American Journal of Environmental Protection, 2015, Vol. 3, No. 2, 44-47
Available online at http://pubs.sciepub.com/env/3/2/1

DOI:10.12691/env-3-2-1

The Impact of Climate Change on Composition of Agricultural Output in Nigeria

Akinbobola. T. O.[1], Adedokun. S. A.[1], Nwosa. P. I.[2,*]

[1]Department of Economics, Faculty of Social Sciences, Obafemi Awolowo University
[2]College of Management Sciences, Bells University of Technology
*Corresponding author: nwosaphilip@yahoo.com

Received March 05, 2015; Revised March 30, 2015; Accepted April 08, 2015

Abstract This study examined the impact of climate change on the composition of agricultural output in Nigeria for the period 1981 to 2011. Using an Ordinary Least square (OLS) estimation technique, the study observed that with exception to fishery production, climate change had a significant and positive impact on the composition of agricultural output in Nigeria. This finding is in contrast to a priori expectation and also in contrast to the findings obtained by previous studies. Thus, the study recommends the need for further study on this issue to verify the claims of this and also by using other indicators of climate change.

Keywords: *climate change, crop production, livestock production, forestry production, fishery production, Nigeria*

Cite This Article: Akinbobola. T. O., Adedokun. S. A., and Nwosa. P. I., "The Impact of Climate Change on Composition of Agricultural Output in Nigeria." *American Journal of Environmental Protection*, vol. 3, no. 2 (2015): 44-47. doi: 10.12691/env-3-2-1.

1. Introduction

Climate change has been described as a statistically variation that persist for an extended period, typically for decades or longer. It includes shift in the frequency and magnitude of sporadic weather events as well as the slow continuous rise in global average surface temperature (Intergovernmental Panel on Climate Change (IPCC, 2001). The German Advisory Council on Climate Change noted that climate change is a threat already having substantial impact on human beings and the natural eco-system both in developed and developing countries but at varying degree (WBGU, 2003). For the developed countries, the impact of climate change has been perceived to be less severe due to natural advantage, high adaptation techniques, high technology, mechanised agricultural system and wealth status. The presence of these factors has enabled the developed countries to curtail the adverse effect of climate change. For developing countries (Nigeria inclusive), the impact of climate change is of great momentum given the high temperature level, poor adaptation capacity, lack of early warning system and low national income level of these countries.

Apart from the above, climate change affects economies whose economic activities are natural resource sensitive such as agricultural activities. Further, there is general consensus that climate change may lead to significant reductions in agricultural productivity in developing countries (McGuigan et al., 2002). The effect of climate change on agricultural activities can be view from various aspects. Climate change affects the distribution of rainfall and temperature during a year and this determines the growing season of annual crops and influence yields especially those crops cultivated under rain-fed conditions (Thurlow et al., 2009). Excessive rainfall leads to destruction of arable land, impairment of cultivated crops, increased growth of weeds and greater post harvest loss while a significant reduction in rainfall may culminate in drier land; reduction in water level in streams and rivers; increases farmers' search for water for irrigation and consequently resulting in invaluable man hour loss and reduction in crop yield (Ozor, 2009).

Apart from crop production, climate change affects livestock production due to reduction in the available pasture land; declining of surface water resources for animal; increase in salinity of water resources for animals; increase in salinity at watering points due to increase temperature and evaporation in the face of reduced rainfall (Ozor, 2009). The implication of the above is a decline in the production of livestock, resulting in a reduction in the supply and availability of animal protein including meat, egg, milk and other animal produce such as hides and skins (Ozor, 2009).

Also, fisheries supply through marine, river and stream constitute an important source of the world fishery supply and represent greater importance for local or regional food security in developing countries where fish provides an important source of protein. However, the decline in availability of surface water, increase in salinity of water resources and increase evaporation in the face of decline rainfall also affects fishery production.

Climate change also affects forestry due to erosion and excessive wind thereby resulting in decline in forest produce such as wood and canes; the consequences of which is not only reduction in forestry produce and low income but an increase in building and furniture materials.

