Impact of climate Change on Agriculture and Food Security in Nigeria

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Abstract

This research work examined the impact of Climate change on agriculture and Food Security in Nigeria from 1998 to 2018. The study adopted secondary data and the Ordinary Least Square (OLS) technique, involving a multiple regression model to analyze the causal relationship and coefficient of determination of climate change on food production and food security, as well as considering Agricultural Technology Innovation as alternative solution to the problems of climatic changes in Agriculture. The study employed annual time series data sourced from C.B.N. Statistical Bulletin. Agricultural Output was used as a proxy for Food security (dependent variable). Annual Rainfall and carbon dioxide were used as proxies for Climate change while Value Added in Agriculture and Government Expenditure on Agriculture were used as proxies for Agricultural Technology Innovation. The regression result revealed that there is a negative relationship between the dependent variable Agricultural Output (AO) and the independent variables Average Rainfall (ARF) and Carbon dioxide (Co2), as revealed by the values of their coefficients (-0.341801 and -20.56647). This result indicated that Climate change is not healthy for Food Security in Nigeria. The OLS result also revealed that there is a negative relationship between Agricultural Output and Value Added in Agriculture while there is a positive relationship between Agricultural Output and Government Expenditure as shown by the values of their coefficients (-0.102 and 4.58). The study recommended that the government should take proactive steps in addressing environmental problems which includes effective management of waste, flood and erosion.

Keywords: Climate Change, Food Security, Waste Management, Agricultural Production.

1. Introduction

Climate change is a long-term change in the statistical distribution of weather patterns over periods of time ranging from decades to millions of years. The United Nations Framework Convention on Climate Change (UNFCCC) defined Climate change "as a change of climate which is attributed directly or indirectly to human activity, that alters the composition of the global atmosphere and in addition to natural climate variability, observed over some comparable period of time"(Ibrahim, 2014). The Intergovernmental Panel on Climate Change (IPCC 2007), defined Climate change as "any change in climate over time, whether due to natural variability or as a result of human activity. Nigeria covers an area of 923,768sqkm, physically and climatically diverse and endowed with substantial natural resources (World Atlas, 2017). It has about nine ecological zones which includes; Sahel savannah, Guinea savannah, Sudan savannah, derived savannah, lowlands, mountain savannah, fresh water swamp, mangrove vegetation and coastal vegetation. These ecological systems are currently being affected by climatic changes such as flooding, erosion, drought, soil degradation, deforestation and desertification. As a result of these challenges, the general agricultural potentials of the Nation have been jeopardized and food security undermined.

Some suggested strategies to mitigate the impact of climate change on the environment and food security in particular include; reducing the emission of greenhouse gases by stopping deforestation, use of high yield and disease-tolerant crops and crop cultivation when expecting rain (Osuafor and Nnorom, 2014). These efforts proved unproductive, while Nigeria's food insecurity lingered.

Agriculture has remained the basis of food supply in Nigeria; it contributes 30% to 40% of National Gross Domestic Product (GDP), with majority of the people engaged in subsistence food production (Ikponmwosa, 2016). The quality of food consumed by people determines their quality of health and life thus, faced with the challenge of a rising population of more than 160million people, Nigeria needs to be self-reliant and self-sufficient in food production. This can be achieved by cutting down huge amount of money spent on food importation and channeling such funds to technological innovations that will mitigate adverse effects of climate change as well as other agricultural interventions that will enhance quality food production in commercial quantity. This will in turn re-enforce the link between agricultural productivity and the four dimensions of food security which are food availability, accessibility, stability and food utilization. World hunger rate is rising after many years of decline. According to a United Nations (UN) report, 815 million people did not have food to eat in 2016. UN agencies blamed climate-related shocks and violent conflicts for worsening food security in Asia and Sub-Saharan African Countries which includes Nigeria and Somalia. More than 60% of the world's under-nourished people live in Asia, while 25% live in Africa. The population of those who are hungry however, is higher in Africa, accounting for about 35% of the total population (Premium News, 2018).

The World Food Summit of 1996, defined food security as existing "when all people at all times have access to sufficient, safe and nutritious food to maintain a healthy and active life." In spite of the overwhelming issues prevalent in the world today, food security has remained a major discussion since the mid 70s, after the first world food summit in Rome. At the onset of the millennium, world leaders gathered under the backing of the United Nations (UN) to seek and provide guidelines for tackling economic challenges by 2015. The final outcomes of the series of discussion are summarized in the Millennium Development Goals (MDGs) (Chimaobi and Chizoba, 2015). The first goal is "to eradicate extreme poverty and hunger." This indicates the heightened need for food security and justifies the fact that food is the most important component of life.

In Nigeria, the Ministry of Agriculture 2018 has estimated that 65% of the total population is food insecure, despite the fact that more than half of the population depend on agriculture. The reason is that 90% of the produce comes from subsistence farming, constrained by climate changes; drought and flood, unfavorable temperature, poor infrastructure, pest and disease manifestation, the use of crude implements and limited access to funds and credit thus, Nigeria has more than 13 million people suffering from hunger and malnutrition.

