THE IMPACT OF CLIMATE CHANGE ON ECONOMIC WELFARE IN NIGERIA

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Abstract

Climate change had been a front burner issues and disturbing vices at the world unions and regional conferences, diplomatic contentions and international organisations, most especially, developing countries are prone to its danger. Therefore, this paper assessed the impact of climate change on the economic welfare of Nigeria. Four endogenous variables were used to represent economic welfare such as per capita income growth rate, Human Development Index, Gross Fixed Capital Formation and Savings rate, while carbon dioxide damage, forest depletion, natural resource depletion and carbon dioxide emission considered as climate change variables. Annual data from 1981 to 2019 was sourced from World Development Indicators, 2019. Fully Modified OLS estimator and Granger Causality test were adopted to estimate the impact and causality, respectively, of climate change on economic welfare in Nigeria. The paper discovered that climate change contributed negatively to the per capita incomegrowth rate, human development index and savings rate in Nigeria. Most especially, carbon dioxide emission showed a huge negative impact on economic welfare in Nigeria. Therefore, government environmental agencies should adopt policy measure that will reduce forest depletion, carbon dioxide damage and the degree of carbon dioxide emission in Nigeria by increasing the cost of negative externality.

Keywords: Climate change, Economic, Welfare, GHG and Carbon emission.

1. Introduction

Climate change is synonymous with negative externality and greenhouse gases (GHG) emissions. Climate change has been defined by Intergovernmental Panel on Climate Change, IPCC (2007) to mean change in the condition of the climate that can be identified by changes in the mean of variability of its properties. Two basic causes of climate change have been identified in the literature, which are the bio geographical (natural processes) and anthropogenic (humanity activity processes). The natural process is beyond human control and are mainly an outcome of extraterrestrial and astronomical factors. IPCC (2007) identified that the anthropogenic is the process human activities emit large amount of GHG into the atmosphere that deplete the ozone layer or reduce the amount of carbon the atmosphere needed to absorb. Basically, GHG emissions include, among others, industrial waste, burning of fossil fuel, oil spillage, gas flaring, urbanization, while carbon reduction or depletion includes deforestation, water pollution, alteration in land use and various agricultural practices. Nevertheless, the impact of climate change on the economy has been a subject of controversy. For instance, Ayoade (2004) revealed that if the climate reverse later, even if it occurred over 100 to 150 years, it may not be referred to as climate change but climate fluctuations or climate variability. Nevertheless, this assertion has been refuted by studies that the period of the climate change is not the issue but its impact on the socio-economic factors (Odjugo, 2005; Akpodiogaga and Odjugo, 2010; Tol, 2018).

The effect of climate change on social economic welfare could be detrimental or beneficial, depending on the time horizon and economic needs of the society. It could also depend on focused sector that is economical viable to the country, localization of industry and the kind of output being considered. Field and Canziani (2014) held the notion about the confusion that the effect climate change might have on economic development. For instance, particularly in Nigeria case, the emission of production in the automobile subsector can be overlooked because of the need to develop the manufacturing sector. As Tol (2018) noted that carbon dioxide emission could act as fertilizer to crops and on the negative side, heat stress on the high side can be unfavorourable. Therefore, GHG is a complementary strategy to the process of economic growth and development in developing countries and also an environmental hazard. Thus, developing countries, like Nigeria, needs to pay a closer attention to the trade-off between lower GHG emissions and slower economic growth and development if necessary, and as well considered its negative impact on the environment. The climate change condition can be seen in different dimensions. It could be evident on land degradation, particularly, loss of fertility.

Particularly, Nigeria climate is worsened by oil spillage mostly in the Niger Delta areas and primarily the poor who live in the riverine and coastal areas are more vulnerable to climate conditions. Most of the farmers in the rural areas lack access to high-rate seeds, pesticides and irrigation. Modernization in farming is low in Nigeria and this will not close the yield gap identified in most developed countries, which will make agriculture vulnerable to climate change in Nigeria (Howden, Soussana, Tubiello, Chhetri, & Dunlop, 2007). The reduction in agricultural products will increase food scarcity, which will invariably worsen hunger and malnutrition and drastically reduce the welfare of Nigerians (Stige, Stave, & Chan, 2006).Apata (2010) opined that climate change lead to poor or low agricultural products and it is mostly common in poor countries. Most crops production in Nigeria is primarily based on weather and environmental conditions and not technology driven.

