DEFORESTATION AND ECONOMIC GROWTH IN NIGERIA: Empirical Analysis

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ABSTRACT

This study investigates the economic growth-deforestation nexus with a view to ascertaining the existence of the environmental Kuznets curve (EKC) in Nigeria. The study deployed the Autoregressive Distributed Lag (ARDL) model and the Nonlinear Autoregressive Distributed Lag (NARDL) model. The variables used are net forest depletion (dependent) against real gross domestic product per capita, energy use per capita, agricultural raw materials export and agricultural land (independent). All data used were sourced from the World Development Indicators Data Bank (2019). Findings from the ARDL invalidated an inverted U-shaped EKC both in the short and long run estimations. However, when the analysis was carried out at the level of the NARDL model, the results indicated an inverted U-shaped EKC, suggesting that a nonlinear relationship should be acknowledged between deforestation and economic growth in Nigeria. The key recommendation of this study is that exploitation of forest resources must be consciously managed.

Key words: deforestation, economic growth, environmental degradation, EKC, reforestation

JEL classification: F64, O13, O44, Q23

1. Introduction

The conversion of forest lands to other economic and social uses involves the felling of trees and displacement of rich biodiversity. These continuous displacements have deleterious effects on the environment and ultimately human wellbeing. Deforestation is one of the globally-recognized indicators of environmental degradation. Its effects span the macro and micro levels, moving from adverse impact on the economy to posing danger to human health. The alteration of the carbon dioxide (CO_2) balance in the atmosphere as a result of diminishing forests has been shown to be hazardous to human health (Van der Werf et al., 2009), and deforestation can result in higher incidence of malaria (Petney, 2001). Also, ensuing natural disasters from absence of windbreaks can increase contingent liabilities and reduce development spending (Damnyag et al., 2011).

The scope of study of deforestation extends beyond national boundaries because globalization impacts deforestation, especially through trade in natural resources. Leblois, Damette and Wolfersberger (2017) submit that agricultural export is an important driver of deforestation. However, the impact varies across countries depending on the size of forest cover. Hence, an understanding of development trends globally is important to assessing deforestation trends. From the foregoing, strong agricultural and forest policies will be required to curb deforestation (Culas, 2012).

Given the inherent benefits of forest resources, which include income and economic growth, they are liable to continuous exploitation. This, without adequate policy restrictions can lead to environmental problems that were once prevented by the existence of forests (Manuel et al., 2019). Discourse on the need for sustainable growth has been on the rise in recent times; the ideal requirement states a need to pursue growth in a way that can be reproduced and that will be available across generations. Consequently, the comprehension of the relationship between economic growth and deforestation is pivotal to curbing environmental challenges and achieving sustainable growth.

The interactions that exit between the environment and growth have been prominently explicated in theoretical literature by the environmental Kuznets curve (Kuznets, 1995). The curve posits that economic growth has a positive relationship with environmental degradation up to a threshold beyond which the relationship becomes negative. Furthermore, it is expected that environmental degradation that results from economic growth will not persist due to evolution in taste and technology over time. This may be accredited to varying consumption rate of forests across countries according to their level of development (Ewers, 2006). In addition, the size and spread of the population can determine the extent of biodiversity loss (Armenteras et al., 2006).

Tradeoffs have been identified to exist between productivity, specifically agricultural intensification and environmental sustainability (Ferraro and Gagliostro, 2017). The dependence of aggregate income on the adequate combination of labour and capital has been established in theoretical literature. However, the full cost of production includes the natural capital used (Indarto and Mutaqin, 2016). Forests serve as inputs to production processes; hence, indiscriminate exploitation can result in environmental degradation that reduces economic growth prospects (Azam, 2016). On the other hand, an explanation of a reverse causality from economic growth to deforestation can be proposed. The intensification of resource use and the expansion of urban areas due to growth can aggravate forest loss. Due to the existence of tradeoff between environmental quality and growth (Tan, Lean, & Khan, 2014), policies to reduce deforestation may reduce growth (Doupe, 2014), if the relationship is not studied and managed.

Based on the foregoing, this study explores the dynamic relationship that exists between deforestation and economic growth in Nigeria. The Nigerian literature on deforestation is dominated by the study of its causes and effects (Ogunwale, 2015; Mmom and Mbee, 2013; Ibrahim, Iheanacho & Bila, 2015; and Kalu and Okojie, 2009). Some identified causes of deforestation include poverty, lack of enforcement, and population pressure. Studies expounding the relationship between deforestation and economic growth are scarce and the available explanations have taken various forms. Ibrahim et al. (2015) submit that the impact of gross domestic product (GDP) on deforestation is indirect while Kalu and Okojie (2009) found that the exploitation of forest resources through export of timber increased the GDP. Also, Nathaniel and Bekun (2019) found that GDP increases deforestation in the short run but reduces it in the long run, while Alege and Ogundipe (2013) found nonexistence of the environmental Kuznet curve (EKC) in Nigeria for environmental degradation. Empirical trends also showed that net forest depletion has been on the rise over time (9.2%), moving at a faster rate than the GDP per capita (-1.6%) between 1981 and 2018 (World Bank, 2018).

The objective of this study deviates from existing related studies in a number of ways. Firstly, the study aims to check for the existence of the environmental Kuznets curve (EKC) with respect to deforestation in Nigeria unlike Alege and Ogundipe (2013) whose indicator was carbon dioxide emission in the atmosphere. Secondly, the gross domestic product per capita, a more effective measure of development and growth, is used in this study instead of the GDP as done in Nathaniel and Bekun (2019). Thirdly, we also interrogated the credibility of the existence of a tradeoff between deforestation and economic growth in Nigeria. In order to achieve these objectives, the Autoregressive Distributed Lag model (ARDL) is adopted to check for the existence of the EKC. The ARDL has been credited to be most effective in cases of small samples. For the hypothesis of EKC to hold, the GDP per capita variable is expected to have a negative sign with the square of GDP per capita. To check for the existence of tradeoffs between the key variables, the pairwise causality test is deployed.

