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CLIMATE CHANGE AND AGRICULTURAL PRODUCTIVITY IN NIGERIA: AN ECONOMETRIC ANALYSIS

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ABSTRACT

The growing concern over the threat to world food security calls for a re-examination of the factors that affect agricultural productivity. This threat becomes more worrisome because of the high prevalence of diseases associated with hunger and poor nutrition intake. This paper examines the impact of climate change on agricultural productivity in Nigeria. Carbon emission was used to capture the effect of climate change. We examine the effect of climate change on the short-run and long-run productivity using the autoregressive distributed lag model (ARDL). Our regression result reveals that climate change affects agricultural productivity both in the short run and long run. Other variables that significantly affect agricultural productivity are oil export, subsidy and consumer price index. To ensure food security and sustainable agricultural production in the future, the authors recommend that efforts should be geared towards reducing carbon emission. According to them, this can be achieved by placing disincentives like carbon tax on emission beyond the limits agreed at the Lima 2014 climate summit. Other methods proposed by the authors include: deemphasizing the importance of crude oil in the Nigerian economy, a reduction or an outright removal of agricultural subsidies and shielding farmers from adverse market conditions.

INTRODUCTION

Over the years, there have been growing concerns over the present and the future of world's agricultural productivity. This fear is more pronounced in developing countries where most farmers still make use of crude agricultural instruments. The present concern is linked to the fact that declining agricultural produce may not meet the food and material demand of the ever-growing world population; hence posing grave consequences to world's food security and output. The concern for the future is engineered by the fact that shortage of food today may hamper future world development. One factor that has been attributed to the declining agricultural productivity is changes in climatic factors. Changes in climatic factors do not only impair agricultural productivity, it also poses a threat to human existence.

The situation is worrisome because some agricultural activities produce green house gases (GHG) like carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O); thus further compounding the impact of climate change on agricultural productivity (Adhya, $et\ al$ 2009). Agriculture is estimated to account for about 14% of total global anthropogenic emissions of GHGs and 47% and 84% of total anthropogenic CH_4 and N_2O emissions respectively (US-EPA 2006). Emissions of CO_2 mainly from land use changes, especially deforestation for agricultural purposes, are estimated to account for 15% of anthropogenic CO_2 emissions (FAO 2003). Globally, agricultural emissions have increased by 14% from 1990 to 2005 with an average annual emission of 49MtCO2 eq.yr−1 (US-EPA 2006). US-EPA forecasts acceleration in the global GHG emissions from agriculture for the period 2005–2020. The increase of greenhouse gas concentrations in the atmosphere is raising average temperatures. The consequences include changes in precipitation patterns, more frequent extreme weather events, and shifting seasons. The accelerating pace of climate change, combined with global population and income growth, threatens food security everywhere.

Climate change has an adverse effect on food and water resources which are critical for livelihood in Africa, where agriculture is mainly rain-fed (seasonal). Unfortunately, the agricultural sector is the major employer of labour in the continent with a percentage ranging between 60-70% of the labour force. In addition, it contributes significantly to the gross domestic product and exports. So disruption of the existing food and water systems will have devastating implications for development and economic growth; and as such worsen the challenges climate change already poses to poverty eradication and environmental sustainability. Owing from the above, it is imperative that the protection of the environment (by providing safety-nets and support system for fulfilling all development aspirations of man), should be of paramount importance.

Climate change is the most severe challenge facing the world today and it has been declared a more serious threat than global terrorism (King 2004 and Ayinde 2011). The Niger-Delta region of Nigeria is reported to have over 123 gas flaring sites making Nigeria one of the highest emitters of GHGs in Africa (Akinro et al. 2008). A recent study by World Bank (2008) revealed that Nigeria accounts for roughly one-sixth of the worldwide gas flaring because 75% of her gas is flared. Sub-Saharan African countries including Nigeria are likely to suffer the most because of their geographical location, low incomes, low institutional capacity, rain-fed agriculture, high levels of poverty, low levels of human and physical capital development, poor infrastructure as well as their greater reliance on climate sensitive renewable natural resources sector like agriculture (Eboh 2004 & Watson 1997). Eboh and Anyadike (2009) opined that the effects of climate change are projected to manifest through changes in land and water regimes, specifically, changes in the frequency and intensity of droughts, flooding, water shortages, worsening of droughts, worsening soil conditions, desertification, disease and pest outbreaks on crops and livestock etc.

