UNDERSTANDING THE EFFECTS OF CLIMATE CHANGE ON CROP AND LIVESTOCK PRODUCTIVITY IN NIGERIA

ABSTRACT

Aim: Agriculture entails majorly crop and animal production. Crop and Livestock production provide the major human caloric and nutrition intake. Assessing the impact of climate change on crop and livestock productivity, is therefore critical to maintaining food supply in the world and particularly in Nigeria. Different studies have yielded different results in other parts of the world, it is therefore, very important to examine the linkage between climate change and agricultural productivity in Nigeria.

Study Design: The study utilized secondary data. The study utilize climate data from Nigerian Meteorology Station and Carbon emission, Crop and Livestock production data from FOASTAT

Place and Duration of study: The study was carried in Nigeria and it covers the period between 1970 - 2016.

Methodology: The data were used to estimate the empirical models. Data were analyzed using descriptive statistics, trend analysis, stationarity, Co-integration and Fully-Modified Least Squares regression.

Results: The result of the research reveals that there is variation in the trend of the climatic factors examined and also variation in crop and livestock production over the period covered by the study in Nigeria. The finding also shows that rainfall, temperature and Carbon emission are the climatic factors that significantly affect crop and livestock production in Nigeria. Long term adverse impact of climate change on crop and livestock production index indicates threat to food availability to the country.

Conclusion: The study concluded that climatic variables have significant effect on agricultural productivity in Nigeria. The study recommended the need to put in place measures that will reduce the negative effects of climate on agricultural production.

Keywords: Climate Change, Agricultural productivity, Nigeria

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INTRODUCTION

Agriculture constitutes the backbone of most African economies and is a major contributor to the gross domestic product (GDP) of the region. It accounts for about a third of Africa's` GDP, employs in many countries about 60-90 per cent of the total labour force and is the major source of livelihood for poor people (EU,2007). In addition, most of Africa`s poor live in rural areas, where they depend, directly or indirectly, on agriculture for their livelihood (Oyiga *et al.,*2011). Agriculture primarily provides food for man and raw materials for agro-based industries. It consists of all the productive endeavors of man in collaboration with nature to rear plant and animal for a better harvest. It involves all aspects of farming, fishing livestock, rearing, poultry and forestry (Egwu,2016). The roles of Agriculture to the Economic development of any nation cannot be over emphasized, as no country can achieve long-term development without a well-developed agricultural sector. Agriculture's contribution to the Gross Domestic product (GDP) has remained stable at between 30% and 42%, and employs about 75% of the labour force in Nigeria (Abula and Ben, 2016). The agrarian sector has a strong rural base; hence, generating concern for agriculture and rural development (Nwankwo,2013). Reports shows that food production, including access to food, in many African countries is projected to be severely compromised by climate change (IPCC,2007).

Climate change has been described as the most significant environmental threat of the 21st century. Climate change and agriculture are closely linked and interdependent. Agricultural productivity in Africa, Asia and Latin America is expected to decrease by as much as 20% as a result of the effect of climate change (Greg *et al.,*2011). The impact of climate change is vast. One of its threatening sectors is agriculture as food production is adversely affected by climate change. According to Greg *et al.,*(2011), rural communities dependent on agriculture in a fragile environment will face an immediate risk of increased crop failure and loss of livestock. Climate change leads to sea-level rise with its attendant consequences, and includes fiercer weather, increased frequency and intensity of storms, floods, hurricanes, droughts, increased frequency of fires, poverty, malnutrition and series of health and socio-economic consequences (Von Braun *et al.,* 2008). In most countries where agricultural productivity is already low and the means of coping with adverse events are limited, climate change is expected to reduce productivity to even lower levels and make production more erratic (Greg *et al.,*2011). Climate change affects agriculture through rainfall variability (IPCC 2015). This situation, therefore, makes climate change an important consideration for sustainable agricultural production (Easterling *et al.,*2007).

The accelerating pace of climate change combined with global warming looms food security everywhere including Nigeria, and agriculture is very weak to climate change. While encouraging floods, drought, weed and pest proliferation, climate change eventually reduces yields of desirable crops (Inyang *et al.,* 2018). According to Sivakumar (2013) although the cause and effect relations of climate change and agriculture are seen in many forms and extent, the assessment of those relations and effects of climate change on agriculture and the impact of (both conventional and organic) agriculture on climate change are not properly documented.