The paper is structured as follows: section 2 presents an overview of the study, section 3 is devoted to the literature review, section 4 presents the methods, section 5 presents and discusses the results and section 6 concludes and suggests recommendations for the study.

2. Overview of Deforestation and Economic Growth

Nigeria is a primary-sector-driven economy. The exploration of natural resources has been the mainstay of the economy with little value addition over time. The use of forest resources for economic benefits is not left out of this; the export of timber and price index of timber increased GDP by 0.23% and 13.2% respectively between 1970 and 2000 (Kalu and Okojie, 2009). These benefits have been followed by over exploration and overexploitation that pose harm to biodiversity. Also, urban development and expansion of agricultural lands among other factors in Nigeria impose pressure on forest resources (Nzeh, Eboh & Nweze, 2015). Another study (Ibrahim et al., 2015) revealed that prices of forest products and GDP have an indirect impact on deforestation; and that population and poverty increase deforestation while education reduces it.

Figure 1 presents the trend of the gross domestic product per capita and adjusted saving net forest depletion for the period 1980 to 2018. It is shown that there has been an average increase in the two trends over time with few dips at certain periods. Forest depletion has increased over a 100% within the period. Logging export was banned in 1975; in spite of this, the high deforestation rate persisted till 1988 at a growth rate above 100%. Following the annual afforestation policy, the growth rate declined to 71% over 5 years. Prior to 2005, it returned to above 100% sequel to the commencement of the National Forest Action Plan in 2005. The Millennium Development Goals that came into limelight in year 2000 with 9-point goals, including environmental sustainability, elapsed in 2015. By 2015, the growth rate of deforestation had increased to over 400%. However, by 2018, the rate of forest depletion had declined by 27%. In comparison with the GDP per capita, net forest depletion increased more rapidly over the period under consideration. The EKC for deforestation is not obvious in the trend, but deforestation increased rapidly in periods of higher per capita income. The chart shows a similar movement for the two trends between 2002 and 2016. Increase in per capita income was followed by a rapid increase in deforestation within the period.

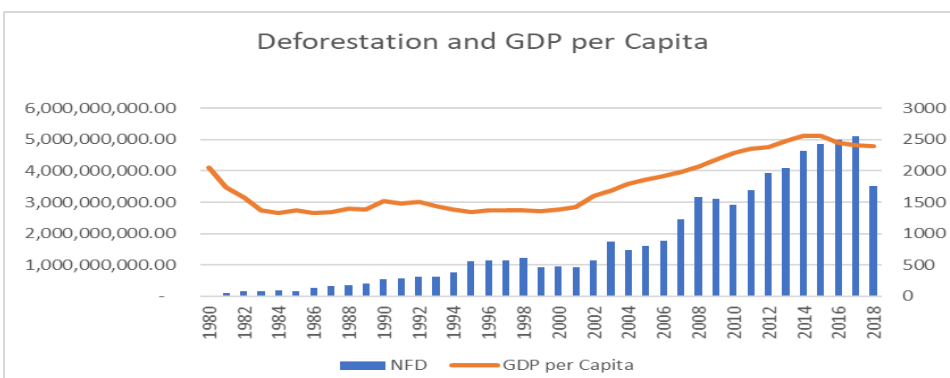

Figure 1. Deforestation and GDP per capita trend in Nigeria, 1980-2018.
Source: World Bank, 2018.

Figure 2 shows an increase in agricultural lands in Nigeria. This implies that conversion of forest land to alternative uses has been increasing over time. This can be inferred from the literature as expansion in agricultural land leads to decline in forest land. Also Figure 3 corroborates what was seen in the deforestation and GDP per capita trend shown in Figure 1. Spikes were observed in the 2000s, the same period when there were higher rates of deforestation. Agricultural value added as a percentage of GDP increased by over 100% between 2000 and 2005. Also, agricultural export increased between 2005 and 2015 in the same degree. This is in line with empirical evidence that states that a boom in the agricultural sector tends to hurt forest resources over time because of land use conversion.

Empirical analysis of deforestation has been mainly in the aspects on investigating the causes and consequences of deforestation. The trade-off that exists between deforestation and national income has been least explored. However, Alege and Ogundipe (2013) found no evidence for the EKC for the deforestation hypothesis in Nigeria. This study intends to check the validity of the EKC hypothesis for Nigeria, employing another method to understand the direction of causality between the two variables. The results will enhance policy trust towards sustainable growth.

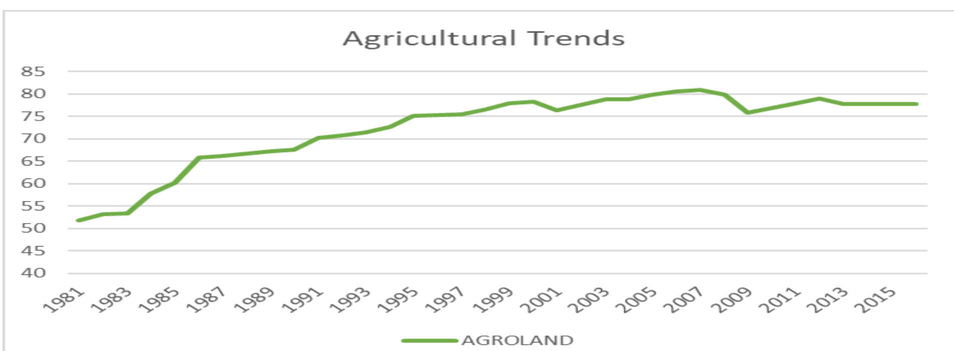

Figure 2. Trend in agricultural lands in Nigeria, 1980-2018.