Specifically, Ozor (2009) stated that the South-South and South-West geo-political zones are mainly affected by sea level rise and deforestation-induced changes; South-East by erosion, flooding and land degradation; North-Central by changes due to de-vegetation and overgrazing; North-East by drought, desertification and heat stress. Related studies on Latin America, Africa and the United States have shown that increase in temperature reduces agricultural productivity, while increase in rainfall increases crop yield and livestock production (See Sala&Paruelo (1994), Adams et al. (1998), Ayinde et al. (2011), Edame et al.(2011)).

Based on the foregoing, the broad objective of this research is to ascertain the impact of climate change on agricultural productivity in Nigeria. The specific objectives are:verify whether or not agricultural productivity and climatic factor(s) co-move in the long run; calculate the long run effects of climatic factor(s) on agricultural productivity; and ascertain the speed of adjustment.

LITERATURE REVIEW

There is almost no disagreement among economists that the full cost to society of burning a ton of carbon is greater than its private cost. Burning carbon has an external cost because it produces CO_2 and other greenhouse gases (GHGs) that accumulate in the atmosphere, and will eventually result in unwanted climate change.

Posner et al (2008) estimated the relative contributions of annual carbon dioxide emissions by country/region as: United States at 23.5%, 22.0%, 19.4%, and 18.5% in 1990, 2004, 2015 and 2030 respectively. While Africa emitted 3.1%, 3.4%, 3.8% and 3.9% in 1990, 2004, 2015 and 2030 respectively.Ibrahim et al (2010) provided hypothetical analyses of the preceding assertion that Nigeria, like many countries within the semi-arid regions of Africa has been beset by several climatic anomalies. They recommended that farmers should adopt new farming approaches and improved varieties.

Ogundele and Jegede (2011) using both primary and secondary data, revealed that food crops are the major crops affected by climate change via soil loss, plant nutrient loss, pest and diseases etc. The study recommended that cover trees should be cultivated to reduce heat and preserve underground water.Kumar et al (2014) using panel regression analysis for thirteen states in India examined the effects of climatic and non-climatic factors on food grain productivity in India. The study covered 1980-2009. Their findings reveal that the productivity of rice and maize crops are negatively influenced by increase in actual average maximum temperature. On the other hand, actual minimum temperature has a negative and significant influence on the productivity of wheat, barley and grain.

Ifeanyi-Obi et al (2012) opined that the effect of climate change on Nigeria is high because her agriculture is rain-fed. They emphasized that the development of resilience and adoption strategies is very important.Nwaiwu et al (2013) using primary data, discovered that farm size, annual income, household size, level of education and climate change are significantly and inversely proportional to agricultural sustainability. They concluded that efforts should be made at both the micro and macro levels of government to improve on mitigating and adaptive strategies of climate change available to farmers by making such more affordable and user-friendly through extension education.

Edame et al (2011) examined the impact of climate change on food security and agricultural productivity in Sub-Saharan Africa (SSA). They noted that wetter climates and more floods are predicted for parts of East Africa and Latin America.Parry et al (2004) analyzed the global consequences to crop yields, production and the risk of hunger of linked socio-economic and climate scenarios. They adopted the basic linked system (BLS) to evaluate changes in global cereal production, cereal prices and the number of people at risk from hunger.

Adams et al (1998) reviewed the extant literature on the physical and economic effects and interprets their research in terms of common themes or findings. They discovered the role of human adaption in responding to climate change, possible regional impacts to agricultural systems and potential changes in patterns of food production and prices. Ayinde et al (2011) discovered that the effect of climate change on agricultural productivity is critical given its impact in the changing livelihood patterns in Nigeria. Descriptive and co-integration analysis were the techniques used to analyze the time series data in their work. They found that the rate of agricultural productivity was persistently higher between 1981 and 1995, followed by a much lower growth rate in the 1996-2000 sub-periods.

