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CLIMATE CHANGE AND AGRICULTURE: MODELLING THE IMPACT OF CARBON DIOXIDE EMISSION ON CEREAL YIELD IN NIGERIA (1961 - 2018)

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ABSTRACT

Amidst increasing evidence of climate change and its impacts on food insecurity and economic growth, the study assessed Climate change and Agriculture nexus: Modelling the impact of Carbon dioxide emission on Cereal yield in Nigeria (1961 - 2018) with a view to assessing the impact of carbon dioxide emission (Co_2) on Cereal production and to contribute to the body of knowledge. The study utilized secondary data from FAOSTAT. The study utilized annual data spanning from 1961-2018 of Carbon emission, Cereal yield and Gross Domestic Product growth. Augmented Dickey-Fuller (ADF) analysis was used to make decisions on whether the variables were stationary or not. Autoregressive distributed lag method of estimation was used to examine the short-run and long-run effect of carbon emission on Cereal crop yield or performance in Nigeria. The result of the short-run model of the ARDL revealed that there was a negative relationship (-0.216025) between Carbon emission and Cereal yield in Nigeria and it's statistically significant at 5% level of significance while the long-run model of the ARDL revealed a direct relationship (0.175135) between Cereals yields and carbon emissions (CO_2), with impact statistically significant. The study concluded that there is direct relationship between Carbon dioxide emission and Cereals yields. The study recommended that efforts should be made to reduce the amount CO_2 or determine the optimal value of CO_2 required in the atmosphere to support plant photosynthesis for future crop production especially in low income countries with a relatively high population.

Keywords: Climate change, Agriculture, Cereal, Nigeria

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INTRODUCTION

Climate change is a serious concern today, and researchers are concerned with understanding its impact on growth and yield of crops, and also identifying suitable management options to sustain crop productivity under the climate change scenarios (Neenu and Subba, 2013). Climate variability results in fluctuations in crop yields to different degrees. Intergovernmental Panel on Climate Change (IPCC) defines climate change as any change in climate over time, whether due to natural variability or as a result of human activity. The impact of climate change varies with some regions experiencing extreme climate events than others while other parts of the world are suffering from indirect consequences such as reduced exports of agricultural products and higher food prices (GFSP 2015; Puma *et al.*, 2015). Empirical evidences show changes in world's climate, principally caused by the growing concentration of greenhouse gases (GHG) in the atmosphere induced by socio-economic development and human activities over time. The Concentrations of GHG, particularly carbon dioxide (CO_2), increased by 70% since 1970 (Sabrina and Donatella, 2014). Climate changes, associated with atmospheric accumulation of greenhouse gases, could alter level of temperature, rainfalls and regional water supplies. Most of the heating occurred in the last fifty years (IPCC, 2007 and 2000) and several researchers have predicted more consistent climate changes in several areas all around the world. There are many areas of the world finding it challenging to cope with the rapidly increasing warming at the surface and with an extreme of weather conditions (Sabrina and Vignani, 2014).

Due to the increasing incidence of climate change, developing economies suffer from water pollution, soil erosion and loss of biodiversity according to the Intergovernmental Panel on Climate Change. Field *et al.* (2012) and Groot *et al.* (2002) explained that climate change also threatens to make some land areas less productive for the use of agriculture. While also causing changes in temperature of the ocean thereby posing a great threat for coral reefs and fish population on which the life of human beings mostly depends. Essentially carbon emission is actually accessible in the environment as a component of earth however human activities enhances additional release resulting in change in the normal carbon cycle (EPA, 2013). The main source of human activities that increase CO_2 in the atmosphere is the combustion of fossil fuels for energy and the use of transportation and the fossil fuels are coal, natural gas, and burning of oil (EPA, 2013).

Carbon dioxide concentration and temperature are two important factors affecting crop production (Emam *et al.*, 2015). It was noted that while increasing CO_2 concentration (a key driver of climate change) could raise production of some crops (e.g., wheat), the changing climate, in general, is likely to have a negative effect on the length and quality of the growing season and also having a higher intensity of droughts and floods with countless consequences on crop production and agriculture in general (Jeremiah, Gershon and Tiena, 2018). On the other hand, temperature increase (a characteristic of climate change) of a few degrees is expected to generally raise crop production in temperate regions and greater warming may decrease crop yields in the tropics (Raleigh and Urdal, 2007).

