The nexus of population growth and deforestation on Carbon Dioxide emissions in Nigeria

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Abstract
Supposedly, population growth and deforestation are said to increase greenhouse gases emissions, predominantly the CO_2 emissions through the rise in human activities. Consequently, this paper aimed to examine this assertion in Nigeria by using Autoregressive Distributed Lag covering 1974-2016. ARLD bound test for co-integration was applied after confirming the existence of mixture of order of integration of the variables in the models via ADF and PP unit root tests, strong co-integration was obtained at 1% level of significance among the variables in the CO_2 model. The outcomes showed that population growth alone cannot cause of CO_2 emissions in the long run. However, deforestation was found to be responsible in increasing CO_2 emissions in the long run. Though, in the short run, almost all the explanatory variables and their lags, (population growth, deforestation, and Urbanization) were found to be statistically significant in determining CO_2 emissions except GDP that was observed to be insignificant. The results recommended that population growth, which is the focal point of the study, might only determine CO_2 emissions in the short run. Hence, population control measures might be a short run effective measure to lesser the emissions level. Moreover, further research can be piloted on how to effectively and efficiently accomplish the population growth–CO_2 emissions nexus.

Keywords: ARDL, Population growth, Deforestation, Urbanization, CO_2 emission.

1. Introduction

From the time when the dawn of human history, the fortune of humans and trees has remained firmly bound. Forests have exerted a remarkable influence on the livelihood and economic development of many societies. One of the most important concerns of this age is the question of population growth and whether the earth's resources can endure the rapid expansion of population in most parts of the world. This has reignited an all-encompassing debate worldwide on the relationship among population growth, depletion of resources and environmental sustainability. The world population quadrupled from 1.6 billion to 6.1 billion during the period 1900–2000 (United Nations, 2001).

Globally, increase in carbon dioxide CO_2 emissions have been of enormous concern to countries worldwide over the past century. Presently, global climate change is one of humanity's greatest trials. Global CO_2 emissions, particularly from population growth and deforestation continue to increase. The focus at large when it comes to global anthropogenic CO_2 emissions has always been on the advanced world and developing economies in Asia because they jointly contribute to about 80% of the global anthropogenic CO_2 emissions. For example, the top ten emitting countries in the world in the year 2012 which were all advanced economies and emerging economies in Asia accounted for about two-thirds of the global anthropogenic CO_2 emissions (IEA, 2014). Africa as a continent during the period 1980-2005 accounted for only 2.5% of the global anthropogenic CO_2 emissions (Canadell et al., 2009).

Nigeria embarked on the divergence of the economy since 1960 after its liberation with rising industrial, manufacturing, agricultural, financial, and tourist sectors. These sectors necessitate a strong dependence on fossil energies for their energy demands. The increase in use of fossil fuels for energy generation increases CO_2 emissions in the country. Besides fossil energy consumption, human activities such as devastation of forests (deforestation), bush burning, ranching, and building are said to increase GHG constantly in the atmosphere. In most situations, CO_2 emission is associated to anthropogenic activities and that is the emission that is troublesome. On the contrary, anthropogenic activities increases with a rise or growth in human population, hence leading to increase in CO_2 emission (Sulaiman, 2018).

Emissions of greenhouse gases (GHGs) produced by human activity add to climate change. In specific, experts attribute most of the warming of the climate to emissions of carbon dioxide CO_2 emission. Though the use of fossil energies for fuel is the primary source of CO_2 emissions, the loss of forests is also a major contributor. Forests disturb the amount of CO_2 in the atmosphere in a number of ways. As forests develop, they remove CO_2 from the atmosphere and rivet carbon into wood, leaves, and soil, where it can be kept for a prolonged period. When forests are cleared, stored carbon may be released into the atmosphere, depending in part on how much of the wood is shattered. For example, using fires to clear forested land for agricultural production or other uses produces more emissions than does cutting timber for wood products, which if predisposed of in landfills at the end of their use will continue to store carbon (Natalie Tawil. 2012).

Most people in Nigeria depend on fuel wood as the prime energy source for domestic activities like cooking. A lot of forests and wood lands were detached as a result of these activities with attendant consequences of erosion and desertification threats. Vincen, A. (2012), maintained that over 50 million metric tons of fuel wood is used every year in Nigeria which considerably leads to erosion and desertification. He also added that more than 80% of Nigerians and 60% of rural societies used fuel wood as energy source. This shows how people rely on fuel wood which causes most of the deforestation stirring particularly in friable ecosystems of northern Nigeria. (Boafo, 2013) described that in Africa as a whole, deforestation is occurring at the rate of around 3.4 million hectares/year.