MODEL SPECIFICATION AND METHODOLOGY

Our present work focuses on verifying the long run and short run effects of climate change variables on agricultural productivity. The functional form of the model will be

$$AGV = f(CLI, Sub, GCF, CPI, Oilex) \ldots\ldots\ldots\ldots\ldots \quad (1)$$

$AGV$is a variable for agricultural productivity, CLI is a proxy for climate change. And it is the sum of carbon dioxide, methane and nitrous oxide emissions. The other variables are gross capital formation (GCF), consumer price index (CPI), subsidy (Sub) and oil export ($Oilex$)

Since we are working with secondary data, there is a possibility that some of the variables might be trending; hence they might not be stationary at level. To forestall this possibility, unit root tests will be carried out on each of the variables. Since our present focus is on estimating the short-run and long-run impacts of some variables (including climate change), some of the variables of interest may be stationary at level or at first difference. When this is the case, the Johansen Cointegration test procedure breaks down. Hence, we resort to the autoregressive distributed lag approach to cointegration (Bounds Testing Approach) proposed by Pesaran and Shin (2001). The bounds testing approach to cointegration is very flexible because it is able to manage variables with different levels of stationarity. The ARDL model convenient for this purpose is specified below:

$$\Delta AGV_t = \sum_{I=1}^{n} \pi_i AGV_{t-I} + \delta_0 CLI_t + \sum_{i=1}^{n} \delta_i \Delta CLI_{t-i} + \beta_0 SUB_t + \sum_{I=i}^{n} \Delta\beta_i SUB_{t-i} + \alpha_0 OIL_t + \sum_{i=1}^{n} \Delta\alpha_i OIL_{t-i} + \lambda_0 CPI_t + \sum_{i=1}^{n} \Delta\lambda_i CPI_{t-i} + \Omega_0 GCF_t + \sum_{i=1}^{n} \Delta\Omega_i GCF_{t-i} + u_t$$

The bound testing approach developed by Pesaran and Shin (2001) will be convenient in this case. This method enables us to ascertain simultaneously whether or not these variables co-move and their speed of adjustment.The study area is Nigeria. The scope of the research will be from 1980-2014. Data were sourced from the National Bureau of Statistics (NBS), Central Bank of Nigeria (CBN) Statistical Bulletin, African Development Indicators (ADI), African Development Bank (ADB) Database, World Bank Database, Agricultural Organization Publication (FAO), African Meteorological Agency and Nigerian Meteorological Agency.

RESULTS AND DISCUSSION

Table 1 Unit Root Results

Variables	Level	P values	First Difference	P values
Agric	Not Stationary	0.999	Stationary	0.003
CLI	Not Sationary	0.2484	Stationary	0.000
Subsidies	Not Sationary	0.578	Stationary	0.046
GCF	Not Stationary	1.000	Stationary	0.032
CPI	Stationary	0.049	---	---
Oilex	Not Stationary	1.000	Stationary	0.045

The table above presents the unit root tests for each of the variables. All the variables, except consumer price index (CPI) are stationary after first differencing. CPI however is stationary at level. The mixture of variables that are stationary at different orders of staionarity lends support for our choice of the ARDL approach as a method of analysis. We therefore proceed with our model estimation.

Table 2 presents the bounds cointegration test obtained from the parsimonious ARDL model (available on request)

Table 2: Bounds Cointegration Test

F-statistic	5.071138	
Significance	Lower Bound	Upper Bound
10%	2.26	3.35
5%	2.62	3.79
2.50%	2.96	4.18
1%	3.41	4.68

The table shows that all the variables are cointegrated in the long run. This is so because the calculated F-statistic of 5.07 is greater than the lower and upper bounds at all levels of significance. With this result, we then proceed to the estimation of the short run and long run regression results. Table 3 presents the short run error correction results obtained from the most parsimonious ARDL result