Cereal are crops, typically grasses grown for their edible grains. Globally, cereal grains are produced in higher quantities than any other type of crop and deliver more food energy to human beings and livestock than other crops (Sarwar *et al.*, 2013). Cereal plant metabolic processes are controlled by weather variables like maximum and minimum temperature, solar radiation, carbon dioxide concentration and availability of water (McKevith, 2004). According to Nwaiwu *et al.* (2013), rainfall and temperature are the two major climate parameters that significantly affect the growth and productivity of most food crops. Ismaila, *et al.* (2010) noted that temperature specifically affects cereals production by controlling the rate of physio-chemical reaction and rate of evaporation of water from the crops and soil surface. Many researches had been carried out in Nigeria on the impact of climate change on agricultural production using secondary data. For example, Ayinde, *et al.* (2011) used co-integration method to analyse the effect of climate change on agricultural productivity in Nigeria. They found that temperature exerted a negative effect while rainfall change had a positive effect on agricultural productivity. Ajetomobi and Abiodun (2010) used trend and regression analysis to assess the climate change impacts on cowpea productivity in twenty states of Nigeria and their findings revealed negative and significant relationship between cowpea yield and temperature in the northern states; while increase in precipitation leads to an increase in yield in the southern states of Nigeria. Also, Igwe, *et al.* (2013) determined the direction of causality and effect of climate change on food grain output in Nigeria (1970-2010) using the Granger causality and regression analysis. Granger causality result showed that changes in rainfall and temperature positively affected food grain output in Nigeria. Ayinde *et al.* (2013) used unit root and co integration to evaluate the effects of climate change on rice production in Niger State, Nigeria. The result showed that humidity has a negative effect while minimum temperature had a positive effect on rice production. However, there is a dearth of research on impact of CO_2 on cereals production in the country especially having gathered from literature that in the last few decades, CO_2 emission is considered as the main source of global warming which is produced due to the development activities going on developing countries.

In developing countries like Nigeria, much attention has been paid to the relationship of CO_2 with financial growth, revenue rates, energy usage, and trade ease of access, with less emphasis on the relationship between CO_2 and major staple crops like cereals, it is against this background that this study examined Climate change and agriculture nexus: modelling the impact of carbon dioxide emission on cereal yield in Nigeria (1961 - 2018).

MATERIALS AND METHODS

Study area

The study was Nigeria. The study was carried out in Nigeria by using annual time series data of Nigeria Cereal yield, Carbon emission and GDP growth. National aggregates data for the country was used for the study. Nigeria is situated along the coast of West Africa between latitudes 4° and 14° N and longitudes 3° and 15° E. It shares a common boundary with Niger on the West, Cameroun Republic on the East, and Gulf of Guinea on the south. Nigeria occupies a land area of 98.3 million hectares, of which only about 34.2 million hectares are actually being cultivated and less than one percent of the arable land is irrigated (NBS, 2008).

Method of Data Collection

Data for this study were obtained from a secondary source such as FAOSTAT. This study used annual time series data which include Cereal yield, Carbon emission and GDP growth of Nigeria. The study covers a fifty-seven-year period of 1961 to 2018.

Method of Data Analysis

Inferential statistics was used to analyze the data of this study. Unit root or stationary test was conducted to make decisions on whether the variables are stationary; the Augmented Dickey-Fuller (ADF) test was used for this test. The ADF F-ratio critical value was used to make decision on the unit root of the variables and points Autoregressive Distributed Lag (ARDL) as the appropriate modelling technique for the study. The ARDL was applied to estimate both the short and long run relationships.

The Model

The study examined the effect of Carbon emission on cereal output in Nigeria. The model was specified as follows:

That is CY = f(CO2, GDPGR)

as the functional relationship of the model.

The mathematical form of the model as;

$CY = b_0 + b_1CO_2 + b_2GDPGR + e$ …… (1)

Where;

CY = cereal yield

CO_2 = carbon dioxide emission

GDPGR = gross domestic product growth rate

Data on cereal yield were logged to present all data in rates and enable interpretation in percentage.

$LnCY = b_0 + b_1CO_2 + b_2GDPGR + e$ …… (2)

The model is estimated in log linear form.

Where,

$\beta 0$ = The intercept/mean of the equation

$\beta 1$ to $\beta 2$ = The coefficients of the variables to be estimated

μ = The error term.

RESULTS

Stationarity Test Results

Table 1 shows the Stationarity Test result of the variables (CEREAL, CO_2 and GDP GROWTH (GDPGR)) by Augmented Dickey-Fuller (ADF) test. The findings revealed that one of the series (GDPGR) is stationary at level, while others (CEREAL and CO_2) were stationary at order of one. Therefore, the order of Stationarity is mixed and this made Autoregressive Distributed Lag (ARDL) an appropriate modelling technique.