Crops are sensitive to climate change, including changes in temperature and precipitation, and to rising atmospheric CO_2 concentration Rosenzweig *et al.,* (2014) and Wheeler and Von Braun (2013). Changes in crop productivity are mainly attributed to the projected temperature increase, crop-water stress, pests and diseases, which are seen as challenges for the agricultural sector. According to Parry *et al.,*(2007), crop productivity would be at risk of decreased crop yields at even 1-2^{o}C. Furthermore, Livestock is an integral part of the farming systems in the country. It is the source of many social and economic values such as food, power, fuel, cash income, security and investment (Deressa, 2006). Livestock are adversely affected by the detrimental effects of extreme weather. Climatic extremes and seasonal fluctuations in herbage quantity and quality will affect the well-being of livestock, and will lead to declines in production and reproduction efficiency (Sejian, 2013). This is because, native pasture or rangeland is still the most important livestock feed source for several countries in the region. In general, overall productivity decline in livestock nomadic system is stemming from erratic rainfall and moisture decline (Thomas 2008). Climate change impacts livestock production and health through changes in the quantity and quality of available feeds, heat stress, available water, livestock diseases and disease vectors, and genetic diversity (Thornton et al. 2009). A reduction in rainfall will result in the loss of natural pastures leading to a loss of adapted animal genetic resources. Accelerated feed shortages are likely to worsen the rangeland degradation further. A predicted loss of 25 % of animal production (Sequin 2008) relate to only reduced feeds and increased heat stress in the mixed crop- livestock system.

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FAO (2008) estimates indicate that the number of hungry and malnourished people due to insufficient food availability, have increased from about 90 million in 1970 to 225 million 2008, and was projected to add another 100 million by 2015. As a result, for the next decades agricultural productivity needs to be rigorously increased to provide more food to meet the demands of growing populations. The impact of climate change on agricultural production in Nigeria has received limited attention despite the fact that over 60% of the active populations of Nigerians are farmers. Studies on climate change globally and in Nigeria have revealed that the potential impacts of climate change will include every aspect of the four dimensions of food security; food availability (production and trade), food accessibility, food stable supplies, and food utilization (Nwafor, 2007). However, the extent to which climate conditions could be held responsible for the changes in agricultural productivity, particularly crop and livestock productivity is still an emerging subject of empirical research. The overall objective of this study was to analyze the relationship between climate change and crop and livestock productivity in Nigeria.

METHODOLOGY

STUDY AREA

Nigeria is the study area. Nigeria is in West Africa region between Latitudes 4^o to 14^o North and between Longitudes $2^o2'$ and $14^o3^{0}{}'$ East. To the north the country is bounded by the Niger Republic and Chad; in the west by the Benin Republic, in the East by the Cameroon Republic and to the south by the Atlantic Ocean. The country takes its name from its most prominent river, the Niger. Nigeria has a land area of about 923,768 km^2 (Eroarome, 2009). Relatively recent population estimate indicated a population of 182million in 2017 with a mean annual growth rate of 2.2 percent (NPC,2017). Nigeria is a country of marked ecological diversity and climatic contrasts. Nigeria has diverse biophysical characteristics, ethnic nationalities, agro-ecological zones and socio-economic conditions. Nigeria, by virtue of its location, enjoys a warm tropical climate with relatively high temperatures throughout the year (Eroarome, 2009). Over 65% of Nigeria's population is engaged in agriculture as their primary occupation and means of livelihood (CBN, 2005). The climate of Nigeria has shown considerable temporal and spatial shifts in its variability and change. Extreme climate and weather events (drought, flood, heatwaves, ocean surges, etc) have become more regular.

Sources and type of data

The set of data for the study were mainly time series data from secondary sources. Data for the study were national aggregates and climate variables (temperature, rainfall and carbon dioxide) obtained from Nigerian metrological Agency, Food and Agricultural Organization (FAO), FAOSTAT website and other secondary sources. The data covered a fifty year period of 1970 to 2016.

