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Effect of Climate Change, Damage to Environment and Human Development Index on Economic Growth in Nigeria

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Abstract

This study investigated the relationship between climatic change, damage to nature, human development and economic growth in Nigeria. The data were collected from secondary sources, mainly the Central Bank of Nigeria's Statistical Bulletin, Word Development Indicator, and the National Bureau of Statistics, Nigeria. The authors undertook data analysis to establish a relationship between these factors using multiple regression and the Cobb-Douglas test. The analysis proved that climate change has imposed many constraints that have hindered human development and consequently severely impacted Nigeria's environment and economic growth. The study recommended continual intervention of the governments, international development agencies, and non-governmental organisations (NGOs) in formulating policies and implementing sustainable practices that will minimise

the negative consequences on human capital development and improve economic growth in Nigeria with negligible environmental damage.

Keywords: *Climate change, Damage to human development, Economic growth, Nigeria.*

Introduction

Climate change is a human development issue that negatively impacts the aspirational goals of most developing countries today. The negative impact could be seen in the following areas:

Food security: Climate change can negatively impact food production by reducing crop yields, altering growing seasons and increasing the frequency and intensity of extreme weather events such as droughts, floods, and heat waves. Climate change can lead to food shortages, higher prices, and malnutrition.

Health: It can impact human health through increased exposure to air pollution, heat stress, waterborne diseases, and vector-borne diseases such as malaria and dengue fever. These impacts can be particularly severe in low-income countries with inadequate healthcare systems.

Climate change has been described as "a change in the atmospheric composition that is over and above their natural variations, and such changes are attributed directly or indirectly to humanity" (Odjugo, 2010). The IPCC report of 2007 describes climate change as manifested in rising temperatures, variability in precipitation, sea level increase, and the aggravation of natural hazards such as floods, storms, landslides, and droughts.

Climate change imposes Nigeria's human development challenges in fundamental ways. The country's farming sector is dependent on the weather conditions. The fast southern expansion of the Sahara Desert has limited access to water, increased the incidences of drought and desertification, and aggravated the degradation of agricultural yields. The lives of more than 50 million Nigerians located along the low-laying coastal regions and Nigeria's oil facilities located within these areas are threatened by gully erosion.

It is, therefore, no wonder that Nigeria was ranked 162nd in 2023 by UNDP. In Nigeria, life expectancy is just 47.7 years. The country's population shows a 37.4% probability of persons not surviving till 40 years of age. More than 53% of the population in Nigeria has no access to safe sources of water supply, and the literacy rate is just 72%.

The climatic changes in the form of increasing change in natural temperature, rainfall, storms, and sea levels have significantly stressed resources such as land and water in Nigeria. The inadequate dealing with resource shortages has negatively impacted human development (Sayne, 2011). This leads to population displacement, sickness and hunger, ultimately lowering economic growth. Although some empirical research on Nigeria has examined the challenges of climate change on its economic growth, they have so far not been able to identify a systematic, causal relationship between the impact of climate change on human development and, thereby, economic growth. The paper's main aim is to empirically explore the relationships among Nigeria's economic growth, climate change, and human development.

Literature Review

There are many theoretical and empirical studies available on probable ways through which climatic condition could affect the economic activity. Firstly, the harmful impact of climate change on ecosystems from soil erosion, flash floods and drought, the extinction of various species, and deaths resulting from extreme weather condition cause long-lasting damage to economic growth. The economic implication of dealing with the impact of increase in temperature would lower the availability of investment quality in social and physical infrastructures, R&D resulting in lower economic growth (Ali, 2012).

