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IMPACT OF ECONOMIC ACTIVITIES ON DEFORESTATION IN NIGERIA: A TIME SERIES ANALYSIS

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Abstract

Forest resources serve as essential facilitators for human daily endeavours; however, their degradation is often exacerbated by insufficient planning regarding their replacement. This results in a multitude of economic and environmental challenges. This research ascertained the long-term effects of economic activities on deforestation within Nigeria and utilizing annual data spanning from 1991 to 2023. The results derived from the ARDL bound test indicate the existence of a long-term cointegrating relationship among the examined variables. Furthermore, the study disclosed that the long-term estimates demonstrate that the linear coefficients of the annual growth of gross domestic product (GDPPA) exert a positive influence on deforestation and are statistically significant at the 1% level, suggesting that heightened economic activities in the preceding period have been beneficial to forest areas and are unlikely to induce deforestation. Nevertheless, the findings pertaining to the quadratic term for gross domestic product (GDPPA_2) and population growth (POPA) revealed a negative and significant impact on deforestation in the long run; conversely, the coefficients for the short-term results indicate an inverse relationship. The study advocates that governmental bodies and all relevant stakeholders should promote afforestation initiatives and enforce sustainable regulations to mitigate the practice of tree felling, alongside fostering sustainable forest conservation efforts.

Key words: *deforestation, economic activities, population.*

JEL Classification Codes: *044, Q56, and R11*

1. Introduction

The net loss of forested areas represents the aggregation of deforestation and any increments in forest cover over a specified timeframe. From 2010 to 2020, there has been an annual loss of 4.7 million hectares, amounting to a total of 10 million hectares of forest being felled each year (the Food and Agricultural Organization, [FAO], 2020). Nigeria experienced a reduction of 207,000 hectares of natural forest, which corresponds to 118 megatonnes of CO_2 emissions, and in the year 2020, the nation possessed 20.4 million hectares of natural forest, encompassing approximately 22% of its total land area. **(**Global Forest Watch [GFW] 2021). The Food and Agriculture Organization (FAO, 2023) has estimated the annual rate of deforestation in Nigeria to be 163,000 hectares from 2015 to 2020. Regarding tree cover, the nation has witnessed a 12% decline from 2001 to 2022. Activities such as logging, wood harvesting, and the expansion of agricultural practices are among the most recognized contributors to deforestation within the country (Global Forest Watch, [GFW], 2023).

The natural resources may encompass products derived from forests, as well as non-forest products that are accessible in forested regions; countries within sub-Saharan Africa are included in this context. Certain activities may encompass: the cultivation of agricultural land, mining operations, service provision, manufacturing processes, construction projects, and industrial and commercial engagements pertaining to forest products and similar undertakings, which may ultimately lead to deforestation. Forest-related activities in sub-Saharan Africa make a substantial contribution to the Gross Domestic Product (GDP) of numerous nations, with over 70% of the population relying on forests and woodlands for their sustenance (John, 2023). Nigeria, recognized as the most populous nation in Sub-Saharan Africa, is characterized by elevated levels of unemployment ranging from 3.8% in 2011 to 3.1% in 2023 (World Bank 2025); and regarding poverty, 64% people in Nigeria are living below poverty line (World Bank 2025). These circumstances compel its citizens, particularly those residing in rural areas, to depend on forest resources as a means of livelihood.

Deforestation constitutes a grave environmental issue. It is accountable for the depletion of forest resources, the diminishment of animal species, and the eradication of natural vegetation. Nevertheless, natural calamities such as wildfire, earthquakes, volcanic eruption are not predominantly observed in Nigeria as happen in other countries such as volcanic eruption in Karymsky Russia, Bulusan Philippines, Stromboli Italy, all in 2025 (Smithsonian institution, 2025) and wildfire in USA and Israel both in 2025. Consequently, this study predominantly emphasizes anthropogenic factors contributing to deforestation. The interaction between humans and the environment is accountable for numerous environmental challenges, including deforestation, climate change, soil erosion, flooding, pollution, the depletion of natural resources, and the loss of biodiversity (United Nations Environment Programme, 2019. The forest reserves in Nigeria are subjected to such pressures. The peril posed to the forest is indeed substantial. It incites considerable concern among governments, private entities, non-governmental organizations, and individuals alike. Forest resources are being utilized at a pace surpassing their natural replenishment capacity. The predicament is further exacerbated by ambiguous property rights, inadequate monitoring and enforcement, inefficient resource utilization, minimal community involvement in policy-making, poverty, unequal profit distribution, as well as the presence of aggressive intermediary market traders.

The issues associated with deforestation encompass the overexploitation of alternative natural resources, inefficiencies in forest tax collection, the misuse and exploitation of forest resources, a decline in forest stocks, and a lack of prioritization in reinvesting in forestry development, alongside poor land management. Angelsen and Kaimowitz (1999) emphasized that deforestation is often driven by economic incentives that encourage the overuse of forest resources, particularly in developing countries where agriculture and logging are key income sources. In addition to these causes and partial consequences of deforestation, it also plays a significant role in environmental degradation, the loss of forest cover, the reduction of the livelihood base for millions of individuals, an increase in rural poverty, and unemployment. In light of the ramifications of deforestation, it is imperative to safeguard forest resources and their biodiversity. Furthermore, consistent with the principles established during the 1992 Rio Earth Summit and the United Nations Environment Programme Convention on Biological Diversity (1992). It is essential to preserve forests to ensure their continued provision of vital life support systems, including clean air, food, and water.