In the face of a growing population, concerns have risen about the current and future availability and affordability of quality and sufficient food in Nigeria, due to low level of investment in research and development and technological innovations that can improve food productivity in the agricultural sector. Some of the areas in which technological advancement in agriculture is crucial include irrigation, processing and storage for the prevention of food loss and wastages (Mojisola, 2017). However, as a Nation dependent on subsistence agriculture, little is has been achieved in technology adoption and application, as well as mitigating the adverse impacts of climate change on food production. Therefore, Nigeria's Agricultural sector and food security has become highly vulnerable to climate change.

2. Statement of the Problem

The global climatic change has affected agricultural activities in most countries of the world thus, output has drastically declined and food shortage on the increase. During the last two decades, 200 million people have been lifted out of hunger and the prevalence of chronic malnutrition in children has decreased from 40% to 26%. In spite of this progress, according to the World Bank, 702 million people still live in extreme poverty and according to its report on the State of Food Insecurity in the World (SOFI), 793 million people are undernourished (Skullerud, 2018). Climate change which includes increase in the concentration of atmospheric gases such as carbon (IV) oxide, chlorofluorocarbon amongst others, increases the frequency and intensity of some disasters such as droughts, floods, storms, pests and disease which have the potentials to destroy crops, infrastructure and livelihoods. Scientists have discovered that the earth's rising temperatures are fueling longer and hotter heat waves, more frequent droughts, heavier rainfalls and more powerful windstorms (Macmillan, 2016). In Nigeria, the amount of rainfall and high temperatures are important elements of climate change. As a result of that, the Northeast region is increasingly becoming an arid environment accompanied by fast reduction in the amount of surface water. (Ayinde *et al.*, 2011). Climatic fluctuation exacerbates pests and disease infection, thereby subjecting Nigeria's agricultural system to serious stress, threats, shortage of food supplies and even increase in the prices of food thus, affecting the four dimensions of food which includes; Food availability, Food stability, Food accessibility and Food utilization. This limits a large part of the population from physical, social and economic access to sufficient, safe and nutritious food. Today, despite its vast agricultural potentials, Nigeria is still a major importer of food with majority of the people engaged in subsistence food production. According to a recent United Nations report, Nigeria's population will surpass that of the United States of America by 2050 and being the seventh most populous country, its population is estimated to reach 398 million people in the next 33 years thereby raising concern about the current and future availability and affordability of food.

Over the years, the Nigerian agricultural sector has been neglected with clear indications of low investment in technological innovations and other interventions that will enhance food production. This negligence has created some barriers for adapting to, or for mitigating the effects of climate change Such as; limited knowledge and skills on information/communication on the risk of climate change through campaigns, billboards and sensitization, as well as inappropriate public policy provisions and technological innovations for promoting adaptations of farmers to climate change (Idowu *et al.*, 2011). Thus, the Country became heavily dependent on food importation. The rural areas have become vulnerable to erratic food supplies, malnutrition, unaffordable food cost, low quality food and sometimes complete absence of food. This situation is more prevalent in the northern part of Nigeria. Agriculture in Nigeria has remained the largest non-oil contributor to the national economy, accounting for about 41.84% of the GDP in 2009 and employing almost 70% of the National work force. The farmers are mostly small-scale subsistence farmers totaling about 14 million. (Saheed and Isa, 2017). Despite the fact that the sector has been neglected by the federal government sequel to the discovery of commercial quantity of petroleum resources, the centrality of agriculture to the Nigerian economy cannot be over emphasized. The major concern of this study is to evaluate the impact of climate change on food security in Nigeria and proffer solutions.

3 Research Questions

The following research questions emanate from the problem of study to guide the objectives.

a. Is there any significant causal relationship between climate change and food security in Nigeria?

b. What are the impacts of climate change on food security in Nigeria?

c. Does technology innovation mitigate the impact of climate change on food production and food security in Nigeria?

4 Objectives of the Research

The main objective of this study is to assess the impact of climate change on food security in Nigeria.

Other objectives include;

i. To investigate the impact of technology innovation on climate change and food security in Nigeria.

ii. To find out if any significant relationship exists between agricultural technology innovation and food security in Nigeria.

iii. To contribute to knowledge in the subject matter of climate change and food security.

5 Significance of the Study

Everything we eat, wear, drink or use comes from the environment. Climate change is undermining the environment and current efforts to address food security in many countries. The impact of climate change on food security is endemic among sub-Saharan African Countries including Nigeria, where most of the population depends on climate sensitive agro-economic activities. Unfortunately, adequate research is not carried out to tackle the problem. This study is focused on providing substantial knowledge on the effects of climate change on food production in Nigeria. Projections at different times, indicate that amount of rainfall is decreasing in the northern zone of Nigeria resulting to drought, while heavy amount of rainfall is experienced in the southern and western zones, resulting to flood thereby altering food production. These phenomena decrease food availability, accessibility and utilization which in turn, cause increase in food prices with resultant increase in hunger rate and poverty in Nigeria. However, the need to conduct this study is paramount due to the fact that Nigeria's agricultural sector is backsliding as a result of this menace thus, solutions such as agricultural technological innovation, is seen as a way forward as well as a solution that should be proffered to cushion the adverse effects of climate change on food production. This will go a long way in enhancing the quality, availability, accessibility and utilization of food.