The objective of this study was to look at the consequence of Population growth and Deforestation on Carbon dioxide (CO_2) emissions in Nigeria. Many studies showed in Nigeria only considered the effect of Population Growth alone on CO_2 emissions or the consequences of Deforestation and Urbanization on CO_2 emissions, Therefore, this study seeks to investigate the effects of both deforestation and population growth on CO_2 emission in Nigeria as the gap. Accordingly, this study wanted to empirically test the effects of this affirmation in Nigeria by employing Autoregressive Distributed Lag (ARLD) model advanced by Pesaran, Shin and Smith (2001) in a Recursive form.

2. Literature review

2.1 Introduction

This chapter will cover three major sub sections. That is, the conceptual Literature, the Empirical literature as reviewed by various researchers in relation to this study, and lastly the Theoretical Literature. Also, the section will present the variables to be used in this research as conceptualized by previous researches and recognized by national and international institutions.

2.2 Population Growth

John R. (2005) defined population growth as the combination of mortality, fertility, and migration of a particular given region or nation. Population Reference Bureau, (2013) defined Population growth as the rise in the number of individuals in population. Global human population growth aggregates to around 83 million yearly or 1.1% per annum. The global population has matured from 1 billion in 1800 to 7.774 billion in 2020. It is projected to keep increasing, and estimates have put the total population at 8.6 billion by mid-2030, 9.8 billion by mid-2050 and 11.2 billion by 2100 (World Population Prospects, 2016). Many countries with speedy population growth have low standards of living, whereas many nations with low rates of population growth have high living standard (Population Reference Bureau, 2013).

2.3 Deforestation

Deforestation has been well-defined in diverse senses by many organizations and researchers. According to (Fearnside, 1993) it is the loss of original forest for temporary or lasting clearance of forest for other uses. While (Kaimowitz & Angelsen, 1998) describe deforestation as a state of complete long-term elimination of tree cover. For others, such as Collin (2001), explains deforestation as permanent destruction of original forests and woodlands. Food and Agricultural Organization (1993) defines deforestation as the transformation of forest to another land use or the long-term lessening of the tree canopy cover below a lowest 10 percent threshold.

2.4 Carbon-Dioxide (CO_2) Emissions

Carbon emission (CO_2) is defined as the discharge of carbon into the atmosphere, which results to speedy rise in global warming (IEA, 2005). CO_2 is a gas that is naturally produced by plants and animals during respiration. It is also produced by human activities, such as the burning of fossil fuels, the clearing of forested land and industrial process like cement manufacturing. CO_2 is also a Greenhouse gas (GHG) due to its ability to trap heat inside earth's atmosphere.

Among the greenhouse gases, carbon dioxide (CO_2) is most affected by human activities. The major source of CO_2 is largely emitted from the burning of fossil fuel. Half of its emission remains in the atmosphere, contributing to the increase in global temperature, and the other half is enthralled by natural land and ocean carbon reservoirs. Some studies focused on the nature of connection among population growth and CO_2 emissions applying diverse methodologies and different types of data. It should be noted that a large percentage of studies concede a positive relationship among population growth and CO_2 emissions (Shi, 2003; Cole and Neumayer, 2004; Morales-Lage*et al.*, 2006; Muhammad *et al.*, 2011; Hossain, 2012).

Some researchers have also ascribed the rise in CO_2 emissions globally to urbanization. Zhu and Peng (2012) clarify in three different methods through which urbanization increases CO_2 emissions. First, urbanization rises residential consumption and energy demand as cities tend to make use of a lot of energy thereby increasing CO_2 emissions. Second, urbanization tends to increase demand for houses which also increases demand for housing materials such as cement which is a vital source of CO_2 emissions. Thirdly, the rise in the demand for houses requires the clearing of trees and grasslands conversion which discharges the carbon stored in the trees to increase CO_2 emissions. Studies on the impact of urbanization on CO_2 emissions have not quite been intensively explored mainly in Sub-Saharan Africa (SSA). A balanced panel study by Poumanyvong and Kaneko (2010) covering the period 1975-2005 and considering different development stages revealed urbanization to directly affect CO_2 emissions for all income groups. The positive relationship between urbanization and CO_2 emissions revealed by Poumanyvong and Kaneko (2010) was also confirmed by a number of studies (Cole and Neumayer, 2004; Liddle and Lung, 2010)