Source: World Bank, 2018.

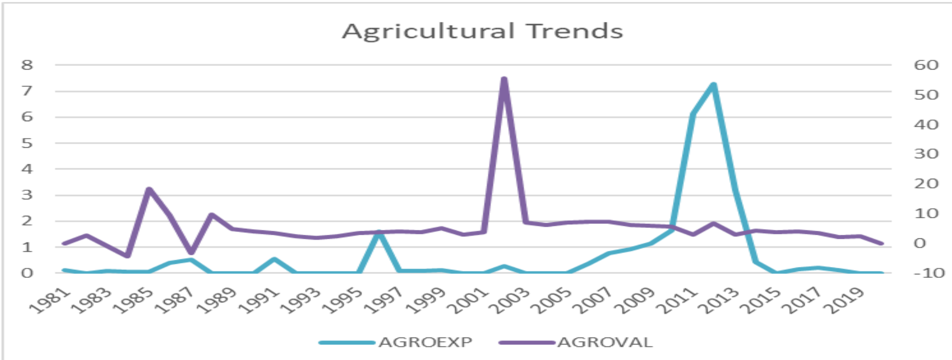

Figure 3. Trends in agricultural export and agricultural value added in Nigeria: 1980-2018.
Source: World Bank, 2018.

3. Literature Review

Theoretically, the relationship between economic growth and environmental quality has been popularly explained in the literature using the environmental Kuznets curve. The hypothesis describes the relation as an inverted-U shaped curve; that is, environmental degradation positively relates to growth at its initial stage and eventually turns negative at higher levels (Kuznet 1995). Other related thoughts include the use of production possibility frontier to explain the tradeoff that exists between the environment and economic development, and this is known as the Environmental Transition Theory (Antle and Heidebrink, 1995). Similar to Kuznets, the state of the environment declines at initial increase in income and at higher levels of income, demand for environmental protection increases, hence an eventual improvement. The environmental transition hypothesis draws on Ruttan's hypothesis that postulates the existence of income elasticity for the environment; this implies that as income increases, the demand for better environment increases (Ruttan, 1971).

A number of empirical studies such as Grossman and Krueger (1991; 1993), Holtz-Eakin and Selden (1995), Panayotou (1993), and Shafik and Bandyopadhyay (1992) have induced more studies into discussions regarding the shape and nature of the relationship between economic growth and environmental degradation. Some of the studies strongly rejected the earlier consensus of intellectual debates; suggesting a linear relationship between economic growth and environmental decline. However, Panayotou (1993) found a replica of an apparent inverted "U" shape linking environmental degradation to economic growth. This finding gave rise to the concept of the environmental Kuznets curve (EKC) hypothesis. Put simply, the EKC hypothesis posits that, in early phases of development, emphasis is placed on economic expansion with little or no attention devoted to environmental cleanliness. This untamed aspiration for economic growth inadvertently leads to the extensive and explosive resource extraction which sometimes happens with the use of technologies that are not friendly to the environment. Hence, environmental degradation in different forms emerges side by side with economic growth.

Alternative views exist in the literature (Everett et al., 2010). The limits theory postulates an existing environmental limit beyond which production declines and the economy shrinks after hitting a threshold of economic degradation. This view refuted the possibility of a level of growth beyond which demand for environmental quality increases due to adverse effect of degradation to the environment. The New Toxic View on the other hand propounds the possibility that environmental challenges will grow as income grows, hence resulting in continuous environmental degradation at higher levels of income. Furthermore, another view submits that environmental degradation will become perpetuated in poor countries due to dumping by developed countries. Also, the relationship between income and the environment has been postulated to be driven by the size of production (scale effect), the composition of production (composition effect) and the technology utilized in the production process (technical effect).

Theoretical underpinnings of the EKC suggest a unidirectional causality from economic growth to the environment. Thus, expectations from the EKC theory posit that in the long run, a panacea to any indicator of environmental degradation may be economic growth. Studies carried out over the years have tested a variety of indicators of environmental quality such as carbon dioxide emissions, sulfur monoxide, deforestation, and ecological footprint among others, with a view to confirming the EKC hypothesis. Amazingly, similar to other measures of environmental quality, establishing the presence of an EKC for deforestation has not been very straightforward. Indeed, various studies have produced different findings leading to conflicting options, which are divided as to the true nature of the EKC for deforestation. Nevertheless, a valid EKC for the deforestation hypothesis will imply that deforestation will increase with income up to a specified income threshold and then decline afterward with further increase in income beyond the specified threshold (Minlah et al., 2021).

3.1 Economic growth and the environment

Achieving economic growth is a constellation of processes that involve the use of inputs. One of the inputs is natural capital supplied by the environment. The continuous use of the natural capital in an unsustainable way can hurt the growth garnered over time, hence the advent of the term sustainable growth as a policy goal. Empirical studies in this line have provided insights into the interaction between growth and the environment. Asici (2013) considered the major forms of degradation, including deforestation using a composite indicator called the natural disinvestment component of the adjusted net savings to investigate the impact of economic growth among other factors. It was found that economic growth increases the pressure on nature, but increased income decreases pressure on forest resources. A reverse impact from the state of the environment to growth was shown in Azam (2016), where it was found that environmental degradation has a significant negative effect on economic growth. The length of time of reference is an important consideration in order to understand the relationship between economic growth and deforestation as postulated by the EKC. Taking this into consideration, Tan et al. (2014) found a decline in environmental quality as a result of increased growth in the short run and identified a requirement of consistent growth over a long time for a reversal to occur.