Method of Analysis

Descriptive statistics, trend analysis of the climate variables in the study (temperature, rainfall and carbon dioxide) as well as the trend of crop and livestock productivity for Nigeria was also described through the graph to establish the pattern of climate variables. The study carried out unit root test using Augmented Dickey-Fuller (ADF) test, ADF F-ratio critical value was used to arrive at a the decision on the unit root of the variables. Co-integration test was also carried to test for co-integration in the model. Fully-modified least squares Co-integration regression was used to estimate the effects of climate change on crop and livestock productivity to see how much of productivity is attributable to changes in climate variables.

The regression model in implicit form is;

$Y = f(X_1,X_2,X_3,e)$

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Y = Productivity index (for crop and livestock productivity index)

X_1 = Average annual Rainfall (mm)

X_2 = Average annual Temperature (^{O}C)

X_3 = Carbon emission (ppm),

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RESULTS AND DISCUSSION

Table 1: Descriptive Statistics

	Crop Prod_	Livestock	Rainfall	Temperature	Co2_Emission
Mean	64.88957	74.81255	103.0591	26.62658	0.638088
Median	63.71000	69.63000	102.9429	26.52885	0.649214
Maximum	125.7700	123.6500	128.9314	27.96000	1.010017
Minimum	26.96000	28.05000	81.44357	25.94523	0.325376
Std. Dev.	32.83725	29.69516	10.97276	0.455215	0.188216
Skewness	0.328264	0.162427	0.514277	1.255687	-0.057879
Kurtosis	1.691747	1.810079	3.064638	4.889878	2.042946
Jarque-Bera	4.195833	2.979490	2.079951	19.34566	1.819982

Probability	0.122712	0.225430	0.353463	0.000063	0.402528
Obs.	47	47	47	47	47

Source: Authors computation, 2020

The Jarque bera test in Table 1 rejects the null hypothesis for normal distribution for temperature while other variables are normally distributed. The kurtosis for the Rainfall and Temperature exceeds three, an indication of fat tails (leptokurtic), and other variables are platykurtic (thin tail) because their values are less than three. Skeweness of the variables shows that they are positive except for carbon emission which was negative.

Trend analysis of Rainfall

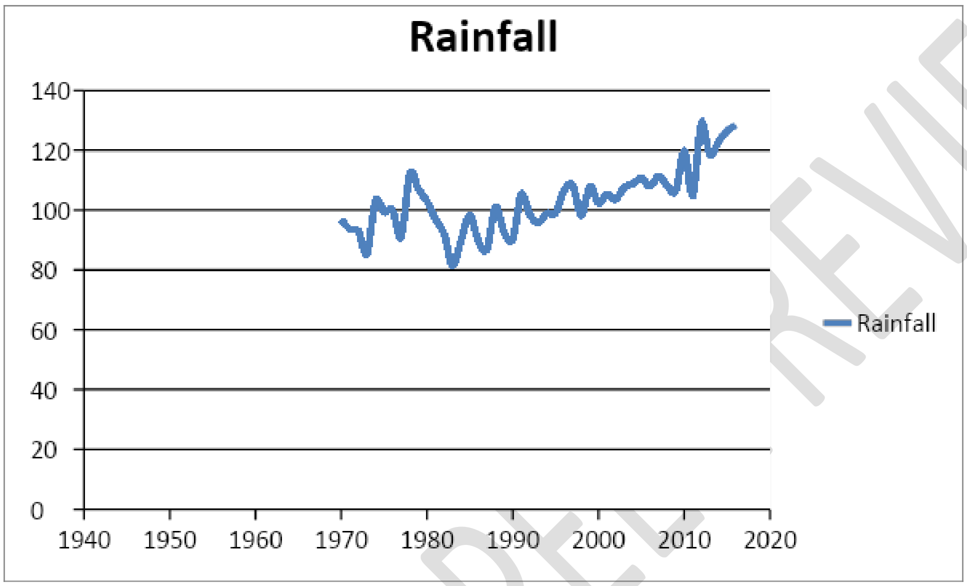

Figure 1: Rainfall pattern

The statistical information of rainfall in Nigeria between 1970-2016 shows a rising trend with highest trend in 2012 and lowest in 1983. The value of the highest rainfall was recorded as 128.93mm while the lowest recorded as 81.44mm. The mean and standard deviation of rainfall in the country over the period of study from 1970-2016 are 103.05mm and 10.97mm respectively. The standard deviation shows that there is a large variability in the rainfall from year to year.