This study is necessary due to the rising prices of food in the Nigerian economy, believed to be caused by low farm yields resulting from climatic changes such as drought, flood, pest and disease manifestation which have not been controlled effectively. Food imports and smuggling activities have increased, with Nigeria experiencing the highest inflation rate of 17.5 percent in 18 months. Through this study, it is expected that Nigeria will invest more in modern agricultural technological innovations and research and development especially in climate change. There is urgent need for policy measures that would check and address the adverse effects of climate change on food security. This will enhance agricultural productivity and improve food quality in the long-run, thereby reducing hunger, malnutrition and poverty. This study also provides relevant conceptual and empirical basis for further researches on the subject matter.

6 Hypotheses Of the Study

1. Ho: Climate change has no significant impact on agriculture and food security in Nigeria.

   Hi: Climate change has a significant impact on agriculture and food security in Nigeria.

2. Ho: Agricultural Technology Innovation does not significantly reduce the effects of climate change on food security.

   Hi: Agricultural Technology Innovation Significantly reduces the effects of climate change on food security.

.7. Literature Review

The Intergovernmental Panel on Climate Change (IPCC 2001) defined climate as the average weather or more rigorously as the statistical description in terms of the mean and variability of relevant quantities over a period ranging from months to thousands or millions of years. These quantities are most often surface variables such as temperature, precipitation and wind. The National Air Space Agency (NASA) defined climate change as a broad range of global phenomena created predominantly by burning fossil fuel, which add heat trapping gases to the earth's atmosphere. These phenomena include the increased temperature trends described by global warming, but also encompass changes such as sea level rise; ice mass, loss in Greenland, arctic and mountain glaciers worldwide, shifts in plant blooming and extreme weather events (Lewis 2017).

Based on a research by Holly *et al.,* (2018), humans are increasingly influencing the climate and the earth's temperature by burning fossil fuel and cutting down rain forest. Such activities add enormous amount of greenhouse gases to those naturally occurring in the atmosphere, increasing the greenhouse effect and global warming. Thus, greenhouse effect as discovered through scientific research is the main cause of global warming. Such effect is referred to as warming that result when the atmosphere traps heat radiating from earth towards space. Certain gases in the atmosphere block heat from escaping and those gases that contribute to greenhouse effect include;

1. **Water Vapour:** this is the most abundant greenhouse gas which increases as the earth's atmosphere warm thereby, enhancing greenhouse effects.

2. **Carbon dioxide (Co2):** this is a minor but very important component of the atmosphere which is released through natural processes such as respiration, volcano eruptions and through human activities such as deforestation and burning of fossil fuel.

3. **Methane:** a hydrocarbon gas produced both through natural sources and human activities including the decomposition of wastes in landfills, agriculture and manure management associated with domestic livestock. Methane is a far more active greenhouse gas than carbon dioxide but also, one which is less abundant in the atmosphere.

4. **Nitrous Oxide:** it is a powerful greenhouse gas produced by soil cultivation practices, especially the use of commercial and organic fertilizers, fossil fuel combustion, nitric acid production and biomass burning.

5. **Chlorofluorocarbons (CFCs):** these are gases released from synthetic compounds entirely of industrial origin used in a number of applications, but now largely regulated in production and released to the atmosphere thereby, contributing to the destruction of the ozone layer.

Over the last century, the burning of fossil fuels like coal and oil has increased the concentration of atmospheric carbon dioxide (Co2) and the clearing of land for agriculture, industry and other human activities have increased concentrations of greenhouse gases. Changes in temperature and precipitation associated with continued emissions of greenhouse will bring about changes in land suitability and crop yields. According to IPCC, in temperate latitudes, higher temperatures are expected to bring predominantly benefits to agriculture; a moderate incremental warming in some humid and temperate grassland may increase pasture productivity. While in drier areas, there is a little or no benefit, due to increased evaporation, transpiration and lower soil moisture level. Temperature rise also expands the range of many agricultural pests and diseases (Schmidhuber and Francesco 2007).

The United Nations (UN) estimates that more than 50 million people in Africa are actually threatened by famine. Climate change has adverse effects on agriculture and food security. Higher temperature leads to higher evaporation rate and reduced soil moisture which lowers the ground table water leading to a decline in agricultural productivity. Erratic rainfall pattern can affect seed germination and cause crop failure while increased frequency of storms can cause damage to farmlands, crops and livestock. Globally, climate change has adverse impact on food security, while developed Nations can easily mitigate against this challenge by adopting technologies to scale up agricultural productivity, developing nations with the world's poorest people experience difficulty in tackling the impact of changing temperature (Adeyeye 2017).

The Food and Agricultural Organization (FAO) in its final report of the 1996 world food summit, defined food security as a situation that exists when all people at all times have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.(IFPRI 2014). Household food security exists when all members at all times, have access to enough food for an active and healthy life. Individuals who are food secure do not live in hunger or fear of starvation (Edward 2002). The IFPRI also stated that over the decades, a changing climate, growing global population; rising food prices and environmental stressors have significant yet highly uncertain impacts on food security. Food security is anchored on four pillars or components which include; food availability, food accessibility, food utilization and food stability (FAO 2008).