A few of the existing research prove a negative relationship between climate change and aggregate economic output (i.e. GDP). Studies undertaken by researchers such as Deschenes and Greenstone (2007) and Salvador, Bertinelli and Strobl (2010) conclude that climate change could negatively impact the growth of an economy. If the impact of climate change is only limited to certain sectoral output, for example, lower agricultural yields when the temperature increases (precipitation decreases), then that logically implies that a fall in temperature (precipitation increases) – resulting from stringent abatement of emissions – would return the GDP to its earlier level. However, this is not the case when climate change affects the economy's growth rate. There are several reasons behind it. First, the economic growth rate will be lower even if GDP returns earlier due to forgone consumption and investment during the higher temperature period. In addition, when countries spend resources to adapt to climate change, they incur opportunity costs for not utilising these resources on R&D and capital investment. Such opportunity costs have adverse effects on a nation's economic growth.

Economic growth (development) and environmental sustainability have become an important area of research in the current period. From 1991, when economists identified a systematic relationship between the per capita income and the quality of the environment, EKC (Environmental Kuznet Curve) became a standard tool in technical conversations about environment-related policy formulation (Grossman & Krueger, 1991). EKC is a statistical representation that summarises, in a two-dimensional space, certain critical aspects of aggregate human behaviour. A chart exhibiting an Environmental Kuznets Curve reveals how a specific measurement of sustainability changes as the country's per capita income changes over time. When it was first reported, EKC revealed a surprising result. The early estimates showed that some significant indicators of environmental quality, like the concentrations of sulfur dioxide and other particulates in the air, actually improved as incomes and levels of consumption grow. This positive outcome occurred when incomes were at a much higher level. However, at lower income levels, environmental quality degrades as incomes begin to increase. This essentially created an inverted U-shaped curve, showcasing the relationship between per capita GDP and environmental quality. These results quickly generated a two-fold response from various scholars. The first category was in the form of efforts to replicate and extend the early findings. The latter response came in the form of a serious examination of data, methods of estimation, and to what extent the EKC could be generalised. Thanks to these responses, we now have better knowledge about how economy and environment are linked, but there is still quite a bit we may not know. The advent of EKCs raises various questions: How did the name 'Environmental Kuznets Curve' come into existence? What have we learnt about the statistical relationships between different measures of environmental quality and income? Do every aspects of environmental quality become worse or improve systematically with economic growth? Does the property rights and contract enforcement make a difference? A comprehensive literature study by Yandle, Vijayaraghavan and Bhattarai (2002) addresses some of such questions about EKCs.

Another paper by Cole, Rayner and Bates (1997) explores the relationship between per capita income and various environmental indicators using cross-country panel sets. Their analysis overcomes many weaknesses associated with how EKCs are estimated, as highlighted by Stern et al.(1996). Their findings show that meaningful EKCs exist for local air pollutants. In contrast, indicators with a more global impact either increase monotonically with income or have predictable turning points at higher income levels with significant standard errors – unless developed out of a multilateral policy initiative. In his research article, Bo (2011) concludes that if, on the one hand, some factors are key reasons to EKC, including income elasticity of environmental quality demand, scale, technological and composition effects, international trade, FDI and history accidents, etc., then, on the other hand, from the empirical literature of EKC, the environmental quality indicators improved with public health. He also observes that different data types lead to different empirical results, so it is important to choose suitable indicators and data. Omisakin and Olusegun (2009) investigate the relationship between economic growth (GDP) and environmental quality in the Nigerian context. They tested the Environmental Kuznets Curve (EKC) hypothesis with the annual data of carbon emissions capita and GDP per capita from 1970 to 2005. Their study reveals that there is no causal or long-run relationship between carbon emissions and income in Nigeria. The curve depicts a 'U-shaped' rather than an 'inverted U-shaped' curve, meaning that in Nigeria, with increase in income, carbon emission first experiences a declining trend and then starts rising again. Interestingly, findings by Musibau, Shittu and Ogunlana (2021) support the EKC hypothesis in Nigeria, as the growth of GDP first worsens the environmental quality, but improves it over time. Further, energy use was found to degrade environmental quality, as CO2 rises by 0.002% for a unit increase in energy consumption in Nigeria. In their research, Akpan and Akpan (2012) use a multivariate vector error correction model (VECM) framework to explore the long-run and causal relationship among electricity consumption, carbon emissions, and economic growth in Nigeria. Utilising annual time series data for a period from 1970 to 2008, they find that, in the long run, economic growth is linked with increased carbon emissions, as higher electricity consumption leads to higher carbon emissions. No evidence was obtained for the environmental Kuznets curve (EKC) in their study. Granger-causality results supported a unidirectional causality from economic growth to carbon emissions, implying that carbon emissions reduction policies could be implemented without reducing economic growth in Nigeria. A paper by Maji (2015), in which the autoregressive distributive lag (ARDL) model is used, studies the impact of clean energy on the growth rate of Nigeria's economy. In this paper, co-integration is applied to determine the existence of co-integration among the variables. The conclusion from the paper shows that Nigeria has potentials of benefits of clean energy to be reaped in near future.