Consequently, this study explored the causes and ramifications of anthropogenic deforestation within Nigeria. The research acknowledges that logging is often rationalized by the necessity to generate employment in rural locales, improve infrastructure in both urban and rural settings, supply raw materials for housing, provide sustenance for domestic animals, furnish clothing for individuals, and generate essential

revenue. Nevertheless, it is imperative to address the repercussions of anthropogenic deforestation to preserve ecosystem services and realize sustainable development.

The nation involved in this research is classified as a developing country that prioritizes agriculture, mining, and service industries. Nigeria faces challenges of deforestation and forest degradation due to a variety of human activities. It is endowed with favourable climatic conditions characterized by two principal seasons - wet and dry. Additionally, it boasts a significant abundance of natural resources, including gold, oil, diamonds, and timber. The objective of this study is to investigate the impact of economic activities on deforestation. Specifically, it aims to evaluate the overall impact of economic activities in terms of GDP.

2. Literature Review

2.1 Conceptual Literature

Concept of Economic Growth

Generally, the concept of economic growth means a positive change in the standard or quality of life of the people. According to Rangongo and Ngwakwe, (2019), opined that, growth is a steady process which involves increasing the level of output of goods and services in the economy. In a book written by Jhingan (2005), further stated that growth has to do with quantitative sustained increase in a country's per capita output attached to an expansion in manpower and volume of trade. This implies that economic growth is the sustained increase in an economy's output followed by other factors that influence growth such as infrastructural development, technological advancement as well as human capital development. Economic growth is the increase in the inflation-adjusted market value of the goods and services produced by an economy over time. It is measured as the percentage rate of increase in the real gross domestic product (IMF, 2012). In the same vein the World Bank (1993), identified economic growth as more rapid output and productivity in growth; and by growth, it, therefore, implies the expansion of a country's potential GDP. Economic growth result to increase in gross domestic product, per capita income, employment opportunities as well as reduction in poverty among people.

Growth in national income is an indicator of economic growth. And national income is measured through different method which include, income method, output method and value-added method. The output method has to do with summing up of the total value of all products and services produced in a country for the period of one year. It consists of components of all goods and services produced under agricultural sector, manufacturing sector, service sector, mining and industrial sector as well as all other economic sectors of the economy. The values of the national income may change over years subject to the productive capacity of the economy.

Concept of Deforestation

Deforestation has been well-defined in diverse senses by many organizations and researchers. Deforestation can be defined to incorporate the change or conversion of a natural forest to a non-forest for purposes of agricultural services and development (Bodo, 2021). According to Fearnside (1993), it is the loss of original forest for temporary or lasting clearance of forest for other uses. While Angelsen and Kaimowitz (2001) describe deforestation as a state of complete long-term elimination of tree cover. For others, such as Ajanaku and Collins, (2021), 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.

The major causes of deforestation in Nigeria include: Bush Burning- This is the most common process of deforestation in the SSA region of Africa. Fires are often deliberately triggered off by some hunters, villagers and during farm clearing. Hunters also who search for game set fire in bushes which destroy natural vegetation; Cultivation- Considering the fact that, people in this part of the world engage in farming, therefore farm lands are cleared and prepared for cultivation. Only few economic trees, such as

mangoes, and other trees that bear fruits are usually left. After, the ground has been cultivated for several years; it may become exhausted leading to shifting for another more fertile land. This is regarded as a considerable decrease in number of trees. Furthermore, with increase in human population and therefore more pressure on land; the soils are not given enough time to recover, and the vegetation is therefore eliminated (DGB Group, 2023).

Fuel Wood Fossils- Poverty has been identified as one of the key factors facilitating deforestation visa-vis fuel consumption in the area IPCC (2019). This is so because, a good number of youth and perhaps other middle-aged people engage in tree cutting as a means of livelihood due to unemployment.

Grazing is seen as another cause of deforestation - Intense grazing in the savanna by domesticated animals contribute towards upsetting ecological balances, because there is much greater grazing pressures on certain species which are actively selected by animals Geist, and Lambin, (2002). Hence, there will be decrease in the number of favoured species and a consequent deterioration in the volume of the grazing lands.

Urbanization process is another strong factor in the issue of deforestation (UNEP, 2019). Lack of awareness on the adverse effects of deforestation has caused the destruction of over 8.5 million hectares of tropical forest permanently yearly for the construction of buildings and new urban areas (FAO. 2020). This might be the reason for uncontrollable and continuous destruction of forest resources. Other causes of deforestation in Sub-Saharan Africa include clearing of forest for logging, agricultural activities, felling of trees by rural dwellers for sales as a means of sustenance due to poverty and using of trees as wood for fuel which causes serious damages with an end result of desertification. Infrastructural developments such as building and constructions, roads constructions, reservoirs and others lead to serious loss in plants and animal communities (Hosonuma *et al.,* 2012).

2.2 Theoretical Literature

Environmental Kuznets Curve Hypothesis

The hypothesis was found by Simon Smith Kuznets, who was a Russian-born but American economist and statistician who received the 1971 Nobel Memorial Prize in Economic Science for his empirically founded interpretation of economic growth which has led to new and deepened insight into the economic and social structure and process of development.