Climate Change is one of the most serious environmental threats facing mankind worldwide. It affects agriculture in several ways, including its direct impact on food production. Climate change is attributable to the natural climate cycle and human activities, which have adversely affected agricultural productivity. (Ziervogel *et al*., 2006). As the planet warms, rainfall patterns shift and extreme events such as droughts, floods and forest fire become more frequent which result in poor and unpredictable yields thereby, making farmers more vulnerable, particularly in Africa (Zoellick and Robert, 2009).

In addition, the Intergovernmental Panel on Climate Change (IPCC) in its fourth assessment report summary for Africa described a trend of warming at a rate faster than the global average rate and increasing aridity in many countries. Climate change exerts multiple stresses on the biophysical as well as the social and institutional environment that underpins agricultural production (IPCC, 2007). According to (FAO, 2007), warmer conditions support the process of natural decomposition of organic matter and contribute to the nutrient uptake mechanism. Mark *et al*., (2008), added that the process of nitrogen fixation, associated with greater root development is also predicted to increase warmer conditions with higher CO2 if soil moisture is not limiting. The increased CO2 level leads to a positive growth response for a number of staples under controlled conditions known as the carbon fertilization effect.

Mark *et al.,* (2008), highlighted some of the direct impacts of climate change on agricultural system as:

a. Seasonal changes in rainfall and temperature, which could impact agro-climatic conditions, altering growing seasons, planting and harvesting time, water availability, disease, weed and pest population.

b. Alteration in evaporation, transpiration, photosynthesis and biomass production.

c. Alteration in land suitability for agricultural production, of which some of the induced changes are expected to be abrupt while others involve gradual shift in temperature and vegetation cover.

Also, Enete *et.,al* (2010), described that climate change has been one of the most serious environmental threat to the fight against hunger, malnutrition, disease and poverty in Africa mainly through its impact on agricultural productivity. The rural populations, who produce more than 70% of the food eaten in Nigeria, are disproportionately poor, facing malnutrition and disease. Both government and private sector who should drive the agricultural sector through consistent policies, robust funding and infrastructural development have failed to give to give this problem the priority it deserves. Most farmers are slow in changing their farming practices such as bush burning, deforestation and rain-fed agriculture and they lack the requisite education, information and training necessary to adapt to climate change.

8. Theoretical Framework

The theoretical framework of this study is anchored on the Anthropogenic Global Warming Theory. This theory contends that human emissions of greenhouse gases, principally carbon dioxide (CO2), methane, and nitrous oxide, are causing a catastrophic rise in global temperatures. The mechanism whereby this happens is called the enhanced greenhouse effect. Energy from the sun travels through space and reaches the Earth's atmosphere which is mostly transparent to the incoming sunlight, allowing it to reach the planet's surface where some of it is absorbed and some is reflected back as heat out into the atmosphere. Certain gases in the atmosphere, called "greenhouse gases," absorb the outgoing reflected or internal thermal radiation, resulting in Earth's atmosphere becoming warmer than it otherwise might be. Water vapor is the major greenhouse gas, responsible for about 36 to 90 percent of the greenhouse effect, followed by CO2 (<1% to 26%), methane (4% to 9%), and ozone (3% to 7%). During the past century, human activities such as burning wood and fossil fuels and cutting down or burning forests are thought to have increased the concentration of CO2 in the atmosphere by approximately 50 percent. Continued burning of fossil fuels and deforestation could double the amount of CO2 in the atmosphere during the next 100 years. A small increase in temperature causes more evaporation, which places more water vapor in the atmosphere, causing more warming. Global warming may also lead to less ice and snow cover, which would lead to more exposed ground and open water, which on average are less reflective than snow and ice and thus absorb more solar radiation, which would cause more warming. Warming also might trigger the release of methane from frozen peat bogs and CO2 from the oceans. Backers of the AGW theory contend the ~0.7°C warming of the past century-and-a-half and ~0.5°C of the past 30 years is mostly or entirely attributable to man-made greenhouse gases. They dispute or disregard claims that some or perhaps the entire rise could be the Earth's continuing recovery from the Little Ice Age (1400-1800). The proponents of this theory used computer models based on physical principles, theories, and assumptions to predict that a doubling of CO2 in the atmosphere would cause Earth's temperature to rise an additional 3.0°C (5.4°F) by 2100. Proponents of the AGW theory believe man-made CO2 is responsible for floods, droughts, severe weather, crop failures, species extinctions, spread of diseases, ocean coral bleaching, famines, and literally hundreds of other catastrophes. All these disasters will become more frequent and more severe as temperatures continue to rise, they say. Nothing less than large and rapid reductions in human emissions will save the planet from these catastrophic events.

9. Methodology

This study utilizes data from secondary resources. Pannerselvam (2006) states that secondary data is collected from sources that have already been created for the purpose of first time use and future uses. The quantitative data are displayed in the form of absolute Agricultural Output as proxy for food security, Annual Rain Fall (ARF) and Carbon dioxide (CO_2) for climate change, value added in agriculture and public expenditure in Agriculture as proxy for Agricultural Innovation. The data are structured annually from a period of 1998 to 2018 (20 years). The sample was chosen mainly on the basis of data availability. All of the quantitative data were collected from various reliable sources mainly from the central Bank of Nigeria statistical bulletin, Annual Reports of CBN, Internet and World Bank.