Musa and Maijama'a (2020) explore the impact of the economic growth and energy consumption on Nigeria's environment for a period of 1981 to 2014. The paper shows that the Nigerian government should emphasise more on the consumption of renewable energy to reduce the detrimental impacts of economic actions and non-renewable energy on the quality of the environment. In his study, Udemba (2020) investigates the mitigation of Nigerian economic growth and ecological footprint with other selected variables in the ascertainment of the initiatives of the country in the global effort to reduce global warming. The conclusions from both the Granger causality and autoregressive distributed lag models corroborate the first stage of the theory (scale effect). The article concludes that the economic growth and ecological footprint are increasing at the same rate.

Richard IIorah (1999) has studied the impact of oil availability at Nigeria on the agriculture, development and wage rates. A study by Solarin et al. (2021) explores the effect of economic growth and urbanisation on the ecological footprint, considering foreign direct investment and trade in Nigeria, using data from 1977 to 2016. Their findings show the relationship among variables in the long run. Their study finds that economic growth an adverse impact on the environment in the short run, but urbanisation has no harmful impact. However, over the long run, FDI and trade damage the environment but economic growth improves environmental quality. The paper recommends that policymakers make the existing environmental regulations more rigorous to curtail harmful trade and create rural infrastructures to minimise urban anomalies.

Dell, Jones and Olken (2012) find evidence for the period 1950-2003 on the effect of climate change on economic growth for more than 130 countries. They develop three significant results from their study. A) Higher temperatures substantial to inferior economic growth in less developed countries. For example, a 1^{0}C increase in temperature in a given year lowers economic growth by 1.3% points on average. B) Warmer weather appears to decrease overall growth rates, not just the level of aggregate output. C) Warmer climate has wide-ranging effects, from health-related issues to the impact on agricultural, social and economic effects to political stability. Ali (2012), in the study on Ethiopia which adopted co-integration analysis, finds a similar negative effect on growth. He observes that variation in rainfall level and its variability has a long-term negative effect on growth.

Akinbobola and Saibu (2004) have investigated the causality between the openness variable and the economic growth in Nigeria. The dynamic effects are even more important relative to the direct effects. Their paper observes that due to a high direct impact, climate change could lower economic growth, and per capita income may decrease. In case of a global warming of 3°C, the direct damages to the economy are estimated, at least, at 15% of GDP. If the effect of capital accumulation and people's propensity to save are considered, the impact would be higher. Ayinde et al. (2011), in their econometric analysis of Nigeria from 1980 to 2005, observe that agricultural productivity is negatively related with temperature fluctuations. The Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) provides some insightful results about the climate change impact on African development. The report estimates that reductions in yields in some nations could be as much as 50%, and crop net revenues could fall by as much as 90% by 2100; the most affected group will be the small farm-holders. It will worsen the water crisis faced by some countries at present, about 25% of Africa's population (nearly 200 million people). The population at risk of greater water crisis in Africa is projected to be between 350 million and 600 million by 2050. There is a possibility that in the national parks of sub-Saharan Africa, between 25% and 40% of mammal species will be endangered (Boko et al., 2007). *Science Daily* (2010) reveals that over the last four decades, highland areas in various parts of East Africa have witnessed the incidence of malaria, which has been related to climate change. About 50 years ago, such phenomena were rare in the cooler highland areas. Tanser, Sharp and Le Sueur (2003) also predicts that due to evolving temperature patterns in Africa, there could be a 5to 7% altitudinal increase in the distribution of malaria with little to no increase in the latitudinal extents of the disease by 2100.