The root of the Environmental Kuznets Curve (EKC) lies in the work of economist Simon Kuznets (1955), who originally proposed a related concept regarding income inequality and economic growth, which is now commonly referred to as the "Kuznets Curve"; the EKC essentially applies this hypothesis to the relationship between environmental degradation and economic development. The hypothesis suggests that. pollution initially increases with economic growth but eventually declines as a country reaches higher income levels, creating an inverted U-shaped curve on a graph. Kuznets initially studied the relationship between income inequality and economic development, finding that inequality tends to rise during early stages of development but then decreases as economies advances.

Economists find Kuznets hypothesis relevance by using the idea in assessing relationship between environmental indicator relationship and economic indicators. For instance, The EKC hypothesized relationship between the quality of the environment and national economic growth in (Grossman and Krueger, 1995). The EKC hypothesis states that at the initial phase of economic development, environmental deterioration expands as per capita income rises. After a specific level of income (called a defining moment), however, environmental degradation starts to diminish as development advances (Grossman and Krueger, 1991, Grossman and Krueger, 1995).

Since forest is one of the components of environment; EKC can be used as examine the relationship between deforestation and economic development. The hypothesis may suggest that a

distinctive relationship exists between economic development and deforestation. That is, deforestation increases in early stages of development but levels off and declines as economies mature.

There are a variety of factors that produce such a curve. One of the most commonly recognized explanations is the shift away from manufacturing toward service-oriented economies (Grossman and Krueger, 1995). In terms of this sectoral change, very poor nations have limited production functions based on primitive technologies and spiritual attitudes toward the physical world. These factors place a ceiling on productivity and mainly limit economies to subsistence agriculture. With economic limited predominantly subsistence agriculture, deforestation should be relatively low. As countries begin to industrialize, the construction of infrastructure, extraction of natural resources, and heavy industry play central roles in increasing economic development (Grossman and Krueger, 1995).

2.3 Empirical Issues

Oforzor, *et al.* (2022) used time series data span 1980-2015 and applying ARDL method to find out whether there is long run association between the variables in the model. The findings indicated that, poverty, population density, and trade openness all have a significant positive impact on deforestation. The estimated result also suggests that deforestation and income per capita in Nigeria have an inverted U-shaped relationship. Hence, it supports the EKC hypothesis for deforestation in Nigeria. It implies that when income per capita increases, deforestation experiences an increasing trend up to a certain point, after which it reverts with a continuous increase in income per capita.

The relationship between urbanization and deforestation were analysed by scholars. Kojo and Paschal (2018) looked into the impact of urban population growth on environmental sustainability (proxied as on renewable energy consumption and forestry) in Nigeria, using data from 1981 to 2017. The variables used are urban population growth, fossil fuel consumption, carbon emissions, food production index, arable land, and agricultural raw material exports with renewable energy consumption and forest reserves as explanatory variables and analysed using Autoregressive Lag model. The finding indicates that, urban population has significant impact on environmental sustainability while real growth domestic product does not have significant impact on renewable energy consumption and forestry. It also highlights that urban population growth increases renewable energy consumption but decrease forest reserves. The relationship between urbanization and deforestation were analysed by scholars such as Richadson and Nnadi (2018), looked into the impact of urban population growth on environmental sustainability (proxied as on renewable energy consumption and forestry) in Nigeria, using data from 1981 to 2017. The variables used are urban population growth, fossil fuel consumption, carbon emissions, food production index, arable land, and agricultural raw material exports with renewable energy consumption and forest reserves as explanatory variables and analysed using Autoregressive Lag model. The finding indicates that, urban population has significant impact on environmental sustainability while real growth domestic product does not have significant impact on renewable energy consumption and forestry. It also highlights that urban population growth increases renewable energy consumption but decreases forest reserves.

Nathaniel and Bekun (2020), examined the impacts of energy use, urbanization, trade openness, and deforestation on environmental management in Nigeria using time series data from1971 to 2015 and analysed through ARDL estimation techniques. The results suggest both short run and long-run unidirectional casualty between urbanization and deforestation, population density and trade openness and. Moreover, one-way causalities were identified moving from urbanization to trade openness and population density and from economic growth to population density. Amazingly, in both long and short run, we observed causality nexus of, deforestation, economic output, energy consumption, population density and trade openness.

Okafor *et al.* (2023) dwelled on studying the influence of urbanization size and environmental degradation through deforestation on economic growth in Nigeria using of ex post-facto research design and analysis with Autoregressive distributive Lag model. The variables involved were in the study were real gross domestic product, total deforestation, urban population size, non-renewable energy consumption carbon emission, industrial sector carbon emission, electricity generation carbon emission spanning the period from 1991 to 2022. The findings of the research revealed that, in the short run analysis, urbanization size was negative and insignificant while deforestation, environmental degradation was positive also insignificant. Whereas, the long run results suggested long run statistically significant relationship among the variables. Again, all the explanatory variables were statistically significant in the long run analysis. The study recommended that, government should empower the rural dwellers with skills and knowledge on forest management.

Musa et al. (2022), investigated the drivers of deforestation in Nigeria using annual data from 1990 to 2022 and fully modified ordinary least square (FMOLS) method and Eagle and Granger cointegration test. The findings suggested that, fuel wood, foreign direct investment, economic growth and agricultural land have significant positive effects on deforestation in the country. Whereas, urbanization is negatively significant on deforestation. The study recommended government to provide alternative to wood fuel by making kerosene and liquefied natural gas available affordable. Also, adopt modern farming that requires lesser land area for growing modern crops and review all economic activities that involve cutting down of trees and serious public campaign against dangers of deforestation.