Nigeria is the most populated nation in Africa with population of over 200 million people. Equally, the country has the fastest rising population on the Africa's continent with 2.6% yearly growth rate in 2016. The country is placed 44th emitter in the list of over 200 World's nations. However, with the stride at which the country's population is rising, CO_2 equally raises. As such, it is possible that the country's per capita emissions will continue to increase due to the speedy population growth. This will expectedly rise the aggregate CO_2 emissions significantly.

Engelman (1994) revealed that both emissions and population have increased at similar rates since 1970 by plotting the long-term movements in global carbon dioxide emissions and population. Accordingly, he revealed that population growth has been the main force in motivating up global emissions over latest decades. Meyerson (1998) claimed that the global rise in carbon emissions was attributed to population growth over the last 25 years. Satterthwaite (2009) reported that population adds to CO_2 emissions through its influence on production and consumption activities.

(El-ladan, 2015) examined that, environmental problems like deforestation, forest degradation and climate change have become mysterious. These environmental problems rising from unnecessary utilization of forests as basis of fuel wood are not just environmental issues; they are also economic and social issues of dominant importance in Nigeria and other developing countries. Justifying them through renewable energy will be a step forward in the fight against global greenhouse gas build up.

Nordhaus (1990) in his findings revealed that, Deforestation of tropical forests is reported to be contributing significantly to CO_2 emissions: estimate s of carbon released range from 0.5 to 3 billion tons of carbon per year relative to the *6* billion tons associated with the then fossil-fuel used. Many observers argue that forest clearing is to a large extent uneconomic and mainly due to the absence of property rights for rain forests. Nordhaus (1990) noted a significant reduction of emissions might therefore be achieved at low economic cost through a cessation of forest clearing.

Zaccheaus (2014) in his study revealed that, forests serve as Carbon basins. Thus, inappropriate deforestation practice will only increase the amount of CO_2 already in the atmosphere. If this goes abandoned, the subsequent effects will be global warming which will consistently bring about other climate change conditions such as rise in ambient temperature, wind and water erosion causing health hazard and siltation of water body; increase in sea level, coral reef destruction, loss of biodiversity, flooding (e.g. Haiti), famine, starvation and death. The harmful implications of unregulated and improper deforestation are frequent as observed in many facades of the Nigeria sectors which by extension have global consequences. This calls for safety and upkeep of forests visa-vi and suggest that; With the ever-increasing need for reduction in greenhouse gas emissions, unregulated and improper deforestation should be discouraged or with the fall one and plant ten seedling sustainable measures be put in place in Nigeria as is still be done in the United State of America.

(Momodu et al., 2011) revealed in their study that, despite significant contributions of Nigeria forests ecosystem to the well-being of the country in terms of the economy and the environment, it is sad to note that our forests are rapidly "dying" without any noticeable corrective actions being taken. With an aerial cover of about 18 million hectares in 2000, the Nigerian forests have been a vital source of wood for various industrial and construction drives, and domestic fuel especially in form of firewood. This has happened from rising population pressure, economic activities for development and primarily inadequate/neglected management practices necessary for sustainable maintenance of the forests.

(Maji, 2015) found in his study that, the long-run coefficients of trade openness and economic growth were revealed to be significant and negatively associated to deforestation, specifying that trade openness and economic growth lessen deforestation and environmental degradation in Nigeria and therefore, trade and growth did not exist in the cost of deforestation and environmental quality. In order to enhance to those benefits, he proposes that trade relations be augment to their turning point with rest of the world to include concern for greener and pleasant environment. On the other hand, the long-run coefficient of population indicator discloses a direct and significant relationship with deforestation, suggesting that increase in population add to deforestation and environmental degradation. Hence, population increase will be at the expense of forest reservation and quality environment.

Ehrhardt-martinez and Ohio, n.d. (1998) found in their study that, High population growth increases the rate of deforestation in developing countries. The study also revealed that, Results support modernization theory, indicating that the level of urbanization has a curvilinear consequence on the rate of deforestation, that economic growth increases to deforestation, and that sectoral inequality decreases the rate of deforestation. In support of neo-Malthusian theory, population growth results in advanced rates of deforestation. Tertiary education has a mild inverse effect on the rate of deforestation, whereas the effect of trade dependency is insignificant.