Model Specification

In line with the topic of this research and other studies, Agricultural Output (AO) is used to represent Food security as dependent variable. The rationale behind the choice of AO is because the figure shows an indication of food security. Based on this work the Annual Rainfall, Carbon dioxide, Value Added in Agriculture, Expenditure on Agriculture were used as independent variable because they are relevant and related to this study.

Data collection is from secondary sources. Basically, these are time series data on the climate change impact on food security. The ordinary least square (OLS) method is adopted for data analysis.

AO = f(ANR, CO_2) --- (1a)

AO = $\beta_0 + \beta_1 ANR + \beta_2\, CO_2 + \mu$----------------------------------- (1b)

And

AO = f(VAA, GEA) --- (2a)

AO = $\beta_0 + \beta_1 VAA + \beta_2\, \text{GEA} + \mu$----------------------------------- (2b)

AO = Agricultural Output proxy for food security

ANR= Annual Rainfall

CO_2 = Carbondioxide

VAA = Value added in Agriculture

GEA = Government expenditure on Agriculture

β_0= Intercept of the model

β_1, β_2, = are the slopes of the independent variables in equation (1)

μ= error term

The *a priori* expectation of the coefficient of the equation (1) is as is $\beta_1, \beta_2 > 0$, It is expected that increase in annual rainfall and carbon dioxide should have a positive relationship with Agricultural Output (AO).

The *a priori* expectation of the coefficient of the equation (2) is as is $\beta_1, \beta_2 > 0$, It is expected that increase in government expenditure on agriculture and value added to agriculture as proxy for technology innovation for agriculture should have positive relationship with food security (AO).

Techniques of Analysis

The research design employed for this study is the Ordinary Least Squares (OLS) method. Multiple regression model technique is use in determining the effects of climate change on food production and consider technology innovations as alternative solutions to the problems of climatic changes on food production for the period of 1998 – 2018. This study employed the use of econometric view (Eview 9) computer software for the estimation of the Model's parameters. However, before running the OLS the unit root test would be carried out. This is done to avoid spurious regression result.

Pre Estimation Tests

Unit Root Test

Prior to the regression process, this study will conduct unit root test on the data. While the unit root test is a test to determine the existence of unit root in the data and clarify the stationary status of the data. The unit root test, Granger and Newbold (1974) state that a spurious regression could exist with the presence of non-stationary variables. If the series are non-stationary, the OLS model will lead to spurious estimates. For easier understanding, a spurious regression has a high R2 and its t-statistic shows as significant; however, this result is meaningless. The existence of stationary in a time series data indicate that the series have constant variance, constant mean and constant covariance, so the results obtained implied that the existence of a meaningful economic relationship in the regression model.

Granger Causality Test

The Granger Causality tests for whether Climate change is a cause of food insecurity in Nigeria? In order to find out, we therefore perform a Granger causality test. This approach is used to determine whether or not one economic variable can determine another. Focusing on climate change as an engine of food insecurity, we are interested in the bidirectional causal relationship to provide evidence if climate change has caused food insecurity and also if food insecurity has caused climate change between 1998 and 2018. Therefore the hypothesis is considered:

H_0: Climate change does not Granger-cause food insecurity

H_i: Food insecurity does not Granger-cause climate change

The Ordinary Least Squares (OLS) Method.

The OLS method is preferred for this research in view of the fact that it has some ideal or optimum properties. The OLS has the Best Linear Unbiased Estimates (BLUE) properties which makes it preferred over all other class of linear estimators (Gujarati and Porter, 2009) An estimator is BLUE if it is linear, unbiased and has the smallest variance as compared with all other linear unbiased estimators. Within the class of linear unbiased estimators, the OLS estimators have the minimum variance. This provides the main justification for using the OLS techniques (Koutsoyiannis, 2003).

Post Estimation Tests:

Autocorrelation Test

Autocorrelation is common when using time series data in regression. It occurs when the residual does not form a random trend around the regression line. The positive autocorrelation exists when the trend of the residuals is formed systematically above or below the line. One of the ways to eliminate autocorrelation is by identifying the factors responsible for the autocorrelation and extending the regression accordingly. This study conduct Breusch-Goldfrey Serial correlation LM test to detect the autocorrelation problem.

Variability of Climate Change and Food Production in Nigeria

Climate change is caused by natural as well as man-made factors. Notably, it has a negative impact on the environment. Some of the devastating effects include volcano, erosion, flooding, drought, pest, disease and landslide which in turn threaten agriculture and food security in Nigeria. Climate varies on a temporal scale longer than a decade, it is never static. According to Peter (2012), desertification in the Sub-Saharan region of Nigeria leads to a reduction in moisture flux and rainfall in the Sahel, an increase in rainfall moisture flux and precipitation in south Sahel which leads to land degradation, increase in local temperature and decrease in rainfall levels. These variations in climate cause changes in amount of crop yield annually. For instance, changes in the yield of some selected crops as a result of variation in climate are shown below;

Table 1 Wheat Production, supply and Consumption

Wheat	2015/2016	2016/2017	2017/2018
Area Harvested	60,000 hectares	60,000 hectares	60,000 hectares
Total Production	60 million tones	60 million tones	60 million tones
Total Supply	4.67 million tones	4.760 million tones	4.6million tones
Total consumption	4.20 million tones	4.11million tones	4.10 million tones