The vulnerability of Nigerian economic to climate change has been proven by extant studies and most of them concluded that climate change is detrimental to economic conditions. However, the issue of the direction of the impact between climate change and economic welfare is dearth in literature. Additionally, the long-run impact of climate change economic welfare of Nigeria, which the income per capita, Human Development Index, investment and savings is considered, have not been fully addressed in previous studies. Therefore, the paper seeks to address such issues on long-run impact of climate change on economic welfare, and also consider the causality direction of their relationship in Nigeria.

These findings in extant studies concentrate more on developed countries rather than developing or third world countries, especially in Nigeria. Thus, their estimates may not provide definite conclusions about the effect of climate change on social economic welfare in Nigeria base on some salient points. The basic underlying facts that could make climate change impact on economic welfare in Nigeria be different are enumerated as follows:

i. The level of degradation and deforestation in Nigeria is not the same with that of developed countries**.** For this reason, Nigeria is adjudged to be vulnerable to climate conditions because of extinct of animal species and degradation agricultural practices.
ii. The extent of industrial development in Nigeria is still low, based on the percentage contribution of manufacturing sector to GDP (less than 10%) when compared with these developed countries (Chete, Adeoti, Adeyinka, & Ogundele, 2014, Onyejiuwa, 2019). Additionally, industrialized countries, to an extent are protected from the vagaries of weather conditions and the capacity to adaptive measures towards climate change is high.

iii. The environmental institutions that could help to protect against environmental degradation are weak and the adaptive measures to reduce the menace of climate change in Nigeria can be said to be low.
iv. Nigeria's climate condition is hotter than most developed countries, which signifies that Nigerian ecosystems are closer to their biophysical upper limits, and any activities that emit heat substance to the atmosphere will cause more damage than necessary.
v. The technology know-how of Nigeria is lower than most advanced countries, and tends to incur huge cost to acquire sophisticated technology that could reduce the effect of climate change.
vi. The political will to mobilise resources and judiciously use them for large-scale infrastructure such as irrigation, species protection, recycling of waste products and coastal protection is weak.

2. Some Empirical Evidence of Climate Change

It has been established from comparative static analyses that climate change affects economic growth (Fankhauser and Tol, 2005**;** Lemoine and Kapnick, 2016). The mechanism by which it affects growth is through the size and productivity of labour force, capital stock and technological progress. Studies carried outside Nigeria scope gave evidence) of climate change impact on economic growth. For instance, Dell, jones and Olken (2009) discovered that poor countries income would be reduced by higher temperatures. The study of Barrios, Bertinelli and Strobl (2010) found a huge effect of heavy rainfall on sub-Saharan Africa economic growth, while Bloom, Canning and Sevilla (2003) discovered that long-term growth of poor countries is mainly affected by large unpredictable rainfall and hot and wet weather conditions. Tol (2018) argued that instead of subsidizing the GHG, it should be taxed. This is based on the theoretical foundation of d'Arge, Schulze and Brookshire (1982)that the welfare impacts of initial warming are positive on net and any additional warming will lead to net damages. A further review of Tol (2018)estimates on climate change impact showed that it does not significantly deviate from zero until 3.5^{o}C warming. Lewis (2013) argued that the cause of climate change in highly industrialized countries is stronger than that of developing countries due to the stronger volume of industrial activities in developed countries.

On the contrary, Mendelsohn (2013) argued that the impact of climate change on world economic growth will be be strong over the next 40 years. He posed a reson based on the size of the climate change during the next 40 yeasrs to be small and insignficant to have much global net impact. He further assert that the net market impacts are predicted to be between 0.1 and 0.5. however, the impacts of climate change would be signficantly felt in most affected areas than when it is globally aggregated. The work of Hallegatte, Henriet and Corfee-Morlot (2008) specifically concentrated on assessment of the potential incidence and economic cost associated with extreme chnages in cities by comparing impacts under different uncertainty about both mitigation and adaption responses. They discovered a direct economic losses caused by climate change at the sector level, which was amplified by spatial or sectoral difussion into the wider economic system.

Fankhauser and Tol (2005) disaggregate the impacts of climate change on capital accumlation, savings rate and economic growth by apllying four model specifications. Their findings show that the impact of climate change on growth is negatively increasing overtime in all the four mdeol specifications. They also found out that cliamte change affects capital accumulation and people's propensity to save. It shows that climate change has negative effects on capital accumulation and savings in all the four model speficiations.