Conclusively, many studies conducted in Nigeria considered either the consequence of population growth alone on CO_2 emissions or the effects of deforestation on CO_2 emissions. Thus, this study seeks to analyze the effects of both deforestation and population growth on CO_2 emission in Nigeria as the gap. Consequently, population growth is supposed to have a positive relationship with CO_2 emissions because an increase in population means a rise in human activities that aid CO_2 emissions, but only empirical tests could authenticate this.

3. Methodology

The objective of this paper is to examine the effect of Population growth and Deforestation on carbon emission in Nigeria. To distinguish our work with preceding literature, agricultural land percentage of land area was employed as proxy to deforestation and population growth rate as proxy for population Growth. To model the nexus among our variables the paper adopts the Autoregressive Distributed Lag (ARDL) bounds test to co-integration of Pesaran et al. (2001). Equally we begin by modeling the functional link amongst Population growth and deforestation, with Urbanization and Gross Domestic Product (GDP), as control variables. Carbon Emission (CO2) which is the explained variable was expressed as a function of other variables mention earlier. This relationship is shown in Eq. 1

$$CO_2 = F\left(PG, DF, URB, GDP\right) \quad (1)$$

Where:

CO_{2t} = Carbon emissions
PG_t = Population Growth
DF_t = Deforestation
URB_t = Urbanization
GDP_t = Gross Domestic Product

To lessen skewness in time series data, the log linear description provides better result related to functional form of linear equation. As such, subsequent Authors like Ahmed et al. (2015), Scrieciu (2007) and Culas (2007) adjust and established a log linear econometric model to contain the drift parameter and the stochastic error term, where the error term is projected to be normally distributed with zero mean and constant variance. The econometric connection of our variables is shown in Eq. 2 below:

$$\ln CO2_t = \beta_0 + \beta_1 \ln PG_t + \beta_2 \ln DF_t + \beta_3 \ln URB_t + \beta_4 \ln GDP_t + \mu_t \quad (2)$$

To check for the presence of co-integration relationship among the dependent variable and the independent variables in the model equation 2, it is specified and estimated using ARDL bound test for co-integration. The model is jointly stated with the null and alternate hypotheses which may be excluded or accepted. This set a turning point when the null hypothesis of long-run connection among the variables of the model is accepted, then some models which includes vector error correction model [VECM] amongst others can be ably applied. If on the other hand there exist co-integration connection as a result of rejecting the null hypothesis, after that long run and short run value can be estimated (Sulaiman, 2018).

The [ARDL] model was used to verify the long run equilibrium connection among the explained variable Carbon emission (CO_2) and the explanatory variables of Population growth (PG), Deforestation (DF) and extra control variables in the model. Some of the benefits of using the ARDL bound test include: 1) it provides good property for lesser sample size. 2) Use of level or first difference of variable stationarity or mixture of both. 3) Concurrent computation of long run and short run results to include error correction coefficient and elasticity of choosing optimum lag that curtail degree of freedom. 4) The model does not necessitate formal unit root test. Thus, the specified model for co-integration connection is given in equation 3 below:

$$\begin{aligned}\Delta \ln CO2_t = {} & \phi_0 + \sum_{i=1}^{m} \beta_{1i}\,\Delta \ln CO2_{t-i} + \sum_{i=0}^{m} \beta_{2i}\,\Delta \ln PG_{t-i} \\ & + \sum_{i=0}^{m} \beta_{3i}\,\Delta \ln DF_{t-i} + \sum_{i=0}^{m} \beta_{4i}\,\Delta \ln URB_{t-i} \\ & + \sum_{i=0}^{m} \beta_{5i}\,\Delta \ln GDP_{t-i} + \alpha_1 \ln CO2_{t-i} + \alpha_2 \ln PG_{t-i} \\ & + \alpha_3 \ln DF_{t-i} + \alpha_4 \ln URB_{t-i} + \alpha_5 \ln GDP_{t-i} + \varepsilon_t \end{aligned} \quad (3)$$

Where:

$H_0 : \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = 0$ $(No\ Co-\text{integ}ration)$