Oyeranti et al., (2022), examined the relationship between economic growth and deforestation in Nigeria using annual time series from 1980 to 2018, through both linear and nonlinear ARDL models to confirm the assertion postulated by EKC hypothesis. 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). The results of the findings revealed that, the linear ARDL model did not confirm EKC hypothesis. Whereas, nonlinear ARDL model confirmed EKC hypothesis for Nigeria. This indicates the existence of nonlinear relationship between economic growth and deforestation in Nigeria.

A negative impact of deforestation on agricultural productivity has been observed in a study carried out by Ibrahim et al. (2016); in which 1% increase in deforestation lead to 1.7% decrease in agricultural productivity, while other variables - average rainfall and number of tractors showed both long-run and short run positive relationship with agricultural productivity; with 1% increase in average rainfall and number of tractors, agricultural productivity will increase by 0.5% and 2.4%, respectively. Error correction model affirmed the persistent impact of deforestation on agricultural productivity. The study recommends that, government has to device alternative sources of energy and conserve forests through legislation and proper judicial action.

Pairwise granger causality test was utilized by Leelee (2022), to detect if causation exists between environmental deforestation (tree cover loss) and climate change in Nigeria using annual data from 1990 to 2018. The findings of the study revealed that, there was no causation of any form between deforestation (tree cover loss) and climate change because the p values is more than 5%. So, deforestation does not cause significant effect on climate change.

Suleiman and Anakhu (2023), examined the effects of deforestation on carbon stocks in Nigeria, using data from 2010 to 2022, for 36 states and Federal Capital Territory Abuja. The variable were tree cover loss, above-ground biomass, below-ground biomass, soil organic Carbon, and dead organic matter for each state and FCT. The data were analysed using Geographic Information System (GIS) techniques and statistical tools. The finding of the research revealed that, the analysis of tree cover loss and carbon stocks revealed significant variations across Nigeria's 36 states and the FCT. Between 2010 and 2022, the average tree cover

decreased by 35%, while carbon stocks reduced by 30%. States with significant forest reserves, such as Cross River, Ondo, and Osun, were found to have higher carbon stocks (averaging 2000 tC/ha), while states with lower forest cover, such as Kano, Sokoto, and Borno, had lower carbon stocks (averaging 500 tC/ha). The highest carbon stock of 2700 (tC/ha) was estimated in the Ovia South West (OSW) LGA, while the lowest CS value point of 22.2 (Tc/ha) was obtained in Oredo Edo (OE) LGA.

Garba et al. (2020), investigated the relationship between Deforestation, sectorial CO_2 emissions and climate change in Nigeria using annual time series from 1975 to 2012 by means of Autoregressive distributed lag model. The findings suggested that deforestation, transport sector CO_2 emission and other sectors CO_2 emissions which are the focal variables affected climate change in both the long run and the short run periods. The ARDL bound test result revealed strong long run relationship among the variables. The ARDL long run model indicates that transports sector CO2 emission, urbanization and deforestation were found to have positive and significant impact on climate change. But other sectors CO_2 emissions have significant negative impact on climate change. The short run coefficients directed that transports sector CO_2 emission, other sectors CO_2 emissions and deforestation have significant negative impact on climate change. In order to check the robustness and reliability of the findings, dynamic OLS, Fully modified OLS and Canonical CR were equally employed. The results acquired substantiate the results of the ARDL long run model.

Aluwani et al. (2023), looked into the relationship between deforestation and sectoral CO_2 emission on environmental pollution in Nigeria using annual data spanning from 1970 to 2016, through Autoregressive Distributed Lag Model. The findings of the study revealed long-run relationship among the estimated values of transport sector CO_2 emissions, power sector CO_2 emissions and deforestation thereby impacting the environmental pollution in the country.

Maji (2017), explored the relationship between trade openness and deforestation for environmental quality in Nigeria using annual series from and autoregressive distributed lag model method of analysis to cointegration to achieve the long-run equilibrium relationship among the variables. Other variables used as controlled are Economic growth, energy consumption and population. The long run findings show that the coefficients of trade openness and economic growth are significant but negatively related to deforestation. This suggests that trade openness and growth reduce deforestation and improves environmental quality. Contrarily, the long-run coefficient of population is significant and positively related to deforestation, meaning that population increases deforestation and environmental degradation.

Kustanto (2022), investigated the relationship between trade openness and causes of deforestation using a panel data method in 20 provinces in Indonesia from 2008 to 2018. As reported from the findings, trade openness, economic growth, and activities of logging and forest conversion each contribute to changes in forest cover. Moreover, increase in population/density and price of commodities also decreases forest cover in the study area.

Tama (2022), investigated on the relationship between population growth, deforestation and carbon emission CO2, and using ARDL cointegration techniques. The results revealed that, there were long run cointegration among the variables. Moreover, all the explanatory variables- population growth, deforestation and urbanization were statistically significant determinant of carbon emissions in the country with exception of GDP, which was insignificant. The study suggests that, measures to ameliorate the trend in population growth have to be employed. In addition, since Nigerian economy is majorly involved on energy use especially from fossil energy; there is need to adopt policies to curb increasing carbon emissions.