Evidence of climate change impact in Nigeria are diverse, depending on the parameters used in the study. Akpodiogaga and Odjugo (2010) using trend analysis discovered that Nigeria mean air temperature (26.6^{o}C) has risen more than the global mean temperature (0.74^{o}C) over a span

of 105 years. They also found out that rainfall amount in Nigeria has dropped by 81mm, which corresponds to the period of sharp temperature upsurge. It was observed by Odjugo (2005) that the pattern of weather conditions in Nigeria is erratic and has detrimental effect on agricultural activities. Odjugo and Ikhuoria (2003) showed that climate change has a significant contribution on desertification. Nwafor (2007) showed that climate change is global but affect developing countries, especially those in Africa, more than developed countries due to their level adaptive measures. Investigation of climate change impact on economic growth in Nigeria was carried out by Ogbuabor and Egwuchukwu (2017). The study found that carbon emission adversely affect growth both in short-run and long-run. However, and forest depletion has a shorter period negative effect on economic growth in Nigeria.

Apata (2010) adopted Multinomial choice and stochastic-simulation model to examine the impacts of frequent climate change on the production of grain and population growth rate in Nigeria. He calculates the production, consumption and storage of grains under different climate scenarios for 10 years and found out that in most scenarios, either an optimistic baseline annual increase of agricultural output of 1.85% or a more pessimistic appraisal of 0.75% was used. The rate of natural increase of the human population exclusive of excess hunger-related deaths was set at 1.65% per year. Results indicated that hunger-related deaths could increase if grain productions do not keep pace with population growth in an unfavourable climatic environment.

In summary, the need to have an in depth knowledge of the economic impacts of climate change is more urgent now than previously. With population projections which see Nigeria's population hitting 250 million by 2030, the pressure on national resources is bound to be quite high. It is therefore necessary to quantify the impact of climate change on income loss, deforestation and agricultural production, and food security, as to guide government policy at mitigating the impact. This is the focus of this research.

3. Theoretical Framework and Analytical Model for Climate Change and Economic Growth

Fankhauser & Tol (2005) introduced a basic linkages between economic welfare and climate change by adopting a standard Ramsey-Cass-Koopmans growth model. In this growth model, social planner maximises identical consumers utiity function in the following intertemporal optimisation problem. Given as below:

$$\max \int_0^{\infty} u(c,E)e^{(n-\rho)t}dt \qquad 1$$

$$\text{subject to: } \dot{K} = Q(K,L,E) - cL - \delta(T)K \qquad 2$$

$$\dot{L} = n(E)L, \qquad L_0 = 1 \qquad 3$$

where u means the utility function, c denotes the per capita consumption; Q is the output; K is the capital and depreciate at rate δ, while L is labour that grows at rate n and ρ denotes that discount rate. Climate change is represented by E (for greenhouse emissions). The Ramsy-Cass-Koopman model is identical to the Solow-Swan model, except that the savings rate is determined by intertemporal optimization. The models are presented in three forms, namely capital stock model, saving rate model and growth model(Fankhauser & Tol, 2005). Therefore, this study examines the impacts of climate change on the capital stock % contribution to real GDP, savings rate and economic welfare (proxy by Human Development Index) in Nigeria context.

Following quantification of the above climate effects, the research will develop and estimate appropriate econometric model to assess the impact of climate change (represented by appropriate variables) on economic welfare of Nigerian population.

Specifically, the paper will adopt the Fully-Modified Ordinary Least Square (FMOLS) long-run estimator and granger causality test following the study Fajingbesi & Abraham (2019). The FMOLS is specified as:

$$\sum_{i=1}^{i} EC_{it} = \alpha + \sum_{k=1}^{K} \beta_i CC_{kt} + \sum_{I=0}^{K} \phi_i CV_{kt} + \mu_t$$

Where $EC_{it}$is Economic welfare (dependent variables) proxy byGDP per ca

pita growth rate,Human Development Index (HDI).capital stock (CAP) and savings rate (SAV). The independent variables are denoted by CC_t and CV_t.CC_t denotes climate change variables such as CO2 emissions, kg per 2010 of GDP (COEM), Adjusted savings: natural resources depletion % of GNI (ANRD), Adjusted savings: carbon dioxide damage % of GNI (ACD), Adjusted savings: net forest depletion % of GNI (AFD). The concept of adjusted savings is to put in considerationthe true rate of savings in an economy after taking account of carbon dioxide damage, forest depletion and natural resources depletion due to climate change effect. CV_t is control variables or economic welfare determinant such as lag of income per capita, inflation rate, gross fixed capital formation and population growth rate.The subscript 'k' represent the number of variables in the group. α is the intercept value, β_i and ϕ_i are the coefficients of the climate change variables and control variables respectively, while μ_t is the stochastic term in the equation.

