SPM_brochure_en.pdf
[19]. Kandlinkar, M., &Risbey, J.(2000). Agricultural Impacts of Climate Change; if adaptation is the answer, what is the question? *Climate Change*, 45, 529-539.
[20]. King, D.(2004). Climate change science: Adapt, mitigate or ignore? *Science*, 303, 176-177.
[21]. Manning, M., &Nobrew, C.(2001). Technical Summary Impact, Adaption and Vulnerability: A Report of Working Group II of the Intergovernmental Panel on Climate Change. In: J McCarthy, O.F. Canziani, N.A. Leavy, J.D., Dekken, C. White (Eds.): *Climate Change 2001: Impact, Adaption and Vulnerability*. Cambridge: Cambridge University Press, 44-65.
[22]. Manyong, V.M., Ikpi, A., Olayemi, J.K., Yusuf S.A., Omonoma, B.T., Okoruwa, V.,&Idachaba, F.S.(2005). *Agriculture in Nigeria: Identifying Opportunities for Increased Commercialization and Investment in USAID/IITA/UI Project Report Ibadan*, Nigeria.
[23]. Mathauda, S.S., Mavi, H.S., Bhangoo, B.S., & Dhaliwal, B.K. (2001) Impacts of Projected Climate Change on Rice Production in Punjab (India). *Tropical Ecology*, 41, 95-98.
[24]. Medellín-Azuara, J., Harou, J.J., &Howitt, R.E. (2010). Estimating economic value of agricultural water under changing conditions and the effects of spatial aggregation. *Sci. Tot. Environ*. 408(23), 5639–5648.
[25]. Mendelsohn, R., Dinar, A. (eds) (2009). *Climate Change and Agriculture-An Economic Analysis of Global Impacts, Adaptation and Distributional Effect*: *New Horizons in Environmental Economics*. Cheltenham: Edward Elgar.
[26]. Mohammed-Lawal, A., &Atte, O.A.(2006). An Analysis of Agricultural Production in Nigeria. *African Journal of General Agriculture*, 2(1), 1-6.
[27]. Narayan, P. K (2005). The saving and investment nexus for China: evidence from cointegration tests. *Applied Economics*, 37(17), 1979–1990.
[28]. Nastis, S.A., Michailidis, A., &Chatzitheodoridis, F. (2012)Climate Change and Agricultural Productivity. *African Journal of Agricultural Research*, 7(35), 4885-4893,DOI: 10.5897/AJAR11.2395
[29]. Ngene, U. (2012) Climate change: Any impact on Nigeria? Vanguard News On line Newspaper,*Vanguard Media Limited, Nigeria News* Thursday 12 May. Available at:http://www.vanguardngr.com/2012/10/climate-change-any-impact-on-nigeria/
[30]. Niggol, S., &Mendelsohn, R.(2008). Animal Husbandry in Africa: Climate impacts and adaptations. *AfJARE*, 2(1), 66.
[31]. Nin, A., Ehui, S., &Benin, S.(2007). Livestock productivity in developing countries: An assessment. In: R. Evenson, Pingali P (Eds.): *Handbook of Agricultural Economics* (3). North Holland: Oxford Press, 2467-2532.
[32]. Obioha, E.(2008). Climate change, population drift and violent conflict over land resources in north eastern Nigeria. *Journal of Human Ecology*, 23(4), 311-324.
[33]. Ogen, O. (2007). The agricultural sector and Nigeria's development: Comparative perspectives from the Brazilian agro-industry economy, 1960-1995. *Nebula*, 4(10), 184-194.
[34]. Pesaran, M. H., Shin, Y.,&Smith, R. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics,* 16(3), 289–326.
[35]. Pielke, S.R. (2009). Climate Change: The Need to Consider Human Forcings besides Greenhouse Gases. *Earth Observation Satellite (EOS),* 90, 413.
[36]. Simon, D., Alex, B., Charlie, D., & Philip, G.(2016). Climate value at risk' of global financial assets. *Journal of Nature Climate Change*,6(4), 34-42. Available at:www.nature.com/natureclimatechange.
[37]. Stewart, R. (2000). *Welcome Address*. Proceedings of the 7 World Sugar Conference, Durbar.
[38]. Terfa, A. (2012). Climate Change and Food Supply in Nigeria. *Nigerian Journal of Economics and Social Studies*, 54, 209.
[39]. Torriani, D., Calanca, P., Schmid, S., Beniston, M. Fuhrer, J. (2007). Potential effects of changes in mean climate and climate variability on the yield of winter and spring crops in Switzerland. *Clim. Res*., 34, 59-69.
[40]. Torvanger, A., Twena, M., & Romstad, B. (2004).*Climate Change Impacts on Agricultural Productivity in Norway*. Centre for International Climate and Environment Research Working Paper 10.Centre for International Climate and Environment Research, Oslo.
[41]. United Nations Framework Convention on Climate Change (2007) *Climate Change Impacts, Vulnerabilities and Adaptation in Developing Countries.*Bonn: Climate Change Secretariat.
[42]. World Bank Group (WBG) (2013). Making Nigeria's development more climate-resilient and lesscarbon-intensive. Available at: http://www.worldbank.org/