2.4 Research Gap

Despite review of several studies on deforestation in Nigeria (Tama, 2022; Oyeranti *et al.,* 2022; Aluwani, *et al*. 2023; Okafor *et al.*

2023), there is paucity of research attention that combine relevant environmentally related variables such as renewable energy consumption (RENEG) and population growth (POP) for modelling deforestation and economic activities. Even though fewer variables were captured but there is disharmony in their findings. Oyetunji *et al.,* (2020) find that increasing population leads to high rate of deforestation. Umeji *et al.* (2022) employed the ARDL bounds testing approach and found a significant positive impact of renewable energy consumption on economic growth, suggesting that investments in renewable energy can stimulate economic development. Whereas, Umar et al. (2024) discovered that renewable energy consumption had a negative and significant impact on economic growth in the long run, validating the conservative hypothesis. This shows that, there is limited research that uses comprehensive models to understand the interconnectedness among deforestation, population growth, renewable energy use, and economic growth in a single empirical framework.

3. Material and Methodology

The methodology contains, sources of data, unit root tests, theoretical framework, model specification, and estimation techniques as well as the diagnostic tests.

3.1 Source of Data

This paper employs the use of annual time series data for deforestation, economic activities, population, renewable energy and forest rent in Nigeria from 1990-2023. The data for all the variables were sourced from World Bank Data Base (World Bank, 2025). Series such as renewable energy, forest rent and forest area square kilometres, have missing data for the year 2022 and 2023 which are provided through averaging the individual series.

3.2 Theoretical Framework

The theoretical framework used in actualizing the objective of this study is the typical hypothesis used by Environmental Kuznet curve (ECK) in explaining the connection between environmental degradation and economic growth (GDP per capita). The hypothesis put that, in the early time of economic growth, emissions and other human activities that cause pollution in the environment are at high level. This trend continues up to some levels, which later reverses due to high levels of income and economic growth which leads to environmental improvements. By implication means that, environmental impacts or emissions per capita are an inverted U-shaped function of GDP per capita. The environmental Kuznets curve remain the leading approach among economists to modelling ambient pollution concentrations and aggregate emissions since (Grossman and Krueger, 1991) introduced it.

To test the economics activities-deforestation relationship, the study used the EKC hypothesis modelled as follow as adopted from the work of Ogundari *et al.* (2017):

$$EC_t = \delta+\beta_1 GDP_t+\beta_2 GDP^2_t+\beta_j X_t+\mu_t \quad (3.1)$$

Where EC_t is a vector of environmental change (deforestation) at period (t). GDP_t is the per capita income; X_t is the vector representing economic growth, agricultural production, manufacturing output, service output and population. β_1 and β_2 ... β_j are parameters to be estimated. δ is the intercept and μ_t is the error term of the regression. The EKC hypothesis is determined from the statistical significance and directions of β_1 and β_2 estimates: the EKC hypothesis holds if both estimates are significantly different from zero, and if β_1 is positive and β_2 is negative (i.e. $\beta_1>0$ and $\beta_2<0$). In this case, an inverted U-shaped curve is found. A U-shaped curve that indicates over time worsening of environmental quality is, however, found if the signs of the estimates are reversed (i.e. $\beta_1>0$ and $\beta_2<0$).

3.3 Model specification

Following the work of (Oyeranti, & Taiwo 2022; Murshed, 2021), the model can be specified in its generalised form as follow:

$$y'_t = \delta_{0j} + \sum_{i=1}^{p} \gamma_j y_{t-i} + \sum_{i=0}^{q} \beta'_j x'_{t-j} + \varepsilon_{jt} \quad (3.2)$$

Where, y'_t is a vector of dependent variables, x'_t are the independent variables that are allowed to

be purely I(0) and I(1) or co-integrated. β and γ are slope coefficients, δ is the constant, j=1-k, p, q are optimal lag orders for dependent and independent variables respectively, ε_{jt} is the vector of the term. The dependent variable is a function of its lagged values, the current and lagged values of other exogenous variables in the model.

To perform the bound test for cointegration, the conditional ARDL (p, $q_1 \ldots q_n$) is specified as:
$H0: = \beta_{1j} = \beta_{2j} = \beta_{3j} = \cdots \beta_{8j} = 0$

$H1: = \beta_{1j} \neq \beta_{2j} \neq \beta_{3j} \neq \cdots \beta_{8j} \neq 0$.

Where, j = (1, 2, 3).

The study first test for the aggregated effect of the GDP, estimates on deforestation before the disaggregated effect of Agriculture sector and manufacturing and service sector on deforestation. The specification of model 1 for this objective takes the following form:

$$\Delta lnDEFR_t = \beta_0 + \sum_{i=1}^{p} \beta_j \, lnDEFR_{t-1} + \sum_{i=1}^{q} \delta_j \, lnGDP_t + \sum_{i=1}^{q} \gamma_j \, lnGDP_t^{\,2} + \sum_{i=1}^{q} \theta_j \, lnPOP_t + \sum_{i=1}^{q} \sigma_j \, lnRENEG_t + \varepsilon_t \quad (3.3)$$

Where, DEFR stands for deforestation proxied by percentage of forest land area which is assumed to fluctuate over time (increase or decrease). The increase in forest land area means reforestation while decrease means deforestation. GDP means gross domestic product, measured with GDP annual growth rate, GDP^2 means gross domestic product squares which is measured nonlinear form of the variable and POP means population growth measured as population annual growth rate. RENEG means renewable energy consumption. All the variables were logged. β_0 is the constant term and other β_s family, are the slope coefficients of the independent variables. While ε_t is the random error term containing t which denotes the annual time period (t =1…,T). The decision rule for bound test model suggests to reject the null hypothesis of no cointegration among the variables if the F statistic value is greater than the I(1) critical value at desired level of significance (usually 5%). The test accepts the null hypothesis if the F statistic value is lower than the I(0) critical values at certain level of significance and conclude that there is presence of long run cointegrating relationship among the variable.