Source: USDA Foreign Agricultural Services (2017)

Table 2: Rice Production, Supply and Consumption

RICE	2015/2016	2016/2017	2017/2018
Area Harvested	2.5 million hectares	2.5million tones	2.58million hectares
Total Production	4.3 million tones	4.29 million tones	4.444 million tones
Total Supply	5.801 million tones	5.301 million tones	5.101 million tones
Total Consumption	5.2 million tones	5 million tones	4.8million tones

Source: USDA Foreign Agricultural Services (2017)

Table 3: Maize Production, Supply and Consumption

Maize	2015/2016	2016/2017	2017/2018
Area Harvested	3.8million hectares	4 million hectares	3.8million hectares
Total Production	7 million tones	7.2 million tones	6.9 million tones
Total Supply	7.661 million tones	7.661 million tones	7.261 million tones
Total Consumption	7.3 million tones	7.3 million tones	6.8 million tones

Source: USDA Foreign Agricultural Services (2017)

The data above indicates that the production and yield of major crops which include wheat, rice and maize varies annually with increase in yield in some periods and decrease in some other periods due to changes or variations in climate across Nigeria.

Gradual increases in temperature and carbon dioxide and other gases result in restricted yields by extreme heat, floods and drought. Consequently, Livestock are at risk from heat stress and reduced quality of food supply thus, extreme weather conditions can cause reduction in agricultural productivity leading to increase in food prices.

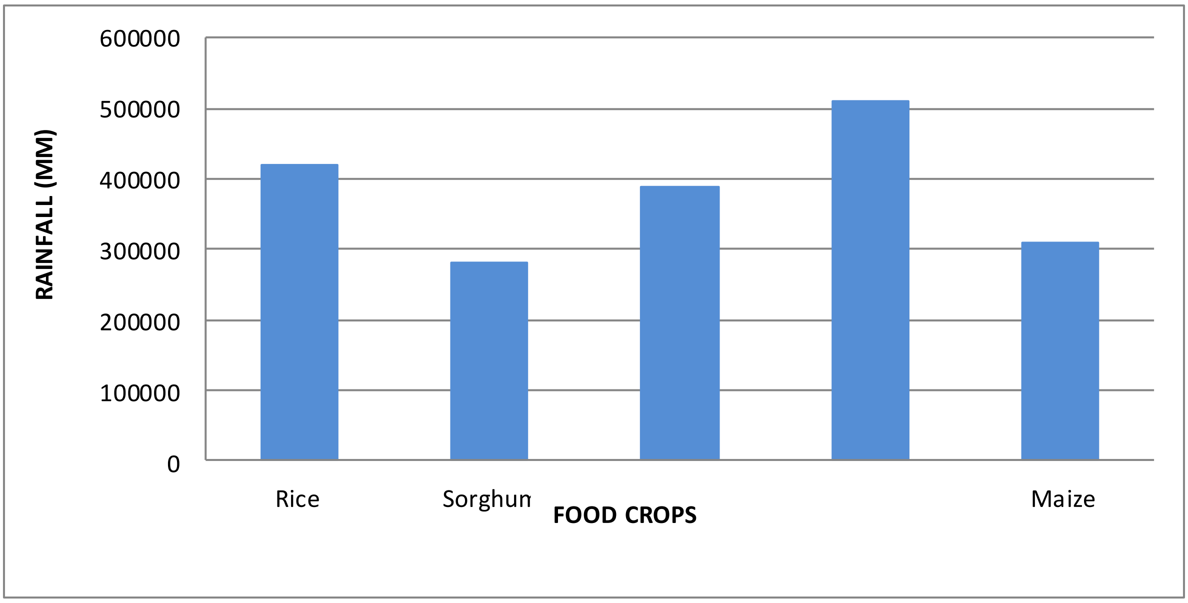

Fig.1: Rainfall and Food Production. Source: FEWSNET (2016).

The bar-chart above shows the impact of flooding on major food crops which include; rice, sorghum, cassava, yam and maize. It indicates that due to excessive rainfall from July to October and flooding from several dams across the Nation, about 1.9million hectares of cropland was destroyed and a decline in harvest of such major food crops was recorded.

10. Data Analysis and Interpretation of Results

Unit Root Test Result

Table 4. Unit root test

Variable	ADF Statistics	Critical value @5%	Level of Stationarity
AO	-4.449911	-3.710482	I(0)
ARF	-5.958987	-3.020686	I(0)
CO2	-4.454129	-3.029970	I(1)
VAA	-11.44221	-3.065585	I(0)
GEA	-3.603892	-3.098896	I(2)

Source: Researcher's computation with the aid of E-View 9

Unit root test was employed as pretest to check the stationarity of the data used in estimating the model. From the table 2 above, Agricultural output (AO), Average Rainfall(AFR) and Value added to agriculture were stationary at levels I(0), Carbon dioxide was stationary at first difference I(1) while Government expenditure was found to be stationary at second difference I(2). Hence, the data used is free from spurious result. (Granger and Newbold 1974).