Gallup, Sachs and Mellinger (1999) submit that vector-borne diseases, especially malaria, can negatively impact labour productivity, which could keep sub-Saharan African nations trapped in a vicious disease-low productivity-poor health care cycle. In Africa, the second largest continent in the world, land is the most important asset for food production, nutritional health, and economic progress. Unfortunately, about 500,000 square metres of land annually in Africa is lost due to soil erosion, salinisation, pollution, and deforestation. This loss of land can damage agricultural productivity, nutrition, and, subsequently, human progress.

Rabassa, Skoufias and Jacoby (2012) prove that weather shocks aggravate child morbidity and mortality in Nigeria's rural areas. Erratic rainfall also has a statistically significant and robust impact on the health of children in the short run for incidences of diarrhoea and weight-for-height and height-for-age.

The available studies, in summary, show climate change could impact the economic growth and the living standard of the population. The subsequent section attempts to create a systematic linkage between economic growth, climate change, and human development.

Theoretical Framework

A theoretical framework is being presented in this section to analyse the link between climate change, human development, damage to nature, and economic growth in the context of the Nigerian economy. The intervening factors studied need to be fully understood to appreciate the true nature of the relationship among these variables.

An integrated economic assessment model that links climate and economic simulation is one of the most extensively used models in studies related to climate change (Stern, 2007). Such models are based on the assumptions of rational actors, perfectly competitive markets and optimisations (Chandran & Sandya, 2012). It has been found by Stern (2007) that the difference among models mainly results from different assumptions related to the rate of discount of benefits from climate mitigation and the costs of such efforts. Weitzman (2007) believes that one has to carefully examine the potential risk, future economic growth, and the social discount rate in case of climate change.

There is increasing realisation among economists that the existing climate models could be of more use in both mitigation and adaptation to climate change. It is even more difficult as the temperature globally rises even further. Recognising heterogeneity in economies and human communities could make the task more realistic.

Standard models of climate change and economic development use the framework of economic well-being. Such models consider per capita GDP as the indicator of economic growth.

Frey and Stutzer (2014) question the basic assumption of income being equivalent to utility and happiness being positively linked to income. Their findings contradict the common notion and shows there is no positive relationship between income growth and well-being, especially when income exceeds some minimal level. In fact, they have proved that even within a standard optimisation model, economic growth and welfare may be negatively related. Amartya Sen developed a holistic calculation of human well-being called the 'Human Development Index' (HDI) (Sen, 1999). The index is constructed by considering some basic aspects of human development: health, education, and income. Since its development, various alternative versions of well-being measurement have been considered.

Research Methodology

This study was based on an extended Cobb-Douglas production function. A generalised Cobb-Douglas production has been extended into a neo-classical growth model, which includes CO_2 emission (climate change) and damage to nature, along with stock of human capital (i.e. human development) as the input of the production function and the real gross domestic product as the output. The fitness of the model has been checked using multiple regression analysis, and the time span taken for this study is 40 years, i.e. 1980-2020.