$H_1 : \alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4 \neq \alpha_5 \neq 0$ $(\text{C}o-\text{integ}ration\ exists)$

To get the short run estimates and the value of error correction term which determine the speed of correction or convergence back to the equilibrium point from disequilibrium point, the equation 4 below is also suitably specified and calculated.

$$\begin{aligned}\Delta \ln CO2_t = {} & \phi_0 + \sum_{i=1}^{m} \beta_{1i}\Delta \ln CO2_{t-i} \\ & + \sum_{i=0}^{m} \beta_{2i}\Delta \ln PG_{t-i} + \sum_{i=0}^{m} \beta 3i \Delta \ln DF_{t-i} \\ & + \sum_{i=0}^{m} \beta 4i \Delta \ln URB_{t-i} \\ & + \sum_{i=0}^{m} \beta_{4i}\Delta \ln GDP_{t-i} + \varphi ECT_{t-i} + \varepsilon_{4t} \end{aligned} \quad (4)$$

Where: $\beta_1 - \beta_4$ are the short-run values, φ is the value of error term, Δ is the short-run sign or the change parameter, M is the maximum or optimum lag length and $\sum$ is the summation or sigma.

To evaluate the long run equilibrium connection between the variables, we test the combine null hypothesis of no co-integration on the level variables beside its alternative hypothesis that suggests the existence of co-integration. The null hypothesis in the equation is $H_0: \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = 0$ while the alternative hypothesis is given as $H_1: \alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4 \neq \alpha_5 \neq 0$. The existence of co-integration or its nonappearance is based on the outcome of F-statistics test obtain through the OLS variable addition test. The joint F-statistics value will then be related with critical values in Narayan (2005) Table. If the computed F-statistics value is greater than the upper bound value of the table, co-integration exists. However, if computed F-statistics is lower than the lower bound, co-integration does not exist. On the other hand, if the F-statistics sprays within the upper and lower bounds, the result is inconclusive.

4. Results and Discussion

As presented in table 1 below, the sample size is between (30 – 80) with a total of 47 observations.

Table 4.1: Descriptive Statistics

	InCO2	InDFT	InGDP	InPOG	InURB
Mean	83.3061	69.4953	2.0000	2.6029	3763
Median	86.1000	71.4396	1.4800	2.5857	3202
Maximum	106.1200	80.9205	4.6400	3.0320	9053
Minimum	29.0600	51.8451	9.5200	2.2860	9942
Std. Dev.	16.5362	9.2581	1.0900	0.1525	2340
Skewness	-0.9547	-0.5317	1.2713	0.8783	0.7013
Kurtosis	4.1598	1.8996	3.2459	4.3841	2.3692
Jarque-Bera	9.7743	4.5853	12.7790	9.7950	4.6322
Probability	0.0075	0.1010	0.0017	0.0075	0.0986
Observations	47	47	47	47	47

Source: Author's Estimation (2021) using E-views software version 9

We have 47 observations for each series, raw data was used in preparing and presenting table 1 above, and all the variables are within the normal zero skewness which is desirable, population growth (PG), Urbanization (URB) and Gross Domestic Product (GDP) are positively skewed variables, only that Deforestation (DF) is negatively skewed. Next is the test for unit root, to confirm that no estimation of spurious regression and conform to conditions guiding the ARDL model is to be used in this study.

Table 4.2: Result of Unit Root Test

Variables	ADF TEST		PP TEST	
At Level I(0)	**Intercept**	**Linear Trend**	**Intercept**	**Linear Trend**
In PG	-7.9649 (0.0000)***		-2.7537 (0.0730)*	
lnDF	-0.6358 (0.8521)	-2.0422 (0.5629)	-0.7879 (0.8131)	-2.3353 (0.4073)
lnURB	-1.5136 (0.5177)	- -	-1.3211 (0.6119)	-1.1709 (0.9047)
lnGDP	0.9076 (0.9948)	-1.0828 (0.9208)	0.5207 (0.9857)	-0.9535 (0.9405)
lnCO2	-3.9625 (0.0036)***	-4.9631 (0.0011)	-5.4306 (0.0000)***	
At Level I(1)	**Intercept**	**Linear Trend**	**Intercept**	**Linear Trend**
In PG	-		-	
lnDF	-4.1437(0.0022)***		-6.8944 (0.0000)***	
lnURB	-4.4544 (0.0009)***		-6.5082 (0.0000)***	
lnGDP	-3.0553 (0.0376)**		-5.2536 (0.0001)***	
lnCO2	-		-	