3.4 Estimation Techniques

The study employed Autoregressive distributed Lag (ARDL) modelling to pave way in determining the existence of a long run relationship between deforestation and economic activities variables proxied by (GDP). Pesaran and shin (1999) model of Autoregressive distributed Lag (ARDL) model is used to determine the relationship between the variables and concurrently taking care of the short-term deviations and an error correction mechanism is incorporated in the ARDL model (Pesaran, Shin and Smith, 2001). Moreover, ARDL method has an upper hand in handling series irrespective of different order of integration, either at level I(0), at first difference I(1) or combination of integration.

The study modelled the non-linear relationship between economic activities variables (GDPP, Agriculture, manufacturing, and services) and deforestation using ARDL model with quadratic terms. In order to capture the nonlinearity in the variables, the study include square terms in each of the economic variables. Economic activities variables often have nonlinear effects on deforestation. For instance, expansion (increase) or contraction (decrease) in economic activities can affect the forest which in turn may lead to deforestation.

4. Presentation and Discussion of results

4.1 Descriptive statistics

Table 4.1: Descriptive Statistics

	FOAREA	GDPPA%	POPA%	RENEG%
Mean	238925.2	4.245752	2.587953	84.48824
Median	238315.5	4.212993	2.641786	84.5
Maximum	265260.9	15.32916	2.802785	88.6
Minimum	213003.5	-2.03512	2.092817	79.9
Std. Dev.	15596.46	3.905546	0.224628	2.580435
Skewness	0.037579	0.500458	-1.25098	-0.27821
Kurtosis	1.832398	3.486541	3.251085	1.926021
Jarque-Bera	1.939335	1.754617	8.957407	2.072639
Probability	**0.379209**	**0.415901**	**0.011348**	**0.354758**

Source: 2025 Author's computation using Eviews 10

Table 4.1 presents the descriptive analysis of the data used in the study. Forest area square per kilometre in Nigeria for the period under study from 1990 to 2023 clearly indicates an averaged 238925.2 and a standard deviation of 15596.46 which shows the deviation from the sample mean.

Furthermore, the highest value for Forest area square kilometre (265260.9) was recorded in 1990 while the minimum was (213003.5sqkm) for Forest area was recorded in 2022. This indicate significant decrease in forest cover and is a sign of deforestation in the country overtime. Gross Domestic Product Per capita was revealed to have average annual percentage of 4.25 for the period under study with a standard deviation of 3.91%. The variable GDPP depict a smooth movement over the period of the study. The maximum value for Gross Domestic Product Per capita (15.33%) was recorded in 2002 and minimum of (-2.04%) was recorded in 1993. Population has a percentage average growth of 2.59% for the period under study with standard deviation of 0.23%. The maximum value for population annual percentage stands at 2.80% in 2011 and its minimum value (2.09%) was recorded in 2022. The renewable energy variable has an average of 84.49% with a standard deviation of 2.58%. The maximum value of the renewable energy for the period of study (88.6%) was recorded in 1994 and the minimum value of the renewable energy (79.9%) was recorded in 2014.

4.2 Unit Root Test

The study employed the widely known unit root techniques of Augmented Dicky fuller test, Phillip Peron test and Kwiatkowiski-Phillips-Schimidt-Shin (KPSS) to ascertain the level of integration in the time series. The variables portray combination of integration which permits the use of ARDL model. The results for the test are in table 4.2 as follows:

Table 4.2: summary of Augmented Dickey Fuller (ADF) and Philip Peron (PP) Unit Root Tests and Kwiatkowiski-Phillips-Schimidt-Shin (KPSS)

	ADF (TREND AND INTERCEPT)		PP (TREND AND INTERCEPT)		KPSS (TREND AND INTERCEPT		
VARIABLEs	**AT LEVEL**	**1ST DIFF.**	**AT LEVEL**	**1ST DIFF.**	**AT LEVEL**	**1ST DIFF**	**ORDER OF INTEGRATION**
GDPPA%	0.0409** (-3.5530)	0.0000* (-3.5578)	0.0305** (-3.5529)	0.0000* (-3.5578)	0.1608** (0.4630)	0.2443** (0.4630)	**I(0)**
POPA%	0.0429** (-2.9717)		0.0429** (-2.9719)	0.2999 (-2.9571)	0.4032** (0.4630)	0.3646** (0.4630)	**I(0)**
RENEG%	0.2554 (-2.9540)	0.0000* (-2.9571)	0.3608 (-2.2627)	0.0001* (-3.5578)	0.5441** (0.7390)	0.0938** (0.4630)	**I(1)**
FOAREA			**0.4064 (-2.9540)**	**1.0000 (-3.5578)**	**0.6482** (0.4630)**	**0.3282** (0.4630)**	**I(0)**

Source: Author's Computation Using Eviews 10; Where ***,**,* indicate statistical significance at 10%, 5% and 1% respectively.