The test for the EKC hypothesis has been used as a tool to understand the relationship between the environment and economic growth in several countries; for example Miah et al. (2011) for Bangladesh. However, in some cases, the EKC hypothesis was nullified due to country characteristics. Azam and Khan (2016) refuted the existence of the EKC hypothesis in upper middle-income and high-income countries. In contrast, however, low-income countries lend support to the EKC hypothesis. The relevance of EKC in low-income countries was further confirmed in Bhattarai and Hammig (2001) for Africa, Asia and Latin America. In some few cases, other approaches, like the generalized method of moments (GMM), were utilized to measure the relationship between environmental degradation and economic growth (Apregis and Ozturk (2015).

One of the key indicators of environmental degradation is deforestation. Forests serve as key aspects of the environment, lending support to the continuity of biodiversity and vitality of the ecosystem. Economic growth can result in deforestation due to evolving needs for alternative land use. Also, continuous deforestation will ultimately have an adverse effect on growth through associated cost of health hazards, natural disasters and depletion of agricultural land nutrients. The environmental Kuznets curve has been tested and confirmed in respect of deforestation across countries (Zambrano-Monserrate et al., 2018; Ahmed et al., 2014). Indeed, Ahmed et al. (2014) showed the existence of cointegration in the long run and short run paths between deforestation and economic growth; and also, that economic growth Granger-caused deforestation in Pakistan. Esmaeil and Nasrnia (2014) found evidences of a long-run relationship between deforestation and GDP per capita in Iran using the Autoregressive Distributed Lag model (ARDL). In addition, the level of development of a country influences the consumption of forest resources; low-income countries with low forest cover have greater tendency to consume the existing portions of forest rapidly, and hence, experience high deforestation (Ewers, 2006). Nevertheless, there are cases where the existence of the deforestation-growth relationship in the EKC framework was not confirmed (Culas, 2007). For the EKC hypothesis and deforestation relationship, only a few studies have been done. Forest depletion in Nigeria negatively affects GDP in the short run (Ogbuabor and Egwuchukwu, 2017). Alege and Ogundipe (2013) could not establish the existence of EKC for Nigeria. However, they found that at the early stage of development, environmental quality was low, and it was further aggravated by weak institutions. Poverty and lack of enforcement affect greening the environment (Ogunwale, 2015).

3.2 Causes of deforestation

Causes of deforestation can be classified into natural causes (natural disasters); factors that relate to the advancement of an economy (such as urbanization, increased agricultural land use); and socioeconomic factors (such as population growth, rural socio-economic condition). Armenteras et al. (2006) showed that rate of deforestation varied according to population density. Further, it was found that socioeconomic conditions, such as poverty rate, strongly influence deforestation, and to reduce its extent, poverty alleviation is imperative (Miyamoto, 2020). Contrarily, other studies argued that no linkage exists between poverty and deforestation, given the fact that all income groups are resource dependent (Deininger and Minten, 1999).

Agricultural factors also play a key role in the deforestation rate due to the tradeoff between forest lands and agricultural lands at the early stages of development (Armenteras et al., 2006). Distortions resulting from agricultural prices increased deforestation in Mexico (Deininger and Minten, 1999). Also, increase in agricultural export share, agricultural value added and rural population result in greater land conversion to agricultural lands, hence increased deforestation (Barbier, 2004).

The socioeconomic characteristics of rural dwellers can influence the sustainability of the environment as a result of their immediate access to biodiversity. In a study analyzing 158 countries (Tanner and Johnston, 2017), the provision of rural electrification led to a decrease in deforestation. Further, rural electrification was more robust in explaining deforestation than population growth and development. Contrarily, Defries et al. (2010) discovered that policy focused on rural population has less impact on deforestation. Their result showed that deforestation is primarily driven by urban population growth and agricultural export. Also, institutions and macroeconomic policy environment were found to influence the rate of deforestation (Bhattarai and Hamming, 2001). Increased government spending led to increase in deforestation through increased forest clearing for agricultural purposes (Galinato and Galinato, 2016). Evidence of the impact of the definition of property right on deforestation was also found in the literature, reiterating the role of governance in environmental control

(Deacon, 1994). Rudel (2015) pointed out that the rate of deforestation in Africa depends on forest types, tax receipts from mineral resources and the key role farmers play relative to other regions. Faria and Almedia (2016) found that increased openness to trade led to higher deforestation in Brazilian Amazon.

Summarily, deforestation is driven by an enormous range of factors including environmental, economic and socio-economic. To curb deforestation, an understanding of the interactions between these factors and deforestation is crucial.

4. Methodology

The dynamics of the hypothesized relationship between deforestation and growth in a country-specific context from year 1990 to 2018 is explored in this study. To estimate the relationship between the environment and growth, the ARDL approach has been mostly adopted in the literature. However, there are a few exceptional cases: Chiu (2002) used the Panel Smoot Transition Regression model (PSTR); and Culas (2007) deplored the Cochrane-Orcutt transformation procedures involving the general least squares method. Also, various indicators have been used for environmental degradation, especially the CO_2 emission. For this study, the focus is deforestation. The model is specified as follows:

$$DEF = \alpha + \beta_1 GDPPC_t + \beta_2 (GDPPC_t)^2 \beta_3 ENERGY_t + \beta_4 AGRICEX_t + \beta_5 AGRICLND_t + u_t$$

where:

DEF = annual net forest depletion

GDPPC = real gross domestic product per capita in US dollars

ENERGY = energy use per capita

AGRICEX = agricultural raw material exports

AGRICLND = agricultural land as a percent of land area.

The dependent variable, net forest depletion is measured by the Adjusted Saving Net Forest Depletion.

According to the Food and Agriculture Organization of the United Nations (FAO), net forest depletion is calculated as the product of unit resource rents and the excess of round wood harvest over natural growth. All data used in this study was sourced from the World Development Indicators Data Bank 2019 of the World Bank. It is worthy to note that the GDPPC is the most important explanatory variable in the model. The EKC hypothesis will hold if the coefficient of GDPPC is positive and its squared value negative. This implies that at lower levels of GDPPC, deforestation increases and subsequently declines as the GDPPC grows higher over time.