The granger causality model is specified as:

$$\sum_{t=1}^{n} y_{nt} = \delta_i + \sum_{I=0}^{K} \delta_i^k EC_{kt} - k + \sum_{I=0}^{K} \varphi_i^k CC_{kt} - k + \sum_{I=0}^{K} \gamma_i^k CV_{kt} - k + \mu_t$$

Where y_{nt} is the dependent variables from *1 to n* which comprises the EC and CC variables, δ_i is the individual specific equation intercept values, and χ_i, φ_i *and* γ_i are the coefficients of their respective variables.

This study adoptedannual data ranging from 1981 to 2017, which was sourced from Nigerian Meteorological Agency, CBN Statistical Bulletin (various editions), and World Development Indicators, 2018.

4. **Results and Discussions**

The results of degree of relationship among the variables is shown in Table 1. The climate change variables such as carbon dioxide damage (ACD) % of GNI, forest depletion (AFD) % of GNI, natural resource depletion % of GNI reveal a positive correlation with growth of GDP per capital and CO2 emissions (COEM) shows a weak negative relationship. Among these variables, only ACD is significant at 5% level. This results implies that the effect of climate change on the environment, forest and natural resources positively correlate with the growth in income per capita in Nigeria. However, the emission of carbon dioxide moves in opposite direction with per capita income growth. This is also the case of the relationship between carbon dioxide emission and Human Development Index (HDI) which shows a negative and significant relationship unlike the other climate change variables. The negative value of -0.74 is significant at 5% level, which suggest a strong negative relationship between carbon dioxide

emission and growth rate of income per capita, which support the findings of Dell, *et al.* (2009). The deduction form this results is that carbon dioxide emission to the environment is not concurring with development in Nigeria. Another vital relationship is that of COEM and Gross Fixed Capital Formation (GFCF). Their correlation result shows a value of 0.60 which is significant at 5% level. It can be deduced from the result that COEM has a strong positive relationship with GFCF, and this is due to the fact that the additional capital stock has the tendency to increase the level of carbon dioxide emission in Nigeria. However, most of the climate change variables are not significant with savings rate (SAV) except ANRD with a significant value of 0.48.

Table 1: Correlation Analysis

Variables	GPCRT	HDI	GFCF	SAV	ACD	AFD	ANRD
HDI	0.36*						
GFCF	-0.66*	-0.86*					
SAV	-0.16	-0.60*	0.54*				
ACD	0.40*	-0.11	-0.22	0.14			
AFD	0.16	0.17	-0.30	0.19	0.57*		
ANRD	0.29	-0.06	-0.12	0.48*	0.51*	0.59*	
COEM	-0.19	-0.74*	0.60*	0.17	0.10	-0.56*	-0.31*

*Source: Author's compilation; results from E-views 10. * denotes significant at 5% level.*

The results in table 2 presented the impact of climate change variables on four endogenous variables such as growth rate of per capita income (GPCRT), Human Development Index (HDI), Gross Fixed Capital Formation (GFCF) and savings rate. The purpose of regressing the climate change variables on these endogenous variables is to disaggregate the effect of climate change on growth, development, capital accumulation and savings in Nigeria.

The carbon dioxide damage (ACD) coefficient shows a positive and significant effect on GPCRT and negatively significant on GFCF. However, it was not significant on HDI and SAV. As observed in the correlation analysis, the ACD has the tendency to increase growth of per capita income due to the fact that savings has been adjusted from carbon dioxide damage. So the real effect of investment has been adjusted in income generation process and the adverse effect carbon dioxide on growth in income per capita has been adjusted. The contrary results of ACD effect on GFCF in the results is an indication that capital accumulation is affected negatively as a result of carbon damage in Nigeria. The coefficient of savings adjusted forest depletion reveals a negative and significant effect on GPCRT and savings rate, SAV. This is a strong indication that forest depletion, after adjusting for savings, contract the growth rate of per capita income and saving rate in Nigeria. However, adjusted savings in respect to natural resources depletion coefficients do not show any significant effect on any of the endogenous variables. Considering the huge revenue from crude oil and its enormous contribution to foreign reserves and foreign exchange earnings, one would not expect otherwise. This is because its depletion due to climate cannot be felt strongly on these endogenous variables.