4.3 Autoregressive Distributed Lag Bound Test

The quadratic Autoregressive Distributed Lag (ARDL) bound testing approach to co-integration was applied. One of the major advantages of this technique is that it can be applied in respective of the order of integration of the dependent variables. The rule of ARDL bound test is that, if the computed F-statistics falls below the lower bound, it would be concluded that the variables are I(0), so no cointegration is possible, by definition. If the F-statistics exceeds the upper bound, it would be concluded that there exist cointegration. Lastly, if the F-statistic falls between the bounds, the test is inconclusive.

Table 4.3: ARDL long run form and Bound Test

F-Bounds Test		**Null Hypothesis: No levels relationship**		
Test Statistic	Value	Signif.	I(0)	**I(1)**
F-statistic	5.832245	10%	2.46	**3.46**
K	4	5%	2.947	**4.088**
		1%	4.093	**5.532**

Source: Author's Computation Using Eviews 10

The result of ARDL long run form and Bound Test in Table 4.3 reveals that the null hypothesis of no long run relationship is rejected. The cointegrating relation is obtained at 5% level of significance. Therefore, table 4.3 provide evidence of the existence of long run relationship among deforestation (DEFR), economic activities (GDP), population (POP) and renewable energy (RENEG). Hence, this suggests that, deforestation in Nigeria depends on economic activities, population and

renewable energy consumption. This result is consistent with the work of Tama (2022), who investigated on the relationship between population growth, deforestation and carbon emission CO_2 and Oyeranti, and Taiwo (2022).

Table 4.4: Result of ARDL long run Estimates

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-5.78E+09	1.62E+10	0.000000	0.0000
FOAREA_2(-1)*	-0.052396	0.061640	-0.850022	0.4054
GDPPA_(-1)	2.85E+08	2.01E+08	0.000000	0.0000
GDPPA_2(-1)	-8116049.	16235816	0.000000	0.0000
POPA_(-1)	-9.40E+09	2.34E+09	0.000000	0.0000
RENEG_(-1)	**3.79E+08**	**2.14E+08**	**0.000000**	**0.0000**

Source: Author's Computation Using Eviews 10

The result of the long run estimates shows that linear coefficients of annual growth of gross domestic product (GDPPA) have positive impact on deforestation and is statistically significant at 1% levels indicating that higher economic activities initially benefit the forest area and does not cause deforestation. This finding aligns with the work of Ahmad *et al*., (2015) in study of the linkages between deforestation, energy consumption, and economic growth in Pakistan but contrary to the findings of Usman *et al.,* (2021) in exploring the role of renewable energy and urbanization in mitigating environmental degradation in BRICS countries in which renewable energy use was found to reduce deforestation and environmental degradation. The nonlinear coefficient of GDPPA is negative and statistically significant at 1% level. This means that, too much economic activities can cause deforestation. Population growth has negative but significant effect on deforestation. This indicates that 1% increase in population annually can leads to 9.4% decrease in forest area in Nigeria. The higher the number of people in the country the more resources will be used. This finding is in line with John, (2023) and Kojo and Paschal (2018); and it conforms to the priory expectation. The linear coefficient of renewable energy consumption however, has positive and significant impact on deforestation; as the renewable energy consumption increases by 1%, deforestation increases by 3.79%. This is expected particularly when the rate of renewal to energy by other sources is less than the rate of deforestation. This finding tallies with Kojo and Paschal (2018).

Table 4.5: Result of ARDL Short Run Estimates

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GDPPA_)	-2.32E+08	1.14E+08	0.000000	**0.0000**
D(GDPPA_(-1))	-2.07E+08	65282930	0.000000	**0.0000**
D(GDPPA_2)	8172127.	6966761.	0.000000	**0.0000**
D(POPA_)	-1.79E+10	8.58E+09	0.000000	**0.0000**
D(POPA_(-1))	2.94E+10	8.89E+09	0.000000	**0.0000**
D(RENEG_)	-1.77E+08	1.41E+08	0.000000	**0.0000**
CointEq(-1)*	**-0.052396**	**0.007922**	**-6.613761**	**0.0000**

Source: 2025 Author's Computation Using Eviews 10

The value of the adjustment coefficient is -0.052 which shows that about 6% of the disequilibrium (deviation from the long run relationship) is corrected each year. The estimates of the short run model reveals that the linear coefficients of the GDPPA annual growth are negative and statistically significant whereas the nonlinear coefficient for GDPPA is positive and

significant. This corresponds with the apriori expectation which means that the increase in economic activities in the economy upset the forest resources through increase demand for the resources leading to deforestation. This does not contradict the result of long run model. The short run coefficients of population growth and renewable energy indicate that the variables have negative and statistical impact on forest area. As population grows by 1% will lead to 1.79% decrease in the forest area; and a 1% increase in renewable energy consumption will lead to 1.77% decrease in forest area. However, population (-1) indicates positive but statistically significant impact on the forest area. This might be due to the size of population in the previous period not as many as at current period.

4.4 Post Estimation Tests

Table 4.6: Test of Serial Correlation

Breusch-Godfrey Serial Correlation LM Test			
F-statistic	0.073857	Prob. F(2,18)	**0.9291**
Obs*R-squared	**0.260464**	**Prob. Chi-Square(2)**	**0.8779**

Source: 2025 Author's Computation Using Eviews 10

The Breusch-Godfrey serial correlation LM test suggests that, there is no serial correlation in the estimated model, since the probability value of the F-statistic for the test is 0.9291, which is greater than the 5% significance level. This implies the acceptance of null hypothesis of no serial correlation in the estimated model.