As shown in previous studies, variables that have been identified empirically as drivers of deforestation were selected to control the model. Forests serve as energy sources, especially in developing countries; with relatively more expensive sources of energy, forest wood serves as an alternative in such context, hence, greater consumption of energy can result in deforestation. Forest resources will remain as alternative energy source, thus the opportunity cost of preservation of forests is regarded as high. Increase in export of agricultural products will engender conversion of more forest lands to agricultural lands. When not adequately managed, conversion of forests to agricultural lands will lead to rapid deletion of forests. The larger the size of cultivated lands, the less the forests that will be left standing; land is a fixed asset which can be converted to alternative use. Rapid conversion of lands for agricultural use will deplete forests.

The Autoregressive Distributed Lag (ARDL) Model Procedure and Model Specification

The ARDL technique allows the use of series integrated at most to order 1, that is, I(0) and I(1). This approach has been found to be more suitable for small samples than other methods (Haug, 2002). The empirical model is specified as follows:

$$\Delta[Log\ (NFD_t)] = \propto + \beta T + \delta_1 Log(NFD_{t-1}) + \delta_2 Log(GDP_{PC_{t-1}}) + \delta_3[Log(GDP_{PC_{t-1}})]^2 + \delta_4 Log(EGY_{t-1}) + \delta_5 Log(AE_{t-1}) + \delta_6 Log(AGL_{t-1}) + \sum_{t=1}^{j} \gamma_t \Delta Log(NFD_{t-j}) + \sum_{t=1}^{k} \gamma_t \Delta Log(GDP_{PC_{t-k}}) + \sum_{t=1}^{l} \gamma_t \Delta[Log(GDP_{PC_{t-l}})]^2 + \sum_{t=1}^{m} \gamma_t \Delta Log(EGY_{t-m}) + \sum_{t=1}^{r} \gamma_t \Delta Log(AE_{t-r}) + \sum_{t=1}^{s} \gamma_t \Delta Log(AGL_{t-s}) + \partial ECT_{t-1} + \varepsilon_t$$

where:

NFD	=	Net forest depletion
GDPpc	=	Gross domestic product per capita
EGY	=	Energy use per capita
AE	=	Agricultural export
AGL	=	Agricultural land

Beyond the use of the ordinary ARDL, the non-linear autoregressive distributed lag (NARDL) is deployed to address the likelihood of a nonlinear relationship between economic growth and deforestation. Shin et al. (2014) developed the nonlinear autoregressive distributed lag (NARDL) model, which is an asymmetrical improvement of the ARDL model advocated by Pesaran, Shin and Smith (2001). Hence, the NARDL model is specified below in consonance with Shin, Yu and Greenwood-Nimmo (2014). Critical examination of the asymmetrical co-integration regression conducted before estimation of the model:

$$\Delta[Log\ (NFD_t)] = \alpha + \beta T + \delta_1 Log(NFD_{t-1}) + \gamma_1^+ Log(GDP\_PC_{t-1})^+ + \gamma_2^- Log(GDP\_PC_{t-1})^- + \gamma_3^+ [Log(GDP\_PC_{t-1})^2]^+ + \gamma_4^+ [Log(GDP\_PC_{t-1})^2]^+ + \delta_1 Log\ (EGY_{t-1}) + \delta_2 Log\ (AE_{t-1}) + \delta_3 Log\ (AGL_{t-1})$$

where γ^+ and γ^- are the long-run parameters related with rising and falling of GDP per capita, respectively.

5. Results and Discussion

5.1 Descriptive statistics of the sample

The descriptive statistics of the data used are presented in Table 1. Mean value is the average of all variables in the series. The means for all variables are positive hence they exhibit a positive trajectory. The standard deviation explains the volatility of the series about its mean value. All variables deviate below the mean, therefore they are predominantly subject to negative shocks. The symmetry of the data series around its mean is measured by skewness. Variables with skewness greater than zero are positively skewed while those less than zero are negatively skewed. All variables, apart from AGL, are positively skewed, which implies that most of the values are below the mean. Kurtosis measures the peakedness and flatness of the data distribution. A kurtosis value of 3 is neither peaked nor flat. When the value is greater than 3, it is peaked, when it is less, it is flat. AE and AGL are peaked while the other variables are flat. If the probability value is higher than 5%, the null hypothesis of a normal distribution cannot be rejected. All variables are therefore normally distributed.

Table 1. Descriptive Statistics of the Sample

	AE Agric. Export	AGL Agric. Land	EGY Energy Use Per Capital	GDP_PC GDP Per Capita	GDP_PCSQ GDP Per Capita Square	NFD Net Forest Depletion
Mean	22.86120	72.69008	723.4382	1758.604	679.1822	1.162127
Median	22.04733	76.39141	718.1542	1548.288	667.1831	1.039862
Maximum	36.96508	80.92054	798.6302	2563.900	722.2403	2.647992
Minimum	12.24041	51.84514	671.9069	1324.297	645.3694	0.059739
Std. Dev.	4.764365	8.110849	38.65707	439.8664	26.37512	0.672622
Skewness	0.438553	-1.330183	0.328034	0.655478	0.427096	0.543655
Kurtosis	4.422711	3.700650	1.694143	1.830759	1.679583	2.763777
Jarque-Bera	4.422913	11.98339	3.381507	4.885743	3.915815	1.960234
Probability	0.109541	0.002499	0.184381	0.086911	0.141153	0.375267
Sum	868.7255	2762.223	27490.65	66826.95	25808.92	44.16082
Sum Sq. Dev.	839.8694	2434.077	55291.66	7158849.	25738.94	16.73956
Observations	38	38	38	38	38	38

Unit Root Test

The unit root test shown in Table 2 was carried out using the Augmented Dickey-Fuller, Phillips-Perron, and Kwiatkowski-Phillips-Schmidt-Shin tests. The results show that all variables except agricultural land were stationary at first difference I(1). Agricultural land, however, was found to be stationary at levels, I(0). Hence, the series is in full compliance with the requirement of the ARDL model. Nevertheless, the application of the NARDL model is to accommodate the fact that the actual relationship between deforestation and economic growth is not linear. This nonlinearity is rational given the fact that the dependent variable (NFD) is being interrogated against the background of more than one variable.