Trend analysis of Temperature

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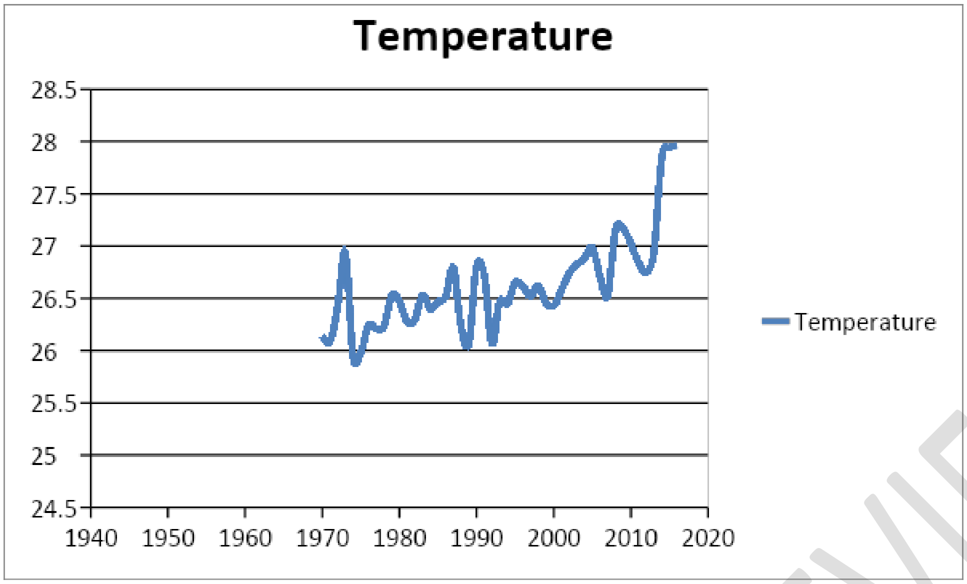

Figure 2: Pattern of Temperature

The statistical information of temperature in Nigeria between1970 - 2016 shows a rising trend with highest trend in the year 2015 and lowest in 1974. The value of temperature was recorded the highest with a value of 27.96°C while the lowest value recorded was 25.94. The mean and standard deviation of temperature over the period of study from 1970-2016 are 26.62°C and 0.45°C respectively.

Trend analysis of Carbon Emission

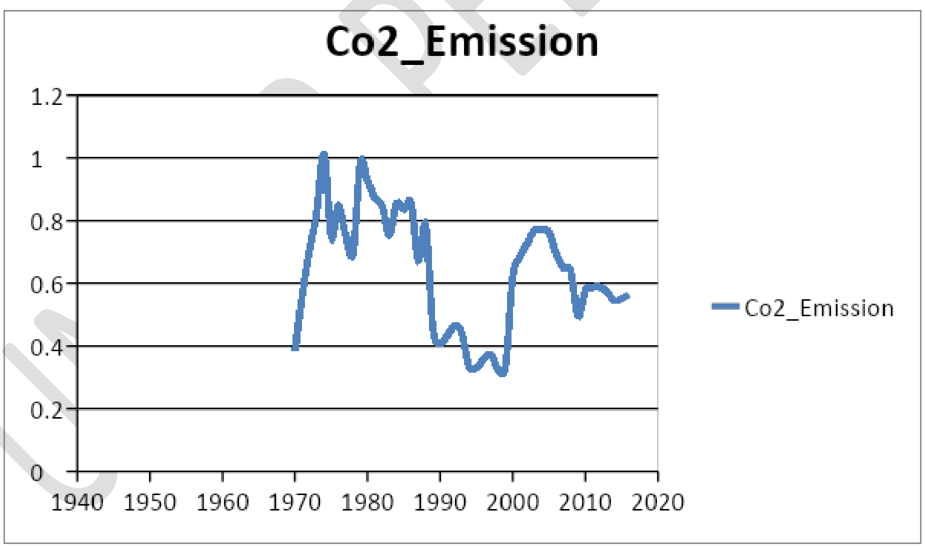

Figure 3: Carbon Emission pattern

The statistical information of Carbon Emission in Nigeria between 1970-2016 shows a rising trend with highest trend in the year 1974 and lowest in 1998. The highest value of Carbon Emission was 1.01ppm while the lowest recorded was 0.33 ppm. The result of the trend analysis for carbon emission in Nigeria shows an initial increase from the beginning of the period of study, after which the pattern became

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unstable. Carbon emission again rose and showed a dwindling pattern all through the period under study. The mean and standard deviation of Carbon Emission in the country over the period of study from 1970-2016 are 0.64 ppm and 0.19 ppm respectively.