Table 4.7: Heteroscedasticity Test, Ramsey RESET Test and Normality Test

Section A:			
Heteroskedasticity Test: Harvey			
F-statistic	1.041063	Prob. F(11,20)	**0.4497**
Obs*R-squared	11.65134	Prob. Chi-Square(11)	**0.3904**
Scaled explained SS	14.73678	Prob. Chi-Square(11)	**0.1949**
Section B:			
Ramsey RESET Test			
	Value	df	**Probability**
t-statistic	0.110393	19	**0.9133**
F-statistic	0.012187	(1, 19)	**0.9133**
Section C			
Normality Test		Jarque-Bera	**Probability**
		0.232246	**0.890366**

Source: 2025 Author's Computation Using Eviews 10

The result of heteroscedasticity test using Harvey approach suggests the there is no heteroscedasticity in the estimated model. This follows the fact that, the probability value for the F-statistic for the test is 0.4497 which is greater than 5% leading to the conclusion that the residuals are homoscedastic. In addition, the result of Ramsey RESET Test indicates that the model is well specified. The probability value for F-statistic is 0.9133 which is greater than 5%. This means that the coefficients of the estimated model are not associated with the problems of serial correlation, model misspecification, non-normality of residual and heteroscedasticity. The Jarque-Bera statistic (0.232246) is also significant with probability value (0.890966) greater than 5% conventional level, indicating

that the residual in the model are normally distributed.

4.5 Stability Test

The stability of the estimated coefficients was evaluated using cumulative sum of recursive residual (CUSUM). The result revealed that the estimated coefficients are stable over the period under study. Figure 4.1 indicates that the series are within the critical bound at 5% level of significance. This shows that the coefficients and relationships observed in the model are consistent and can used for forecasting, policy formulation and analysis.

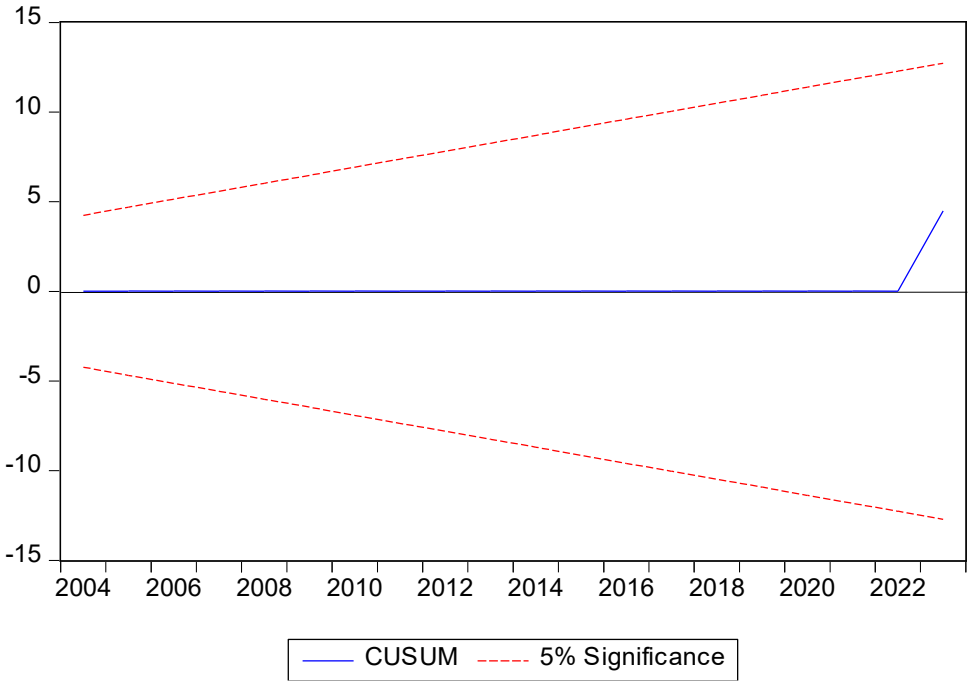


Figure 4.1: The CUSUM Stability Test

5. Policy implication of findings and Conclusion

The study investigated the impact of economic activities on deforestation in Nigeria. The findings revealed that there exists a long run relationship among the variables (deforestation, Gross domestic product, population and renewable energy). The linear result also revealed that, gross domestic product and renewable energy consumption have positive and significant impact on deforestation. The quadratic term for gross domestic product (GDPPA_2) and Population growth (POPA) have negative and significant impact on deforestation in the long run. The short run result reveals an inverse case of long run results. Though the short run coefficients are statistically significant, GDPPA and RENEG but have negative while GDPPA_2 and POPA have positive coefficients; hence exert impact on deforestation.

Deforestation was found to have long run relationship with economic activities, population and renewable energy consumption in the country. Therefore, governments should provide ease access to alternative energy sources such as kerosene, gas which consequently enable large number firewood users to withdraw from using it for cooking at both domestic and commercial settings thereby, relieving the forest against degradation and deterioration. Governments should reinforce regulations against rampant trees cutting; through, securing permission before cutting and to be followed by replanting as well. Government should pay attention in executing massive reforestation, and campaign for continues planting of trees by every ministry, departments and agencies so as to commensurate with the increasing demand for woods by the growing population.

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