Table 2. Unit Root Test

Variables	Augmented Dickey-Fuller		Phillips-Perron		KPSS		Decision
	I (0)	I (1)	I (0)	I (1)	I (0)	I (1)	
NFD	-1.8803 (0.3376)	-5.8865 (0.0000)*	-1.9270 (0.3168))	-5.9114 (0.0000)*	0.1605	0.2332*	I (1)
GDP_PC	-0.5608 (0.8670)	-3.5893 (0.011)*	-0.1063 (0.9413)	-3.4988 (0.0138)*	0.5889	0.3770*	I (1)
GDP_SQ	-0.2396 (0.9237)	-3.7758 (0.0068)*	-0.8549 (0.9937)	-3.7758 (0.0068)*	0.7005	0.3704*	I (1)
AE	-2.4185 (0.1441)	-6.6852 (0.0000)*	-2.6395 (0.0944)*	0.5771 (0.0000)*	0.5000	0.3319*	I (1)
AGL	-3.858 (0.0054)*	-4.5950 (0.0007)***	-10.4570 (0.0000)***	-4.6132 (0.0007)***	0.6130*	0.6622*	I (0)
EGY	-1.0772 (0.7145)	-5.8674 (0.0000)***	-0.7612 (0.8182)	-7.3125 (0.0000)***	0.6768*	0.3089*	I (1)

ARDL Bounds Test for Cointegration

For the existence of cointegration to be established in the series, a bounds test was carried out. It is required that the F-statistic value be higher than the upper bound value for the null hypothesis of no cointegration to be rejected. The result shows that the series is cointegrated at 5% level of significance.

Table 3. ARDL Bounds Test

F-statistics	4.5194	
	I(0)	I(1)
10%	2.75	3.79
5%	3.12	4.25
2.5%	3.49	4.67
1%	3.93	5.23

The Long-run Results

Table 4 shows that gross domestic product per capita has a negative relationship with deforestation in the long run. This implies that an increase in GDP per capita in the long run will lead to a reduction in net forest depletion. In addition, to ascertain the shape of the EKC, gross domestic product per capita squared showed a positive relationship, indicating that EKC is nonexistent in the Nigerian economy. This result was obtained when time trend was introduced into the series. Indeed, the model without the time trend showed that gross domestic product per capita has no impact on deforestation in the long run as against the reports of reviewed studies (Zambrano-Monserrate et al., 2018; Ahmed et al., 2014; Waluyo and Terawaki, 2016). However, with the introduction of a trend variable to the model, a relationship emerged.

Table 4. Long-run Relationship

Variables	Coefficient	t-statistics	Stand. Err	Prob.
Dependent Variable: NFD				
Constant	-158.86	-3.0126	52.7306	0.0054
Trend	-0.7290	-3.0483***	0.2391	0.0050
ln NFD(-1)	-0.3774	-3.7543***	0.1005	0.0008
ln GDP_PC	-26.1446	-2.7811***	9.4008	0.0096
ln GDP_PCSQ	0.4514	2.5417**	0.1776	0.0169
ln EGY	-0.0496	-0.0269	1.8392	0.9787
ln AE	0.9728	2.6414**	0.3683	0.0134
ln AGL	3.9320	3.1784***	1.2371	0.0036

***1% level of significance; **5% level of significance

The presence of a time trend in a series implies that the variable moves with the passage of time due to unobserved factors. The time trend variable measures changes in the dependent variable over time holding all other factors constant. Introducing the trend variable helps to avoid a spurious regression problem, biased estimators, and can make the key variable less or more significant. In cases where the relationship found is because of similar direction in trends between the dependent and the independent variable, then a trend variable will make it less significant or insignificant. But when the dependent variable and independent variable trend in different directions and the movement of the latter about its trend causes the movement of the former away from its trend, the independent variable becomes more significant. In this study, to validate the introduction of a linear trend into the equation, we regressed the trend variable on each variable to check if there are trends in the series. The results are presented in Table 5 which shows that all the variables have time trends, hence the need to capture the effect by introducing a time trend variable to the model.

Table 5. Regression of Time Variables on Dependent and Independent Variables

Variables	Coefficient	t-statistics	Standard Error
ln NFD	0.0353	3.1279***	0.0113
ln GDP_PC	0.0182	9.6846***	0.0018
ln GDP_PCSQ	2.2947	22.7198***	0.1010
ln EGY	0.0043	12.6467***	0.0003
ln AE	0.0081	2.7768***	0.0029
ln AGL	0.0090	8.5838***	0.0010

*** 1% level of significance

Theoretically, an inverted U-shaped relationship as depicted by the EKC requires that the gross domestic product per capita be positive and its squared value be negative, implying that at higher levels of income, deforestation should reduce. Findings from this study for Nigeria present a deviation from the theoretical expectation of an EKC. GDP per capita increases, deforestation declines initially and at higher levels of GDP per capita, deforestation starts to increase suggesting a U-shaped relationship as against an inverted U-shaped EKC. Put differently, as economic growth occurs, deforestation decreases in the early stages and increases eventually as GDP per capita rises. This may indicate that the growth of the Nigerian economy is still largely dependent on exploitation of natural resources that depletes forest reserves. It may also indicate that the income per capita level of the Nigerian economy is still at a very low level, hence, no turning point could be established. The result is in line with Alege and Ogundipe (2013) who found the non-existence of an EKC relationship for Nigeria.