Trend analysis of Crop productivity

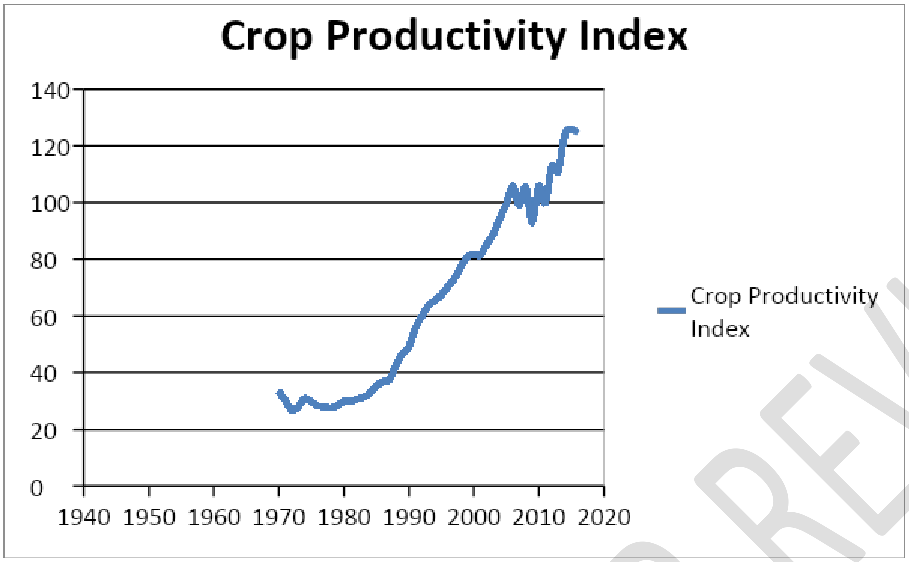

Figure 4: Crop productivity pattern

The statistical information of crop productivity in Nigeria between 1970-2016 shows a rising trend with highest trend in 2015 and lowest in 1972. The value of the highest crop productivity index was recorded as 125.77 while the lowest recorded as 26.96. The mean and standard deviation of crop productivity index in the country over the period of study from 1970-2016 are 66.88 and 32.83 respectively. The standard deviation shows that there is a large variability in the crop productivity index from year to year.

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Trend analysis of Livestock productivity