The negative effects of climate change on GPCRT, HDI and SAV is further confirmed in the negative and significant coefficients of carbon dioxide emission of -13.10, 0.09 and 17.87 respectively. The results further strengthened the findings of Fankhauser and Tol (2005) Lemoine and Kapnick (2016) and Ogbuabor and Egwuchukwu (2017) of huge negative impact of climate change on economic growth and development. The size of the adverse impact of carbon dioxide emission is greater on savings rate, followed by per capita income growth rate and an infinitesimal effect on HDI. This is a clear indication that climate change grossly reduced income and invariably savings in Nigeria economy. However, the effect on GFCF is

positively significant and this is due to the fact that increase in capital stock is as a result of more carbon dioxide emission, which is an inevitable outcome in production process.

Table 2: Fully Modified Ordinary Least Square

	GPCRT	HDI	GFCF	SAV
Constant	211.39* (4.32)	-0.40* (-2.60)	508.47* (4.66)	132.43* (2.35)
Log of GPC	-22.69* (-7.06)	0.11* (10.55)	-13.28 (-1.51)	-9.97* (-2.35)
GFCF	-0.23* (-5.25)	-0.001* (-6.35)		0.13* (2.40)
SAV			1.31* (4.70)	
INF	-0.05* (-2.44)	-0.0001* (-2.94)	-0.004 (-0.06)	0.13* (4.85)
PGRT	33.08* (3.27)	-0.15* (-4.78)	-121.45* (-5.00)	
ACD	4.04* (2.90)	0.01 (1.25)	-19.08* (-5.84)	1.45 (0.81)
AFD	-3.39* (-2.55)	-0.01 (-1.55)	-4.02 (-1.14)	-3.63* (-2.52)
ANRD	0.07 (0.69)	-0.0003 (-1.55)	0.08 (0.29)	0.17 (1.30)
COEM	-13.10* (-2.21)	-0.09* (-4.87)	44.92* (2.77)	-17.87* (-2.30)
Adj R-Squared	0.60	0.96	0.84	0.73

*Source: Author's compilation from E-views 10. * denotes significant 5% level, while t-statistic value in parenthesis.*

The causality test results in table 3 show that ANRD has a predictive power to cause a change in HDI and savings rate. the results further reveal that COEM granger cause the variations in HDI and savings rate. However, it does not have the power of prediction on GFCF, rather it is GFCF that cause the variations in COEM. The granger causality of GFCF on COEM is an indication that the changes capital stock can cause emission of carbon dioxide in Nigeria to change. The adjusted forest depletion (AFD) shows that is has the predictive power to cause a change in savings rate as ANRD also reported. Therefore, most of the climate change variables show a strong and significant granger causality on HDI and savings rate. These results are in line with the findings of Tol (2018) and Dell, *et. al.* (2009) that poor countries income would be reduced by higher temperatures due to climate change.

Table 3: Lags 2 Pairwise Granger Causality Tests

Null Hypothesis:	F-Statistic
ANRD does not Granger Cause HDI	5.50*
HDI does not Granger Cause ANRD	2.01
ANRD does not Granger Cause SAV	6.97*
SAV does not Granger Cause ANRD	2.55
COEM does not Granger Cause HDI	2.74*
HDI does not Granger Cause COEM	0.51
COEM does not Granger Cause GFCF	0.49
GFCF does not Granger Cause COEM	4.88*
COEM does not Granger Cause SAV	3.57*
SAV does not Granger Cause COEM	0.37
AFD does not Granger Cause SAV	6.86*
SAV does not Granger Cause AFD	4.81*

Source: Author's compilation from E-views 10.

5. Conclusion

The issue of climate change is very critical in the global village and its effect on economic welfare has always been a pivotal subject matter. The paper discovered that climate change contributes negatively to the growth rate of per capita income, human development index and savings rate in Nigeria. The findings are in consonance with most of the conclusions in literature and its further strengthen the adverse effect of climate change in the economic welfare of Nigerians. Particularly, the carbon dioxide emission damage on economic wellbeing is huge compared with other climate change variables. The effort of the firms, government and environment agencies in the country should be focused on reducing the degree of greenhouse gases emission in the environment by innovations of new production process that will have low level of emission. Additionally, environmental agencies should enforce that producers and environmental pollutants embark on production capacity that will be environmental friendly.Government environmental agencies should also adopt policy measure that will reduce forest depletion, carbon dioxide damage and the degree of carbon dioxide emission in Nigeria by increasing the cost of negative externality.

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