For instance, the estimated cost of the deforestation and losses in non timber forest products in the last five in Nigeria was put at N120 billion per year, or 1.7% of GDP in 2003 (Onuoha, 2009). From the above discussion, it is evident that climate change portrays a potential threat to the composition of agricultural output in particular and to aggregate agricultural output in general.

Although studies exist in the literature on the effect of climate change on agricultural output and economic development in the developed and developing countries, little or no attention has been paid to the extent to which climate change affects the composition of aggregate agricultural output in Nigeria. Analysing the effect of climate change on composition of agricultural output rather than on aggregate agricultural output is pertinent because the effect of changes in aggregate agricultural output may be the weighted total of the effects on its composition, and by simply analysing aggregate analysis may ignore the individual response of each component of aggregate agricultural output to climate change. The outcome of this study will also inform policymakers on whether or not there is an even effect of climate change on the components of agricultural output, thereby assisting, policymakers in devising appropriate-specific policies for each component of agricultural output rather than the usual one-fit-for-all policy base on the outcomes of previous endogenous studies on aggregate agricultural output-climate change estimates.

In addition to the introductory section, the paper has five parts. Section 2 presents the review of related literature while chapter three presents the methodology through which the objective of the study is achieved. In section four, the empirical estimate is discussed while in chapter five, the conclusion and policy recommendation is presented.

2. Empirical Review

Recent empirical studies have confirmed that climatic change and variability can have substantial impacts on agricultural output (Skoufias *et al.*, 2011). In Ethiopia, Gebreegziabher *et al.* (2011) examined the economic effect of climate change on agriculture productivity using a countrywide computable general equilibrium model. The study observed that the impact of overall climate change will be relatively benign until approximately 2030 and then worsens considerably. Further, the simulation results showed that, over a 50-year period, the projected reduction in agricultural productivity may lead to about thirty (30) percent less average income, compared with the possible outcome in the absence of climate change.

Ozor (2009) using descriptive analysis demonstrated the processes that lead to climate change so as to enable a better understanding of the concept. The study described in details the impacts of climate change on various issues of national development such as low agricultural productivity, food insecurity, resource conflicts, unemployment, environmentally-induced migration, livelihood problems and health issues. The study also noted that these impacts are as a result of devastating effects of flooding, drought, erosion, desertification, sea level rise, heat stress, pests and diseases, erratic rainfall patterns, etc which are all due to climate change. The study further suggested the need for climate policy in Nigeria; the establishment of Nigerian Climate Change Commission (NCCC); the development of a national framework for climate change adaptation; and the embracing of emerging technologies among others. In addition, Ozor (2009) showcased the new role of agricultural extension in the face of climate risk management. These include awareness creation, mobilization, training, assistance, and dissemination of proven measures of mitigation/adaptation to climate change among vulnerable communities in Nigeria.

Onuoha (2009) examined the threats presented by changes in climate all over the world with particular reference to developing countries (Nigeria) where agriculture is a dominant sector and depends on weather and climate. The study utilized the sustainable development model in the form of the Green Wall Sahara Nigeria programme (GWSNP) as a strategy for greening the drought-prone and desert infested areas of Northern Nigeria (11 States). The study concluded with the assertion that the challenges of climate change to economic growth and sustainable development in Nigeria require creative thinking, holistic ideas, innovative solutions and the involvement of all stakeholders.