Time Series Data on Crop Production, Livestock Production, Forestry Production, Fishing Production, Temperature, Rainfall and Total Greenhouse Emission.

Year	Crop Production (N Billion)	Livestock Production (N Billion)	Forestry Production (N Billion)	Fishing Production (N Billion)	Temperature (Celsius)	Rainfall (mm)	Total Greenhouse Emission (kt)
1981	1854.76	341.41	77.90	90.30	26.74	92.70	134625.32
1982	1897.08	361.12	73.91	93.86	26.83	85.55	133455.95
1983	1842.70	393.13	75.28	97.96	27.03	72.97	133295.33
1984	1759.12	399.69	76.69	68.01	27.16	88.54	135013.46
1985	2180.91	428.10	78.08	43.97	26.96	89.78	137868.60
1986	2427.10	421.63	86.59	51.51	26.98	88.99	137043.98
1987	2330.00	433.43	87.59	40.65	27.57	82.56	132908.94
1988	2581.60	444.27	88.91	59.79	27.04	96.57	144640.98
1989	2710.67	453.16	67.31	94.81	26.46	92.31	155364.44
1990	2828.59	462.22	72.61	101.29	27.34	89.44	163274.18
1991	2955.88	454.82	74.79	105.35	26.92	99.95	171312.81
1992	3044.55	458.92	76.51	94.81	26.51	92.04	188562.29
1993	3132.84	461.67	78.04	71.11	26.95	90.77	187613.21
1994	3226.83	466.29	80.07	66.49	26.66	100.37	174508.40
1995	3336.54	485.87	81.83	73.14	26.99	97.28	184046.20
1996	3463.00	499.96	82.24	88.35	27.01	103.98	203140.48
1997	3611.91	512.46	82.98	98.33	26.96	99.69	196351.83
1998	3752.77	526.30	83.98	112.20	27.63	95.95	332361.06
1999	3949.42	541.03	85.07	128.12	27.20	102.42	353503.93
2000	4067.90	553.48	86.35	133.25	26.82	95.89	314978.54
2001	4222.48	570.08	88.07	143.91	26.99	89.02	319145.79
2002	6977.88	597.50	88.69	153.02	27.20	92.83	295068.36
2003	7493.02	622.56	90.02	159.23	27.36	111.78	314942.19
2004	7956.66	663.03	95.87	173.02	27.34	94.56	288145.57
2005	8524.15	707.87	101.55	183.43	27.46	87.14	374421.70
2006	9162.65	756.73	107.66	195.43	27.42	94.73	318579.09
2007	9826.77	809.16	114.25	208.29	27.49	102.32	335201.39
2008	10437.99	864.19	121.22	221.97	27.06	105.38	316058.63
2009	11046.16	920.20	128.31	235.66	27.82	92.99	273156.36
2010	11683.90	979.56	135.72	249.71	27.83	101.83	292211.74
2011	12017.19	999.40	142.46	270.32	27.42	76.65	296799.95
2012	12919.54	972.76	146.09	291.31	27.27	98.24	301010.13
2013	13247.80	1030.94	154.31	317.47	27.38	76.60	296673.94
2014	13793.45	1086.85	161.34	338.75	27.53	90.70	298161.34
2015	14274.94	1151.32	167.26	358.70	27.36	80.39	293002.24
2016	14894.45	1185.12	171.64	356.13	27.68	82.56	300252.86
2017	15437.05	1204.21	177.33	360.91	27.49	82.56	297022.59
2018	15786.44	1208.13	182.75	366.83	27.51	84.05	297109.76

Source: Central Bank of Nigeria and World Bank.