Source: Author's Estimation (2021) using E-views software version 9

Note that ***, **and * are 1%, 5% and 10% significance level and values in parenthesis are the respective p-values

After the test for the occurrence of unit root in the variables as shown in Table 2 above pave way for the test of possible presence of co-integration connection among the series and the result is stated in Table 3 below. The calculate F-statistic value of 7.858 is larger than the lower bound and the upper bound values at 1%, 5% and 10% levels of significance respectively and at this point we reject the null hypothesis that says there is no co-integration link among the series and accept the alternative hypothesis that says there is co-integration link among the variables. Therefore, the explained and the explanatory variables are moving together in the long run.

Table 4.3: ARDL Bounds Test Result

Model Specification	**Period**	**Optimal Lag-Length**	**F-statistics**
F_{CO2} ($lnCO_2$, $lnPG_t$, $lnDF_t$, $lnURB_t$, $lnGDP_t$)	1974-2016	ARDL (1, 2, 4, 2, 2)	7.858^{***}
Critical Value Bounds	**1%**	**5%**	**10%**
I0 Bound (k=4)	3.74	2.86	2.45
I1 Bound (k=4)	5.06	4.01	3.52

Source: Author's Estimation (2021) using E-views software version 9

The strong existence of co-integration relationship between the variables gave the courage for the check of the long run and short run coefficients and the outcomes are conveyed in Table 4 below. The outcome catches the insignificant negative influence of gross domestic product on CO_2 emissions in both the long run and the short run periods and this indicates that economic growth of Nigeria is not contributing to CO_2 emissions for the period under study. This finding contradicts the findings of researchers such as Musa and Maijama'a (2020) who reported that economic growth exerts a direct and significant impact on the level of CO_2 emissions in the country.

Population growth appears to be having significant adverse impact on the emissions of carbon dioxide in the long run. Specifically, 1 percent rise in Population growth is connected with 4.748 percent decrease in the level of carbon emissions dioxide for the period under study and this is an implication that those activities that causes environmental degradation as a result of the growing population in the country are checked by the relevant authorities within the period under study in Nigeria. This empirical outcome has contradicted the finding of (Lukman. et al 2018; Shi, (2003); Cole and Neumayer, (2004); Morales-Lage et al., (2006) reported that population growth has a positive effect on the level of country's CO_2 emissions. Again, the lags of population growth were having significant negative to positive influence on the level of CO_2 emissions in the short run period. Implying that 1 percent changes in the lag 2 and lag 3 of population growth is connected with 31.496 percent and 17.274 percent decrease and increase in the levels of CO_2 emissions in the short run period respectively.

Furthermore, urbanization has a significant impact on the CO_2 emissions in the long run period. This means that growth in urban population by 1 percent is the same thing as increase in the level of CO_2 emissions by 0.794 percent in the long-run period and this shows that urbanization is among the drivers of CO_2 emissions in the country as the empirical finding validate the findings of Ahmad et al. (2013) for South Asian nations, Mahmood and Zamil (2019) for Saudi and Maijama'a and Musa (2020). However, the short run lag 1 coefficient of urbanization exerts negative impact on the level of CO_2 emissions at 5 percent level of significance. Particularly, 1 percent increase in urbanization in the short run is associated with 12.948 percent decrease in the level of country's CO_2 emissions.

Furthermore, deforestation appeared to have an inverse coefficient and significantly associated with CO_2 emissions at 5 percent level of significance in the long run. Particularly, 1 percent increase in deforestation activities in the country would help in reducing the level of CO_2 emissions by 2.972 percent in the country within the long-run period. This indicates that earnings from increase deforestation activities in the country is also flock back in preserving the quality of the environment. This empirical discovery opposes the researcher's results such as Nordhaus (1990) and Achike & Onoja (2014). But in the short run period, the lag of deforestation is having significant positive sign with the level of CO_2 emissions for the epoch under study. 1 percent rise in deforestation activities is connected with about an approximately 1.121 percent rise in the level of CO_2 emissions in the short run.

Sustaining the econometric requirements of being significant, adverse and less than 1 in values of the ECT makes it possible for the presence of the short run coefficients and the ECT value of -0.781 reveals that the speed of convergence to equilibrium position when there is an existence of short-run dynamic disequilibrium is at the rate of 78 percent every year in the country.