Granger Causality Test Result

Table 5: Pairwise Granger Causality Tests

Null Hypothesis:	Obs	F-Statistic	Prob.
CO2 does not Granger Cause AO	19	0.24810	0.7836
AO does not Granger Cause CO2		9.39449	0.0026
ARF does not Granger Cause AO	19	1.63002	0.2310
AO does not Granger Cause ARF		2.07039	0.1630
ARF does not Granger Cause CO2	19	0.72478	0.5017
CO2 does not Granger Cause ARF		1.51256	0.2543

Source: Researcher's computation with the aid of E-View 9

The causality tests show that Agricultural output Granger cause carbon dioxide, this was indicated by their respective F-statistics and probability values which stood at 9.39449(0.0026). However, Carbon dioxide does not Granger Cause Agricultural output. Also other variables do not Granger cause one another as indicated by various F-statistics and probabilities values.

5.2.2 Regression Results

Table 6: Regression result 1

Dependent Variable: AO				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
CO2	-20.56647	33.24171	-0.618695	0.5439
ARF	-0.341801	0.470835	-0.725946	0.4772
C	146.4456	49.78822	2.941370	0.0087
R-squared	0.645434			
Adjusted R-squared	0.600628			
F-statistic	12.42837	Durbin-Watson stat		1.893698
Prob(F-statistic)	0.004950			

Source: Researcher's computation with the aid of E-View 9

Table 7: Regression result 2

Dependent Variable: AO				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
GEA	4.58E-05	7.01E-06	6.532236	0.0000
VAA	-0.101525	0.186249	-0.545106	0.5924
C	92.67489	3.039517	30.49000	0.0000
R-squared	0.722518			
Adjusted R-squared	0.691686			
F-statistic	23.43449	Durbin-Watson stat		0.941128
Prob(F-statistic)	0.000010			

Source: Researcher's computation with the aid of E-View 9

The regression result is summarized as follows

AO = 146.4456 -0.341801AFR -20.56647CO2 - - - - - -- - - - - - - - --- - - (1)

S.E.E = (49.78822) (0.470835) (33.24171)

P-value = (0.00087) (0.4772) (0.5439)

R^2 = 0.65 Adjusted R^2 = 0.60 F = 12.42 DW = 1.893698 N = 19

AO = 92.67 + 4.58GEA -0.102VAA - - - - - - -- - - - - - - - --- - - (2)

S.E.E = (3.04) (0.816) (7.01)

P-value = (0.00) (0.5924) (0.00)

R^2 = 0.723 Adjusted R^2 = 0.692 F = 23.43 DW = 0.941128 N = 19

The regression result in table 4(equation 1) represent climate change and agricultural output as proxy for food security. The OLS result revealed that at 5% level of significance, there is a negative relationship between the dependent variable, Agricultural output (AO) and independent variables Average Rainfall (AFR) and Carbon dioxide (CO2) as revealed by their values of coefficients (-0.341801 and -20.56647) respectively. By implication, a unit increase in Average rainfall and carbon dioxide will lead to about 0.341801 and 20.56647 decrease in agricultural output. It was also confirmed that Average rainfall and Carbon dioxide were statistically insignificance as revealed by the value of their probabilities which stood at 0.4 and 0.5 respectively. The result above implies that, Climate change in Nigeria is not healthy for food security in Nigeria.

The regression result in table 5(equation 2) represent Technology innovation a solution to climate changes on food production. The OLS result revealed that at 5% level of significance, there is a negative relationship between Agricultural output and value added in agriculture and also a positive relationship between Agricultural output and Government expenditure on Agriculture as revealed by the values of their coefficients (-0.102 and 4.58).

By implication, a unit increase in Value added to agriculture will lead to about 0.102 decrease in Agricultural output while a unit increase in Government expenditure on agriculture will lead to about 4.58 increase in agricultural output. It was also confirmed that Value Added to Agriculture statistically insignificant as revealed by the value of it probability which stood at 0.5924while Government expenditure on Agriculture is statistically significant as the probability value stood at 0.0000.

The implication above is that Value added to agriculture which comes as a result of technological innovation is not significant even as the government expenditure on agriculture increase significantly it has not help to improve technological innovation and did not provide a solution to climate changes on food production Nigeria. Furthermore, tables 4 and 5 revealed that the coefficient of determination R^2 or tradition statistical criteria stood at 0.65 and 0.72 per cent respectively. The implication of the above results is that, 65% and 72% of the proportion of the total variation observed in the dependent variable (agricultural output) was explained by the explanatory variable (Carbon dioxide and Average Rainfall, Value added on agriculture and Government expenditure on agriculture) in the model and unexplained variation is 35% and 28% respectively.

Conversely, the adjusted R^2 value of 60% and 69% indicated that even after the adjustment in the model, it still had a good goodness of fit. Considering that agricultural output is caused by several other variables. The F-statistic which measured the joint statistical influence of the explanatory variables in explaining the dependent variables stood at 12.42 and 23.43 respectively with a P-value of 0.005 and 0.0000 respectively. This indicated the influence of the explanatory variable to be statistically significant at 5% level of significance. The

Durbin Watson (DW) test in equation one with the value of 1.83 which is approximately 2 revealed the absence of serial correlation While Durbin Watson (DW) test in equation two with the value of 0.941128 indicate the presence of Serial correlation. As a result of the poor value of Durbin Watson in equation two Serial correlation test was carried out..