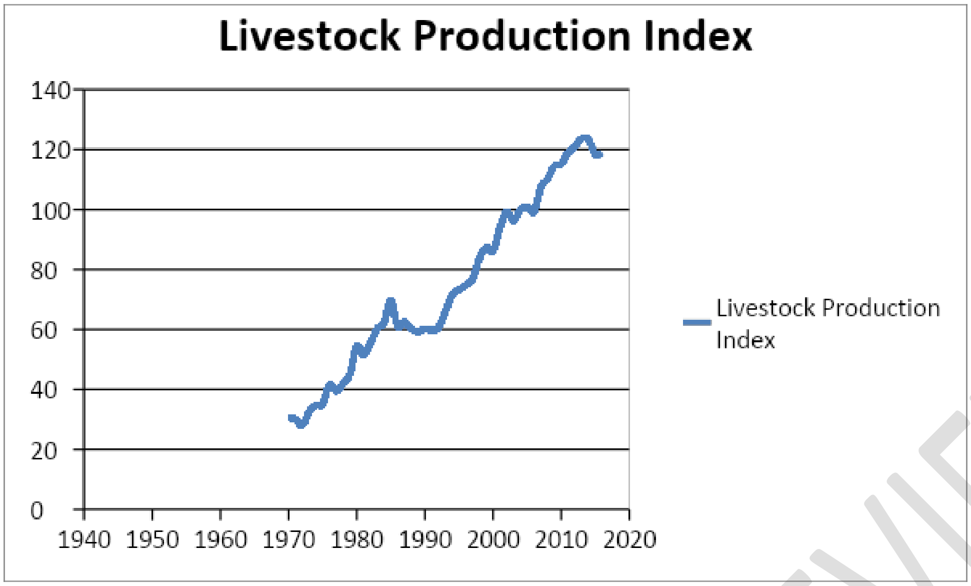

Figure 5: Livestock productivity pattern

The statistical information of Livestock productivity index in Nigeria between 1970-2016 shows a rising trend with highest trend in 2013 and lowest in 1971. The value of the highest livestock productivity index was recorded in year 123.65 while the lowest recorded was 28.05. The mean and standard deviation of Livestock productivity index in the country over the period of study from 1970-2016 are 74.81 and 29.69 respectively. The standard deviation shows that there is a large variability in the livestock productivity index from year to year. From 1960, the trend shows an increase in livestock productivity over the period under study. This increase can generally be linked to various policies initiated by the government over time.

Table 2: Result of Stationary test from Augmented Dickey Fuller unit root test

Variables	ADF Statistics	Critical Value at 5%	Order	Prob.	Decision
Carbon Emission	-7.633533	-2.928142	I(1)	0.0000	Stationary
Crop Productivity	-3.337586	-2.933158	I(1)	0.0193	Stationary
Livestock Productivity	-7.694295	-2.928142	I(1)	0.0000	Stationary
Rainfall	-7.527793	-2.929734	I(1)	0.0000	Stationary
Temperature	-8.106992	-2.929734	I(1)	0.0000	Stationary

Source: Authors Compilation 2020, E-views 10.

Table 2 presents the unit root test to ascertain if the variables used in the models of this study are stationary or non-stationary series. The unit root tests are conducted using Augmented Dickey-Fuller (ADF) procedure. The result of the table shows the stationary test using Augmented Dickey Fuller unit root test, it reveals that all the data are stationery at first difference. The stationary was determined at 5% level of significance. According to these results when crop productivity or livestock productivity index was used as regressand, the null hypothesis of a unit root cannot be rejected at the conventional (10%, 5% and 1%) significance levels. These results imply that each series is non-stationary at level but stationary at first difference.

This is evident from each of their ADF statistics value being greater than the critical value at 5% significance level and their p-values being less than 0.05. This indicates that each of the variables is

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integrated of order 1 series. Hence are regarded as I(1) series. The implication of this result is that using Ordinary Least Squares (OLS) method to estimate the parameters will give a spurious regression result.

Table 3: Co-integration tests results

Hypothesized No. of CE(s)	Engel value	Trace Statistic	0.05 Critical Value	Prob.**
None	0.568287	63.89333	69.81889	0.1356
At most 1	0.245875	26.09359	47.85613	0.8862
At most 2	0.157737	13.39472	29.79707	0.8727
At most 3	0.118358	5.669872	15.49471	0.7341
At most 4	2.76E-05	0.001243	3.841466	0.9712

Source: Computation from E-views 10

Trace test indicates no co-integration at the 0.05 level, * denotes rejection of the hypothesis at the 0.05 level

Table 4. Unrestricted Co-integration Rank Test (Maximum-Eigen Statistics)

Hypothesized No. of CE(s)	Engel value	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.568287	37.79973	33.87687	0.0161
At most 1	0.245875	12.69887	27.58434	0.9009
At most 2	0.157737	7.724850	21.13162	0.9198
At most 3	0.118358	5.668629	14.26460	0.6560
At most 4	2.76E-05	0.001243	3.841466	0.9712

Source: Authors computation

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level, * denotes rejection of the hypothesis at the 0.05 level

Table 5: Regression Result for Effect of climate change on crop productivity

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Rainfall	1.754283	0.369924	4.742277	0.0000
Temperature	46.36955	10.21360	4.539982	0.0001
CO2_Emission	-42.60713	17.67551	-2.410517	0.0206
C	-1320.633	259.4054	-5.091002	0.0000

R-squared	0.753706	Mean dependent var.	62.86455
Adjusted R-squared	0.735234	S.D. dependent var.	30.94122
S.E. of regression	15.92092	Sum squared resid.	10139.03
Durbin-Watson stat	1.265265	Long-run variance	460.7037