Table 1: Result of Autoregressive Distributed Lag (ARDL) Unit Root Test

Variables	Augmented Dickey Fuller Statistics		Augmented Dickey Fuller (ADF)
	Level	First Difference	5%
CEREAL	-1.680158	-8.779625**	-2.913549
CO_2	-2.247576	-7.797942**	-2.913549
GDPGR	-4.719865*	-7.354021**	-2.913549

(*) stationary at level   (**) Stationary at first difference

ARDL Bound Test

Table 2 shows the ARDL Bound Test. The findings show that the F-statistics value is 12.264819. This value is greater than the lower bound critical values I(0) and the upper bound critical values of I(1) at all levels of significance. This implies that, there is a long-run relationship in the model and that ARDL is an appropriate estimation method for the study and therefore, we went ahead to get the Short-run and Long-run relationships of the variables.

Table 2: Result of ARDL Bound Test on Determination of Short and Long run relationship.

Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	12.264819	10%	2.63	3.35
K	2	5%	3.1	3.87
		2.5%	3.55	4.38
		1%	4.13	5

ARDL Short-Run Test

Table 3 presents the short-run forms of the ARDL model used for the analysis of this study. The short-run model revealed that there is a direct negative and statistically significant relationship (-0.216025) at Five (5%) percent level of significance between carbon dioxide emission and cereal yield in Nigeria**,** a**s** captured by cereal yield (Cereal) as a function of carbon dioxide emission (CO_2) with Gross Domestic Product Growth Rate (GDPGR). The coefficient of co-integration (Coint Eq (-1)) which stood at -0.126 is an indication that 12.6% of disequilibrium in the model is corrected annually, this shows a slow speed of adjustment but statistically significant towards long run equilibrium.

Table 3: Short run relationship of the variables employing ARDL Approach

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CO_2	-0.216025	0.122620	-1.761747	0.0402
GDPGR	-0.002291	0.001928	-1.188111	0.2404
CointEq(-1)*	-0.126269	0.040747	-3.098844	0.0032

ARDL Long-Run Test

Table 4 shows the Long-Run estimates of the ARDL. The long-run estimates of the ARDL revealed a direct relationship between cereals yield (Cereal) and carbon dioxide emission (CO_2), this impact is statistically significant at 5% level. The result also shows a negative relationship between Gross Domestic Product growth rate and cereal yield in the long run.

Table 4: Long run relationship of the variables employing ARDL Approach

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
CEREAL	0.657706	0.137385	4.787321	0.0000
CO_2	0.175135	0.070360	2.489127	0.0162
GDPGR	-0.002291	0.002355	-0.972940	0.3353
C	0.794651	0.389618	2.039564	0.0467

DISCUSSION

The mixed order of stationarity of the series made Auto-regressive Distributed Lag (ARDL) the appropriate analytical model to be used in assessing the nature of relationship that exists among the variables and this is in line with principle of ARDL that, ARDL can only be used as an analytical tool for series when the order of stationarity is mixed.

The value of ARDL Bound Test F-statistics of 12.264819 which is greater than the lower bound critical values I(0) and the upper bound critical values of I(1) at all levels of significance confirms that, there is a long-run relationship between Cereal yield in Nigeria and CO_2 emission. In the long-run a unit change in CO_2 will be accompanied by 0.175135 unit increase in Cereals yields and this is at 5% level of significance. This result agrees with Pusp *et al.* (2020) who reported that CO_2 emission has a positive effect on Cereal Production and that, the coefficient of CO_2 reveals that a one percent rise in the carbon emissions leads to a 0.12 percent increase in cereal production. This finding suggests that carbon emission plays a positive role in the growth of cereal crops. Sometimes the adverse effects of climate change can be beneficial for cereal production. This can be understood that carbon dioxide levels are expected to have a positive impact by cutting transpiration rates and increasing their growth rate. This is because the crop plants with increased CO_2 levels may use more water efficiently and effectively, thereby increasing the cereals production in lower-middle-income countries. This finding is consistent with studies in the literature (Loum and Fogarassy, 2015; Onour, 2019; Chandio *et al.*, 2020; Ahsan *et al.*, 2019; Demirhan, 2020; Baig *et al.*, 2020)**.** This result agrees with the findings of Faiza and Wang (2019) who reported that the long-run coefficients, energy consumption and CO_2 emissions have a positive impact on cereal crops production. The results of this research are consistent with the results of Janjua *et al.* (2014), Lili *et al.* (2011) and Chandio *et al.* (2018).

CONCLUSION AND RECOMMENDATION

This study examined the impact of Carbon dioxide emission on cereal yield in Nigeria (1961 - 2018). The study revealed that there is a negative and statistically significant relationship between carbon dioxide emission and cereal yield in Nigeria on the short-run. Also, on the long run there is a direct relationship between cereal yields and carbon dioxide (CO_2) emission and this impact is statistically significant. Based on findings from the study, it is recommended that efforts should be made to determine the optimal value of CO_2 required in the atmosphere to support plant photosynthesis for future crop production especially in low income countries with a relatively high population thereafter, carbon emission should be checked not to exceed the beneficial threshold.

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