Serial Correlation Test

Table 8: Breusch-Godfrey Serial Correlation LM Test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	4.991504	Prob. F(1,17)	0.0392
Obs*R-squared	4.766458	Prob. Chi-Square(1)	0.0290

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GEA	-3.09E-06	6.49E-06	-0.475554	0.6404
VAA	0.095159	0.173801	0.547518	0.5911
C	-0.148726	2.750684	-0.054069	0.9575
RESID(-1)	0.514911	0.230471	2.234167	0.0392
R-squared	0.226974			
F-statistic	1.663835	Durbin-Watson stat		2.143171
Prob(F-statistic)	0.212341			

Source: Researcher's computation with the aid of E-View 9

There was a presence of serial correlation in the equation 2 model as revealed by the Durbin Watson's value of 0.941128 in table 6. Serial correlation test was conducted and the Breusch-Godfrey Serial Correlation LM result in table 6 revealed that the value of Durbin Watson was 2.14 which is approximately 2. Breusch-Godfrey Serial Correlation LM test identified and eliminated serial correlation through adjustment and extending the regression accordingly.

Hence, it can be concluded that the model is free from serial correlation problem. Thus, the result can be used for economic decision making.

11. Discussion of Findings

From the empirical analysis carried out so far in the previous sections of this study, the unit root test revealed that Agricultural output (AO), Average Rainfall(AFR) and Value added to agriculture were stationary at levels, Carbon dioxide was stationary at first difference while Government expenditure was found to be stationary at second difference. Therefore, the data used for this research gave reliable results. The causality tests shows that carbon dioxide Granger causes Agricultural output while Agricultural output does not Granger cause carbon dioxide. Also other variables do not Granger cause each other The regression results in equation (1) revealed a negative relationship between the dependent variable, Agricultural output (AO) and independent variables: Average Rainfall (AFR) and Carbon dioxide (CO2), as revealed by their coefficients values of (-0.341801 and -20.56647) respectively. It was also confirmed that Average rainfall and Carbon dioxide were statistically insignificant as revealed by the value of it probabilities which stood at 0.4 and 0.5 respectively. The result above implies that, Climate change in Nigeria is not healthy for food security. Some form of modern technology innovation in agriculture is needed to mitigate climate change and its impact on food production and food security.

12. Conclusion

The study examined the effects of climate change on food production and considers technology innovations as alternative solutions to the problems of climatic changes on food production for the period of 1998 – 2018. Based on the findings from the multiple regression tests, it is evident that Average rainfall and Carbon dioxide impacts greatly on Agricultural output in Nigeria between the study periods. The Negative impact of value added on Agriculture on agricultural productivity showed a fall out in the technological innovation, as it has not help to salvage the impact of climate change in Nigeria. Hence, we conclude that climate change has significant impact on food security in Nigeria.

13. Recommendations

In view of empirical results of the study, it is recommended that:

1. There is need to mainstream climate change into national, regional and state development plans, adapt policies needed to be an integral part of government initiative, given the cross cutting nature of the impact of climate change on food security.

2. The government should take proactive steps in addressing environmental problems. These include effective management of waste, flood and erosion.

3. Advocacy programs should be organized through workshops, seminars, public lectures, media campaign, climate change and waste water summits, tree planting and other programs.

4. Government and individuals should adopt appropriate technologies to mitigate the scourge at all levels, while there should be strengthening of weak human capacity and infrastructure or mainstreaming climate change in the nation.

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Appendix: Data For Regression

The data in the table 9 shows the variables and the time series data for this study. The variables are Agricultural output, Annual Rainfall, Carbon dioxide, Value Added to Agriculture and Government expenditure (GEA). These variables are measured in billion and percentages.

Table 9: The trend of Agricultural output, Annual Rainfall, Carbon dioxide, Value added to Agriculture and Government expenditure (GEA).

YEAR	AO	ARF	co2	VAA	GEA
1998	77.73	95.21	0.34	4.11	11413.7
1999	81.14	102.97	0.37	5.29	11923.2
2000	81.88	93.27	0.64	2.95	9636.5
2001	81.57	91.53	0.66	3.88	9927.6
2002	85.52	90.48	0.76	55.18	13041.1
2003	89.05	112.25	0.7	6.98	16223.7
2004	94.57	93.57	0.71	6.29	22018.7
2005	99.65	94.61	0.65	7.06	27749.5
2006	105.78	97.9	0.69	7.4	41028.3
2007	99.22	97.09	0.65	7.19	60268.2
2008	105.45	101.59	0.61	6.27	66584.4
2009	93.28	94.4	0.46	5.88	92797.4
2010	106.04	101.72	0.53	5.82	191229
2011	100.08	80.45	0.54	2.92	160893
2012	112.59	100.76	0.55	6.7	248468
2013	111.08	79.92	0.56	2.94	337218
2014	121.61	92.17	0.57	4.27	428215
2015	126	81.18	0.58	3.72	487113
2016	124.6	103.04	0.44	4.11	947690
2017	125.3	92.09	0.51	3.92	717402
2018	124.95	97.565	0.48	4.02	832546

Source: Central Bank of Nigeria, Statistical Bulletin and annual abstract from National Bureau of Statistics 2019.