Table 3: Short Run ARDL Results

VARIABLES	COEFFICIENTS	STANDARD ERROR	t VALUES	p Values
D(CLI)	-17.962116**	6.734078	2.667346	0.0321
D(CLI(-1))	-10.658637	6.407974	-1.66334	0.1402
D(CPI)	0.397608**	0.209163	1.900954	0.0991
D(CPI(-1))	-0.460102	0.650638	-0.70716	0.5023
D(GFCF)	-0.000085**	0.000036	-2.34893	0.0512
D(GFCF(-1))	0.000088	0.000057	1.535502	0.1685
D(OILEX)	-0.000009**	0.000005	-1.63159	0.0468
D(OILEX(-1))	-0.000002	0.000007	-0.32495	0.7547
D(SUB)	0.005339***	0.00332	1.60802	0.0519
D(SUB(-1))	0.033385	0.020666	1.615491	0.1502
CointEq(-1)	-0.780153**	0.222997	-3.49849	0.01

*, **, *** signifies significant at 1%, 5% and 10% respectively

Table 3 presents the short run parameters of the ARDL model specified above. Only one lag was selected for climate change (CLI) and a lag length of two was selected for each of the independent variables. The result shows that climate change has a significant impact on agricultural productivity in the short run. The negative coefficient implies that as activities that contribute to climate change increase, a decline in agricultural value added is the consequence. The second lag of climate change is also negative, although not significant.

Consumer's price index (CPI) and subsidy (SUB) both have positive and significant effects on agricultural value added in the short run. The positive CPI value implies that higher aggregate prices encourage agricultural productivity. Their second lags are however not significant.

Gross capital formation (GFCF) and oil export (OILEX) both have negative and significant coefficients. Although, the effect of GFCF is weak, it implies that an increase in the economy-wide capital stock leads to a decline in agricultural value-added in the short run. The negative coefficient of oil export on the other hand, confirms the result of (Amos, 2009) on the effect of oil sector development on the agricultural sector in Nigeria.

The error correction term is negative and significant as expected. The coefficient of -0.78 implies that approximately 79% of the deviation of agricultural productivity from its long run value is corrected in the current period. It also implies that it will take approximately a quarter for the short run value of agricultural productivity to adjust to its long run value.

Table 4: Long Run ARDL Results

VARIABLES	COEFFICIENTS	STANDARD ERROR	t VALUES	p –values
CLI	-33.594789**	9.811074	3.42417	0.0111
CPI	0.770563	0.514523	1.497627	0.1779
GFCF	-0.000084	0.000087	-0.96005	0.369
OILEX	-0.000014	0.000013	-1.06237	0.3233
SUB	-0.005961	0.029396	-0.20277	0.8451
C	13.045686**	5.203646	2.507028	0.0406

*, **, *** signifies significant at 1%, 5% and 10% respectively

Table 4 presents the long run results. Again, climate change has a negative and significant effect on agricultural value-added. This implies that in both the short run and long run, climate change negatively impacts on agricultural productivity. The long run impacts of other variables are insignificant.

CONCLUSION AND RECOMMENDATION

Over the decades, issues of climate change have occupied central stage in international policy debates. The debates usually stem from the fact that changes in climatic conditions may negatively affect the environment and pose serious health hazards to humans. Another way changes in climatic condition may affect human is through its negative impact on the biosphere. This is so because adverse changes on the biosphere will affect agricultural productivity. In the previous section, it was revealed that climate change impact negatively on agricultural productivity both in the short run and long run. Other variables that significantly impact on agricultural productivity are oil export, subsidy and the consumer price index; though their impacts are pronounced only in the short run.

To ensure food security both in the short run and long run, efforts should be geared towards reducing carbon emission. Given the fact that most of the green house emission emanates as a result of industrial activities, policy makers should ensure that the method of production is environmentally friendly. This can be achieved by placing disincentives like carbon tax on producers that emit carbon beyond the Kyoto 2007 limit.

Other options that can be explored to improve agricultural productivity in Nigeria are deemphasizing the importance of crude oil in the Nigerian economy, a reduction or an outright removal of agricultural subsidies and shielding farmers from adverse market conditions.

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