The R-square value of 0.841 implies that 84 percent variation in the dependent variable (CO_2 emissions) is jointly explained by the population growth, deforestation, urbanization and economic growth while the remaining 16 percent is explained by the error term or other influences that are not taken in the model. Similarly, even after adjustment, population growth, deforestation, urbanization and economic growth jointly explained 75 percent variation in CO_2 emissions while the remaining 25 percent is responsible by the error as shown by the adjusted R-square value.

The Durbin Watson statistic test value of 2.046 is within the range of 1.50-2.50 and hence the model is not distress from the first order serial correlation problem while the second order serial correlation problem is subject for investigation. The F-statistic value of 9.539 was statistically significant at 1 percent and it confirms the existence of joint significancy of economic growth, population growth, urbanization and deforestation in influencing CO2 emissions in the model.

Table 4.4: Long and Short-Run ARDL Results

Model: $lnCO_2 = \beta_0 + \beta_1 \ln PG_{t,} + \beta_2 \ln DF_t + \beta_2 lnURB_t + \beta_3 \ln GDP_t + \mu_t$

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Short-Run Relationship				
$\Delta lnGDP_t$	0.426	0.391	1.090	0.285
$\Delta lnGDP_{t-1}$	-0.451	0.386	-1.168	0.252
$\Delta lnPOG$	-2.981	6.910	-0.431	0.669
$\Delta lnPOG_{t-1}$	25.090	23.896	1.049	0.303
$\Delta lnPOG_{t-2}$	-31.496	17.925	-1.757	0.090
$\Delta lnPOG_{t-3}$	17.274	6.590	2.620	0.014
$\Delta lnURB_t$	1.402	5.595	0.250	0.803
$\Delta lnURB_{t-1}$	-12.948	6.148	-2.105	0.044
$\Delta lnDFT_t$	0.882	0.829	1.062	0.297
$\Delta lnDFT_{t-1}$	1.121	0.501	2.237	0.033
ECM (-1)	-0.781	0.153	-5.101	0.000
ECM = lnCO2 + 0.1270lnGDP$_t$ + 4.7484lnPOG$_t$ - 0.7948lnURB$_t$ +2.9730lnDFT$_t$ - 11.8086				
Long-Run Relationship				
Constant	11.808	4.869	2.424	0.022
$lnGDP_t$	-0.126	0.256	-0.495	0.624
$lnPOG_t$	-4.748	2.297	-2.066	0.048
$lnURB_t$	0.794	0.408	1.945	0.062
$lnDFT_t$	-2.972	1.424	-2.086	0.046
R^2& Adj-R^2	0.841 & 0.753			
Durbin-Watson stat	2.046			
F-statistic	9.539^{***} (0.000)			

Source: Author's Estimation (2021) using E-views software version 9

The dynamic ordinary least squares (DOLS) and fully modified ordinary least squares (FMOLS) were applied because they are the perfect checks for the long run ARDL coefficients and the results were shown in Table 6 below. The outcome of the two estimators revealed the presence of the long run ARDL coefficients with the exemption of Gross Domestic Products (GDP) which seems to be insignificant in the long run ARDL coefficients but is significant under the two estimators respectively.

Table 4.5: Dynamic and Fully Modified Ordinary Least Squares Results

DV= $lnCO_{2t}$	DOLS		FMOLS	
Variables	**Coefficients**	**Std. Error**	**Coefficients**	**Std. Error**
Constant	3.412 (1.646)	2.072	4.774 (1.677)	2.846
$lnDFT_t$	0.404 (0.933)	0.433	-0.222 (-0.307)	0.723
$lnGDP_t$	-0.339^{**} (-2.454)	0.138	-0.250^{*} (-1.881)	0.133
$lnPOG_t$	1.673^{**} (2.467)	0.678	1.385^{**} (2.269)	0.610
$lnURB_t$	0.374^{***} (3.181)	0.117	0.366^{**} (2.086)	0.175
R^2& Adj-R^2	0.593	0.554	0.686	0.618