Agricultural export and agricultural land have positive significant effects on deforestation. This suggests that trade in agriculture and the practice of agriculture in Nigeria have been less environmentally efficient; hence leading to depletion of forest resources. This confirms the postulation by Zambrano-Monserrate et al. (2018) that where no EKC relationship is confirmed, agricultural export significantly increases deforestation. This may be indicative of the role that the level of development and export structure play in the existence of an EKC relationship. Energy consumption has no significant impact on deforestation, suggesting an advanced energy source in the economy.

Also, a pairwise Granger causality test was carried out to ascertain the direction of causality between GDP per capita and deforestation. The result revealed a unidirectional relationship from deforestation to GDP per capita. This may also corroborate the dependence of the Nigerian economy on natural resources as large inputs into its economic growth. Hence, an attempt to reduce deforestation may negatively affect economic growth. The non-existence of a causality relationship from GDP per capita to deforestation may be as a result of the presence of trends in the series that were addressed in the regression above. The result is presented in Table 6.

Table 6. Pairwise Granger Causality Test

Null Hypothesis	F Statistics	Probability
Log(GDP_PC) does not Granger cause log (NFD)	0.9362	0.3401
Log(NFD) does not Granger cause log (GDP_PC)	8.2364***	0.007

***1% level of significance

Short-run Results

The relationship between deforestation and GDP per capita growth in the short run is negative. An increase in GDP per capita decreases annual net forest depletion in the short run. In effect, the short and long-run results reveal that in both of the time horizons, NDF and GDPPC have similar relationships. Incidentally, the results produced a U-shaped EKC both in the short and long run. The results are presented in Table 7. The short-run results show the rate at which a distortion in the short run will return to its long run path. The equilibrium will be corrected by approximately 38% in a year. Hence, it will take three and half years for distortions in the short term to return to its long run time.

Table 7. Short-run Relationship

Variables	Coefficient	t-statistics	Probability
Dependent Variable: NFD			
Constant			
ln GDPPC	-69.2673***	-3.0408	0.0051
ln GDPSQ	0.4514***	2.5417	0.0000
ln AE	2.5773***	2.6501	0.0131
ln AGL	10.4174***	3.9450	0.0005
ln EGY	-0.1313	-0.0294	0.9787
ECT(-1)	-0.3774***	-5.6532	0.0000

***1% level of significance

Diagnostic Test

The model was tested for serial correlation and heteroscedasticity using the Breush-Godfrey Serial Correlation LM test and the Breusch-Pagan-Godfrey Heteroskedasticity test respectively. From the results as presented in Table 8, we did not reject the null hypothesis of no serial correlation and no heteroscedasticity in both cases.

Table 8. Diagnostics Test

	F Test	Probability
Heteroscedasticity	0.5030	0.8436
Serial Correlation Test	1.0601	0.3609

Also, to test for stability, the CUSUM test was deployed and as shown in Figure 4, the statistics fell well within the critical bound, hence the model is stable.

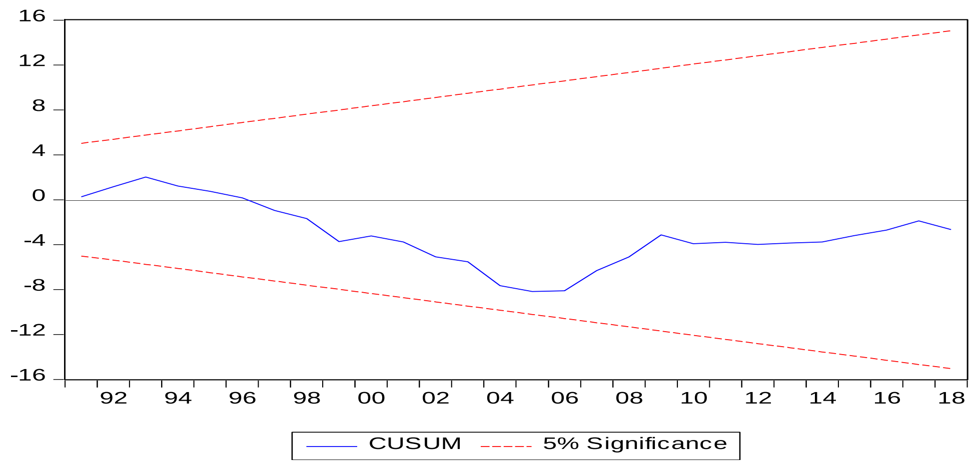

Figure 4. CUSUM Stability Test

The Jarque-Bera estimates also show that the data is normally distributed, with a value of 0.3952 and a probability value of 0.8206. We did not reject the null that the data is normally distributed.

NARDL Bounds Test for Cointegration

Positive and negative components of the primary dependent variable were introduced. The positive component of the independent variable _POS represents an increase while _NEG represents a decrease. The model alienates testing the impact the positive and negative movements of the dependent variable on the independent variable. The hypothesis for the NARDL is consistent with the ARDL specification; the result shows that the series is cointegrated at 1% level of significance.

Table 9. ARDL Bounds Test

F-statistics	5.151	
	I(0)	I(1)
10%	2.38	3.45
5%	2.69	3.83
2.5%	2.98	4.16
1%	3.31	4.63

Long-run Results

The result in table 10 shows evidence of an EKC in Nigeria. In the long run, an increase in GDP per capita increases deforestation while GDP per capita squared indicates a negative significant relationship. This is consistent with the inverted U-shaped EKC, suggesting that initial increase in the GDP will lead to an increase in deforestation and eventually to a decrease. Therefore, when an asymmetric relationship is presumed and the NARDL model is estimated, the inverted U-shaped EKC for Nigeria is established. The direct implication of this finding is that a nonlinear relationship between NFD and GDP per capita is valid for the economy of Nigeria.