1.The Empirical Model

This paper has been adapted from Mobolaji (2012) paper titled,

> Statistical model is represented by the Actual Gross Domestic Product per capita growth rate and is assumed to be affected by the rate of carbon dioxide emission (C emission) and Damage to nature (DN), which includes flora, fauna and soil, as well as human development index (HDI), hence, it can be seen that the economic growth is influenced by carbon emission, and the HDI, is specified.
>
> "$AGDP = f(CO_{2t}, DN_t, HDI_t, PV)$ (i)
>
> The model becomes:
>
> "$AGDP_t = a + b_1 CO_{2t} + b_2 DN_t + b_3 HDI_t + b_4 PV_t + E_t$" (ii)
>
> Where
>
> $AGDP_t$ = Measure the growth rate of the Actual GDP per capita
>
> a= intercept
>
> $b_1, b_2, b_3, b_4,$ = parameter to be estimated

Taking the natural logarithm of both sides of the model produces a linear equation of the form:

"$LogAGDP_t = a + b_1 LogCO_{2t} + b_2 LogDN + b_3 LogPV_t + b_4 LogHDI_t + E_t$" (iii)

E_t = 'The Error term because of unknown factors

The logarithm has been taken to linearise it. It is also necessary to remove variation in the data and minimise bias in the collected data. The time period considered for the study is 40 years, i.e. 1980-2020= 40.

It has been observed in the earlier studies that carbon emission has a negative impact on growth. Using Ordinary Least Square Method (OLS), the data collected from 1980 to 2020 were analyzed for developing the paper.

Analysis and Results

This section analyses the data collected to find whether there is a relationship between the above factors and growth of Nigeria. Therefore, this study examined the time series properties of the data employed in the study. After that, it analysed the impact of climate change, human development, and economic growth.

Table1: Augmented Dickey-Fuller **(ADF)** test for unit root

Factors	**Observations**	**First Difference**	**Second Difference**	**Eigen Values**			**Integration Order**
				.01	.05	.10	
Log(AGDP)	4.31	-1.50	-3.35	-3.7	-2.99	-2.63	I(0)
Log(CO_2)	-1.93	-3.36	-5.59	-3.96	-3.08	-2.68	I(2)
Log(DN)	-1.65	-2.36	-4.352	-3.13	-2.952	-2.936	I(2)
Log(HDI)	-2.61	-13.10	-15.21	-3.74	-2.99	-2.64	(1)
Log(POV)	-1.62	-3.73	-6.04	-3.73	-2.99	-2.64	(2)

We have studied whether the data was stationary; hence, the characteristics of the data were analysed to find out whether it has unit roots and the order of integration using the Augmented Dickey-Fuller (ADF) test, which is shown in Table 1, which shows that all variables have distinct orders of integration. The result of the stationarity test with intercept term is presented in Table 1. Thus, the ADF-test statistic of each factor is more significant in absolute value than the 95 % threshold value. Hence, it is possible that long-run relationships between climate change, Nigeria's actual gross domestic product, damage to nature, and uplift of human population.

Table 2: The Johansen method for checking co-integration

Variables	Observed Value	Expected Ratio	0.05 Critical value	0.01 Critical Value	Hypothesised No. of CE(s)
Log(AGDP)	0.98	97.25	47.21	54.46	None**
Log (CO_2)	0.83	34.69	29.68	35.65	At most 1*
Log (HDI)	0.30	6.53	15.41	20.04	At most 2
Log (DN)	0.56	27.12	18.89	29.64	At most 1
Log (PV)	0.05	0.75	3.74	6.62	Maximum 2

As explained earlier, that all the variables considered are non-stationary, the analysis has been done to infer if these variables are co-integrated, using the Johansen procedure. The observations of the test is given in Table 2 which demonstrates that there is more than one co-integration among the variables. Thus, we can conclude that there is no spurious correlation and there is a chance of long-run relationship between the variables.