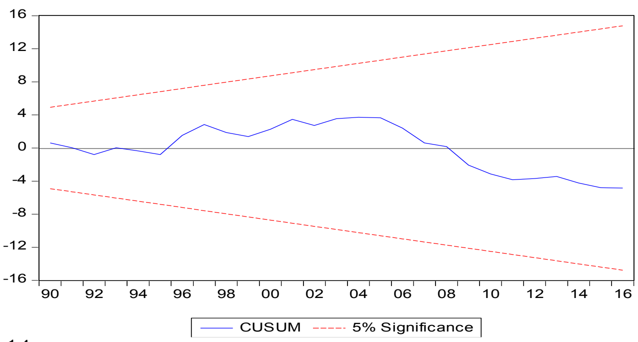
Source: Author's Estimation (2021) using E-views software version 9

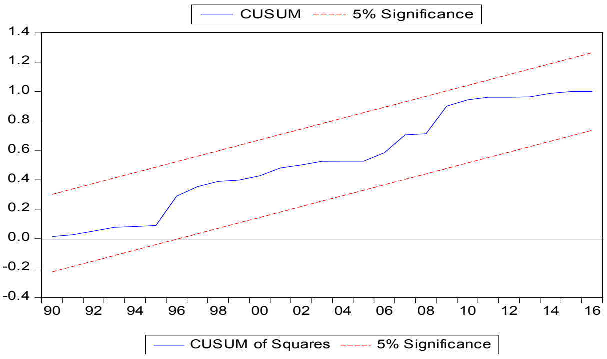
After the estimation of the co-integration, long run and short run models followed the reliability checks in order to define the strength of the estimated model and the result is shown in Table 7 below. The outcome confirmed that for all the tests, their null hypotheses cannot be rejected since their p-values are insignificant and this is a sign of a good and consistent estimated model. As the model has conceded all the reliability tests, but one important thing with regard to the passing all the tests is the stability of the model. The stability test as recommended by Brown et al. (1975) was implemented and the outcome revealed that there is stability between the variables throughout the study periods and the outcome is showed in Figure 1 below the Table 4.5.

Table 7. Diagnostic Test Results

F-statistic	F-version	LM-version
1: Serial Correlation	0.785 (0.466)	2.542 (0.280)
2: Heteroscedasticity	0.776 (0.690)	12.964 (0.605)
3: Normality	1.063 (0.587)	
4: Functional Form	0.114 (0.737)	0.338 (0.737)
CUSUM	Stable	
CUSUMSQ	Stable	

1: Breusch-Godfrey Serial Correlation LM test.
2: Breusch-Pagan-Godfrey
3: Jarque-Bera test
4: Ramsey RESET tests using squares of fitted values.





5.Conclusions and Policy Recommendations

The main objective of this study is to examine the nexus: population growth and deforestation on carbon emissions in Nigeria. The study adopted Auto Regressive Distributive bound test proposed by Pesaran et al. (2001) to confirm the co-integration and equilibrium association between the variables. At first, the paper tried to test for co-integration in models and establish that all the variables in the models were co-integrated. And all the explanatory variables, which includes, Population growth, deforestation and urbanization stood significant in determining CO_2 emissions, except GDP which was found to be insignificance.

The long run coefficients value of population growth and deforestation were found to be statistically significant and proportionally linked to carbon emission, signifying that population growth and deforestation increases carbon emission in Nigeria and therefore, population and deforestation have taken place at the expense of carbon emission. Its implication includes; massive population result to increase in demand for energy for power which leads to rise in CO_2 emissions, and more so, as population increases, Deforestation tends to destroy the forests and occupy in burning of fossil fuels resulting to the discharge of CO_2 emissions to the atmosphere. Population was found to increase CO_2 emissions through its influence on production and consumption activities. Again, Nigerian economy is majorly involved on energy use especially from fossil energy; there is need to adopt policies to curb increasing carbon emissions. In view of the fact that Nigeria's population has continued to rise, and in turn, often lead to increase in Deforestation and the rate of urbanization, the study suggested that, alternative energy policies such as increasing the energy saving strategies, lessen energy intensity, etc. should be accepted. In addition, the country has to use other different source of energy with less carbon emissions, by inspiring the use of low carbon technologies like abatement equipment, renewable energy, and energy utilization efficiency can equally help in reducing CO_2 emissions without decreasing energy consumption, and thereby achieving sustainable economic growth.

The country has to put in place policies that shall reduce the population growth rate, rate of deforestation and rate of urbanization. The study results should pave approach for more research on how these problems can be identified and solved.

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