Table 10. Long-run Relationship

Variables	Coefficient	t-statistics	Stand. Err	Prob.
Dependent Variable: NFD				
ln GDP_PC_POS	0.0195	1.9219*	0.0101	0.0683
ln GDP_PC_NEG	0.0094	1.1721	0.0080	0.2543
ln GDPSQ_POS	-0.8984	-2.6110***	0.3441	0.0163
ln GDPSQ_NEG	0.0132	0.0562	0.2358	0.9558
ln EGY	3.3933	1.0211	3.3232	0.3188
ln AE	3.9517	3.7719***	1.0477	0.0011
ln AGL	-8.001	-2.1031**	43.804	0.0477

***1% level of significance; **5% level of significance; *10% level of significance

GDP_PC_POS = Increase in GDP per capita; GDP_PC_NEG = Decrease in GDP per capita

GDP_PCSQ_POS = Increase in GDP per capita square; GDP_PCSQ_NEG = Decrease in GDP per capita square; EGY = Energy use per capita; AE = Agricultural Export; AGL = Agricultural land

Short-run Results

In the short run, an increase in GDP per capita increases deforestation while an increase in GDP per capita squared decreases deforestation, suggesting an outplay of the EKC postulations even in the short run. The equilibrium will be corrected by approximately 42% in a year.

Table 11. Short-run Relationship

Variables	Coefficient	t-statistics	Probability
Dependent Variable: NFD			
Constant	0.5498	8.9387***	0.0000
ln NFD (-1)	-0.4653	-4.0518***	0.0006
ln GDPPC_POS	0.0037	2.4287***	0.0242
ln GPDC_NEG	0.0048	3.1361***	0.0050
ln GDPSQ_POS	-0.2200	-5.5770***	0.0000
ln GDPSQ_NEG	-0.2478	-6.6815***	0.0000
ln AE	1.6978	3.2330***	0.0040
ln AGL	-3.4377	-2.6111***	0.0163
ln EGY	1.4579	1,0616	0.3005
ECT(-1)	-0.4296	-8.9071***	0.0000

***1% level of significance; _POS = Positive; _NEG = Negative

Diagnostic Test

The model was tested for serial correlation and heteroscedasticity using the Breush-Godfrey Serial Correlation LM test and Breusch-Pagan-Godfrey Heteroskedasticity test respectively. From the results as presented in Table 8, we did not reject the null hypothesis of no serial correlation and no heteroscedasticity in both cases.

Table 12. Diagnostic Test

	F Test	Probability
Heteroscedasticity	0.5902	0.8352
Autocorrelation	1.7286	0.2043

Also, to test for stability. The CUSUM test was deployed and as shown in Figure 4, the statistics fell well within the critical bound, hence the model is stable.

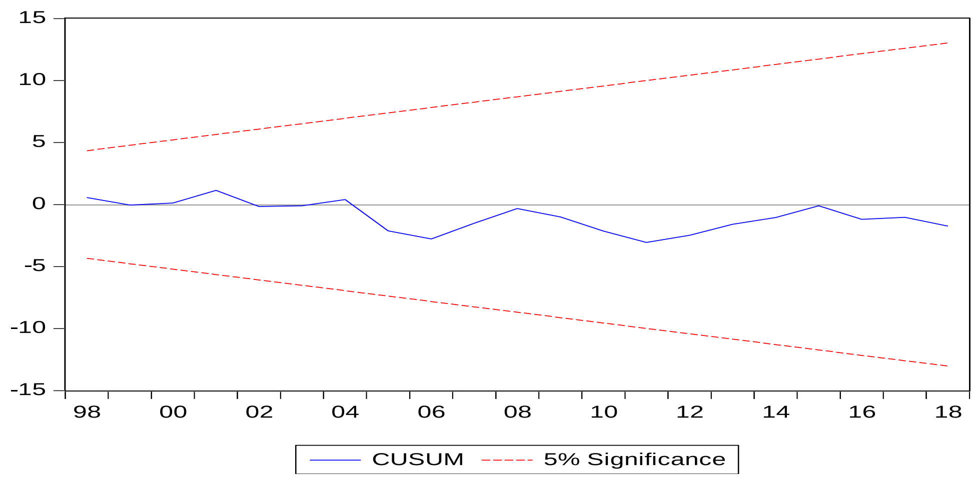

Figure 5. NARDL CUSUM Stability Test

6. Conclusion and Recommendations

This study investigated the interaction between economic growth and deforestation in the context of testing for the existence of the EKC for deforestation in Nigeria and understanding the direction of causality between the two variables. The Autoregressive Distributed Lag Model (ARDL), Nonlinear ARDL and pairwise Granger causality test were deployed to achieve these objectives.

The results for the ARDL showed that the environmental Kuznets curve hypothesis proposition is nonexistent in Nigeria. However, with the NARDL, the EKC is upheld for Nigeria. The main finding of the study then suggests that the EKC should be sought within the context of an asymmetric relationship between economic growth and deforestation as against a presumption of a linear relationship. The results revealed that there is a long-run relationship between economic growth and deforestation.

Furthermore, the Granger causality test showed that deforestation Granger caused economic growth. As proposed earlier in the study, this confirms that depletion of forest resources sponsors growth in Nigeria. Hence, by implication, an attempt to reduce deforestation will affect economic growth even though forest depletion is a loss to natural capital in any economy.

For the sake of managing the delicate relationship between environmental sustainability and economic growth in Nigeria, policy makers should take into consideration the associated tradeoffs with a view to achieving economic growth that is less harmful to forest resources. The key recommendation of this study is that a green growth policy should be pursued. The cost of natural capital in production processes should be fully accounted for and compensated. Specifically, there is the need to promote a reforestation policy, preferably backed up law. Adequate environmental planning is also required to manage reserved areas with a view to preserving biodiversity from destruction by economic activities.

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