Table 3: Regression results using OLS

Variable	Coefficient of Variable	Standard Error	t-test Statistic	Probability
Log(AGDP)	4.03	3.62	1.11	0.28
LOG(CO_2)	0.07	0.52	0.13	0.90
LOG(HDI)	-2.32	0.48	-4.83	0.00
LOG(DN)	0.04	0.46	0.10	0.79
LOG(PV)	1.65	0.87	1.89	0.075
R-squared	0.94	Mean dependent variance	12.34898	
Adjusted R-squared	0.93	S.D. dependent variance	2.48	
S.E. of regression	0.66	Akaike info criterion	2.18	
Sum squared residue	7.94	Schwarz criterion	2.38	
Log-likelihood	-20.00	F-statistic	91.67	
Durbin-Watson stat	1.99	Prob, (F-statistic)	0.00	

From the regression result in Table 3, the constant term (intercept) value is 4.02. This signifies that if the explanatory variable is held constant, the coefficient of the Real GDP is 4.02. While computing elasticity (i.e. coefficient of the explanatory variables), the result suggests that a unit change in carbon emission will lead to a 0.65 unit rise in actual gross domestic product. Similarly, a change of unit in the human development index will cause a 0.06 amendment in the actual gross domestic product (GDP). This infers that whatever will hamper human development must be discouraged.

The coefficient of determination (R^2) is 0.94 for the analysis, which proves that there is a very strong positive linear relationship between the dependent variable, Actual Gross Domestic Product (AGDP) and independent variables, i.e. carbon emission, human development index and poverty index. This implies that the coefficients are as high as 94%. Therefore, the models are a good fit as only less than 6% of the systematic variation is left unaccounted for by the model.

Considering the adjusted R^2 value of 93.86%, it implies that, on deleting the effect of insignificant repressors, the independent variables still account for about 6.14% variation in the actual GDP. Therefore, the model can be considered good fit.

The Durbin-Watson test is used to identify the presence of auto-correlation (it identifies the relationship between values disconnected from each other by a given time interval) from a regression analysis. The test provides the independence of error in the least square regression analysis. As a rule, if Durbin-Watson < 2.0, it implies that the succeeding error terms are, on average, close in value to one another and positively correlated; it, hence, implies the presence of auto-correlation, and if it is near to 2.0, then there is no auto-correlation. The Durbin-Watson statistic for the models is 1.998, which shows that there is no auto-correlation as it is close to 2.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	1.000[a]	1.000	1.000	1633752100.9	1.000	76405238.507	1	281	<.001	1.998

a. Predictors: (Constant), DN

b. Dependent Variable: GDP

This shows that there is no identifiable relationship among the values of the error terms.

The standard error test and the mean of the dependent variable test are done to find out the estimated parameters' correctness, statistical significance, and reliability. The standard error of estimate or C is computed to be 3.62, which is insignificant compared to the mean of the dependent variable (Real GDP), which is 12.35. This is statistically significant between CO_2, HDI, DN, PV, and actual GDP.

This shows that the regression model considered in this study for Nigeria has a reasonable fit. Hence, it can be concluded that relational expression exists between actual GDP, carbon emission, index of human development, damage to nature, and index of poverty.

Conclusion and Policy Recommendations

This study considers an extended Cobb-Douglas production function. A comprehensive Cobb-Douglas production function extends into the neo-classical growth model, including carbon emission (climate change), damage to nature, and stock of human capital (i.e. human development) as the input of the production function and the actual gross domestic product as the output. The model's fitness uses multiple regression analysis, and the period taken for this study is 40 years, i.e. 1980-2020.

In this paper, an empirical study has been performed to determine the contribution of climate change, damage to the environment, and the human development index on economic growth in Nigeria from 1980 to 2020 (four decades). This study concludes that human development has a positive and statistically substantial relationship with economic growth and adverse impacts on Nigeria's environment, as seen in the earlier literature. The damaging effect of climate change on human development and the environment could hamper growth, as indicated in this study. Therefore, the study recommends implementing policy and effective regulation to curb carbon emission pollution. It is a must to examine how the conception of carbon credits will be treated in a way that will deal with the full impact of climate change on the lives of the populace. Finally, the interference of the governments and policymakers at all levels, i.e. federal, state and local, framing policies which will reduce the enormous constraints to human capital development and enhance economic growth in Nigeria, is abjuratory to reduce environmental damage.

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