Agwu and Okhimamhe (2009) conducted two studies on the gender dimensions of climate change in the North-Central parts and South-Eastern of Nigeria. The North-Central study assessed the impact of climate change on the Zumba and Augie communities in Niger and Kebbi states respectively. It equally tackled the issue from a gender perspective which highlighted the challenges and adaptation strategies of the selected communities. From this first study, the study observed that communities had noticed changes in climate but failed to identify their causes. Some of the women in this community attributed the climate change such as environmental degradation to the construction of the Shiroro dam and the resulting massive deforestation. Less scientifically, the Augie women believed that the flood waters from Bakolori and Goronyo dams which destroy their farms and affect the health of their people were calamities inflicted by God. Also, the women accepted that they had contributed to deforestation in their search of fire wood which led to the disappearance of many plant and animal species. Although these resilient communities have put various adaptation measures in place, they were not primarily targeted at reducing the impact of climate change. The Augie community is already practicing a number of coping strategies and requesting for assistance to strengthen them. Specifically, the stakeholders of the community requested for funding, awareness campaigns and capacity building. In Zumba, awareness campaigns is also needed to address traditional beliefs. The second study also focused on two South-eastern communities; namely: Enugwu Nanka in Anambra State and Akama Amankwo Ngwo in Enugu State. The study revealed that the impacts of climate change in South-Eastern Nigeria include: the destruction of shelter (both human and animal), arable farmlands, access roads and economic trees by landslides and tornadoes. Climate change is also responsible for excessive heat, heightened insect activity and the drying up of streams. Drawing from the findings of the two samples region, the study concluded that while ingenious adaptive and mitigation strategies developed by women

were encountered in sample states, better policy making to combat climate change is desperately needed.

Zhai et al. (2009) examined the long-term potential effect of global climate change on agricultural production and trade in the People's Republic of China. Utilizing an economy-wide, global Computable General Equilibrium (CGE) model as well as simulation scenarios of how global agricultural productivity may be affected by climate change up to 2080; the study suggested that, with a declining share of agriculture in GDP, the impact of climate change on the overall macro economy may be moderate. Food processing sectors carry the burden of some crop sectors (wheat, in particular) that are likely to expand due to better demand.

In Sri Lankan, Seo et al. (2005) analysed the effect of climate change impact on agriculture productivity using the Ricardian method and five AOGCM experimental models. The model analyse the net revenue per hectare for four most important crops (rice, coconut, rubber, and tea) in the country. The study focused more on the precipitation effect on crop production due to the greater range of precipitation across the country although the limited range of temperature variation allowed only a simple test of temperature impacts in the study. Both the Ricardian method and five AOGCM experimental models showed that the effects of increase in precipitation are predicted to be beneficial to all crops tested and the benefit ranged from 11 % to 122 % of the current net revenue of the crops in the model. On the other hand, the impacts of increase in temperature were predicted to be injurious to the economy and the loss ranged from −18 % to −50 % of the current agricultural productivity (as cited in Lee et al., 2012).

Barrios *et al.* (2004) examined the impact of climatic change on the level of total agricultural production of Sub-Sahara Africa (SSA) and non-Sub-Sahara Africa (NSSA) developing countries. The study utilized a new cross-country panel climatic dataset in an agricultural production framework. The findings of the study revealed that climate, measured as changes in country-wide rainfall and temperature has been a major factor influencing agricultural production in SSA while in NSSA countries agricultural production seems not to be affected by climate change. Furthermore, simulations using the estimates suggest that the detrimental changes in climate since the 1960s can account for a substantial portion of the gap in agricultural production between SSA and the rest of the developing world.

Rosenzweig and Parry (1994) examined world food supply, food prices and the number of people at risk from hunger in developing countries. The study found that whilst developed countries are likely to experience some increase in agricultural output, developing countries suffer a decrease in the scenarios which were constructed.

From the above reviewed studies, it is evident that studies have paid little or attention on the extent to which climate change affect the composition of aggregate agricultural output, particularly with reference to Nigeria. This is the empirical gap this study intends to fill in the literature.

3. Research Methodology

3.1. Model Specification

To examine the relationship between climate change and agricultural production, this study specifies a simple estimating model as:

$$AGR^{i}_{t} = f\left(CAP_t, LAB_t, CC_t\right) \quad (1)$$

Log-linearizing equation (1) and introducing constant and error term, we have:

$$\log AGR^{i}_{t} = \alpha_0 + \log\alpha_1 CAP_t + \log\alpha_2 LAB_t + \log\alpha_3 CC_t + \varepsilon_t \quad (2)$$

α_0 and ε_t are the constant and error term respectively; α_1, α_2, and α_3 are the coefficient; superscript *'i'* refers to composition of agriculture and subscript *'t'* refers to current time.