This section presents the regression analysis explaining the effect of climate change on crop productivity

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in Nigeria. The Fully-Modified Least Squares regression was used to estimate the parameters of the models. The estimating technique was used because of the behavior of the variables which were all integrated at order of one. The reported R-squared of the model shows that the model explains about 75% of the variations in climate contribution to crop productivity in Nigeria. This implies that the independent variable rainfall, temperature and Carbon emission jointly explained 75% of variation in crop productivity in Nigeria. This indicates that the model is in good fit. The Durbin-Watson statistics illustrate (1.26) absence of auto-correlation. Consequently, the interpretation of the results of the regression indicates that 1% increase in Rainfall will cause 1.75% increase in crop productivity in Nigeria.
The position is consistent with the finding of FAO (2008), that reduction in good quality and quantity of water at critical times of the year will negatively affect crop productivity. Also, 1% in average annual temperature will result in 46.4% increase in crop productivity in Nigeria. Furthermore, 5% increase in carbon emission will result in 42.6% reduction in crop productivity in Nigeria. Carbon dioxide effects are expected to have a positive impact due to, for example, greater water use efficiency and photosynthesis. The finding on Co_2 contradict the result in a study carried out by Oyiga et al.,(2011) which reported that increasing atmospheric Co_2 level is beneficial to plants: it acts as a fertilizer by enhancing the growth and development of crops. As increase in the atmospheric Co_2 levels would stimulate photosynthesis. However, it is important to mention that increased Co_2 would not only improve Co_2 level but would contribute also to greenhouse effects.

Table 6: Regression Result for Effect of climate change on Livestock productivity

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Rainfall	1.387853	0.388551	3.571873	0.0009
Temperature	51.41112	10.72787	4.792294	0.0000
CO2_Emission	-16.52289	18.56551	-0.889978	0.3788
C	-1423.037	272.4669	-5.222790	0.0000
R-squared	0.666012	Mean dependent var		73.83091
Adjusted R-squared	0.640963	S.D. dependent var		28.41670
S.E. of regression	17.02720	Sum squared resid		11597.02
Durbin-Watson stat	1.158665	Long-run variance		508.2663

The reported R-squared of the model shows that the model explains about 66.6% of the effect of climate change on livestock productivity in Nigeria. This indicates that the model is in good fit. The Durbin-Watson statistics illustrate (1.16) absence of auto-correlation. Coincidentally, the goodness of fit for the regression remained low after adjusting for degree of freedom as shown by adjusted R^2 (R^2 = 64.1%). The result also implies that 1% increase in Rainfall will cause 1.39% increase in livestock productivity in Nigeria. Also, 1% in average annual temperature will result in 51.4% increase in livestock productivity in Nigeria. The difficulty facing livestock is weather extremes, e.g. intense heat waves, floods and droughts. In addition to production losses, extreme events also result in livestock death (Gaughan and Cawsell-Smith, 2015). Animals can adapt to hot climates, however the response mechanisms that are helpful for survival may be detrimental to performance. However, increase in carbon emission will result in reduction in livestock productivity in Nigeria, the result was however not statistically significant. Livestock are adversely affected by the detrimental effects of extreme weather. Climatic extremes and seasonal fluctuations in herbage

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quantity and quality will affect the well-being of livestock, and will lead to declines in production and reproduction efficiency (Sejian, 2013).

Conclusion

The study assessed the effect of climate change on agricultural productivity (crop and livestock productivity in Nigeria with a view to providing understanding between the relationship between climate change and agriculture. We found evidence for the impact of the effects of climate change (rainfall, temperature and carbon emission) on agricultural productivity. The society and its economy are strongly dependent on agriculture where substantial proportion of this agriculture is rain-fed. Based on empirical evidence, the study concluded that climate change significant affect agricultural productivity in Nigeria. This is confirmed from the effects of climatic elements on crop and livestock productivity. Agricultural productivity is great impacted by climate change in Nigeria. It can also be said conclusively, that rainfall, temperature and carbon emission all impact agricultural productivity. Based on findings from this study, the study made the following recommendation, since the rising temperature and decreasing precipitation is presently inevitable; a National policy should be put in place to promote adaptation measures. Also, scaling up these adaptation benefits calls public investment to raise awareness and to provide technological support.

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