3.2. Measurement and Source of Data

Composition of agricultural output *(AGR)* is measured by the outputs of the composition (which include crop production (*CRP*), livestock (*LSK*), forestry (*FRY*) and fishery (*FSH*)) agricultural output. Climate change *(CC)* is proxy by variation in rainfall and this is measured by the standard deviation of the annual average rainfall over the study period[1]. Capital stock *(CAP)* is measured by gross fixed capital formation and labour force *(LAB)* is measured by the total working population. Data on composition of agricultural output, capital stock and annual rainfall are obtained from the Central Bank of Nigeria (CBN) statistical bulletin 2011 while data on labour force is obtained from World Development Indicator (WDI) 2012 edition.

4. Empirical Result

The regression estimate on the effect of climate change on the composition of agricultural output is presented on Table 1 below. It is observed from the table that the coefficient of determination (R^2) ranged from 0.78 percent for the FRY model to 0.96 for AGR and CPR models respectively. This implies that over 75 percent of variations in the dependent variables in each of the estimated model are explained by the explanatory variables. Further, the F-Stat. which measures the overall significance of models is statistically significant as shown by the p-value. This also indicates that the models were fit and appropriate for the empirical estimates.

In addition, it is observed that capital stock (LCAP) had a significant effect on fishery production (FSH) while the effect of capital stock on AGR, CPR, LSK and FRY were insignificant. This suggests that a one-percent increase in capital stock will stimulate fishery production by about 33.9 percent. The coefficient of labour force (LLAB) had a positive and significant impact on AGR, CPR and LSK while its impact on FRY and FSH were insignificant. This also suggests that a one-percent increase in labour force will increase production in AGR, CPR and LSK respectively. Surprisingly and in contrast to a priori

[1] Barrios et al. (2004) measured climate change by changes in country-wide rainfall and temperature.

expectation, climate change had a positive and significant effect on aggregate agricultural output (AGR), crop production (CPR), livestock production (LSK) and forestry production (FRY) while the effect of climate change on fishery production was insignificant. This finding in contrast to the findings obtained by Zhai et al. (2009), Soe et al. (2005) and Barrios et al. (2004).

This result suggests that the decline in agricultural production in recent times in Nigeria (which declined from 7.2 percent in 2007 to 5.7 percent in 2011 (CBN, 2012)) is not resultant of variations in rainfall but to other indicators of climate change such as increase in temperature and evaporation, drought and wind. Also, the findings of this study suggest that climate change measured by variation in rainfall may not directly affect agricultural production but indirectly through of the aftermaths of such rainfall such as erosion.

Table 1. Regression Estimate on the Effect of Climate Change on the Composition of Agricultural Output in Nigeria

INDEPENDENT VARIABLES	DEPENDENT VARIABLES				
	AGR	CPR	LSK	FRY	FSH
LCAP	0.0265 [0.3643]	0.0202 [0.2535]	-0.0323 [-0.7266]	-0.0079 [-0.1419]	0.3398 [2.602]**
LLAB	2.1225 [3.5619]*	2.3716 [3.6345]*	1.4515 [3.9933]*	0.7358 [1.6187]	-0.8767 [-0.8201]
LCC	0.0848 [2.9607]*	0.08141 [2.5927]**	0.0643 [3.6768]*	0.0746 [3.4136]**	0.0902 [1.7514]
R^2	0.958	0.957	0.942	0.781	0.831
S.E of Regression	0.124	0.136	0.155	0.095	0.223
F-Stat.	206.580	202.33	145.55	32.07	44.15
F-Stat. (P-Value)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Source: Authors' Computation Using E-views 7. * and ** denotes 1% and 5% respectively.

5. Conclusion

The focus of this study is to examine the impact of climate change (measured by variation in average annual rainfall) on the composition of agricultural output in Nigeria for the period 1981 to 2011. Base on the regression estimate, climate change was observed to have a positive and significant impact on components of agricultural output with exception to fishery production. This result is not only surprising but also in contrast with a priori expectation and the findings of other empirical studies. This study therefore recommends the need for further research on this issue to verify the findings of this study. It is also recommended that further research endeavour should utilize other indicators of climate change to empirically analyse the effect of climate change on the composition of agricultural output.

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