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CARBON FOOTPRINT AND SUSTAINABLE DEVELOPMENT IN NIGERIA

By

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ABSTRACT

This study examined the relationship between carbon footprint and sustainable development in Nigeria from 1980 to 2024, a period characterized by rapid economic growth alongside increasing environmental pressures. The motivation was to determine whether Nigeria's development path aligned with the Environmental Kuznets Curve (EKC) hypothesis or risked unsustainable ecological degradation, with important implications for policy formulation and climate commitments. The study employed the Autoregressive Distributed Lag (ARDL) model for data analysis. The findings revealed that environmental quality positively and significantly enhanced GDP, while carbon dioxide emissions also supported short-run economic growth, reflecting a fossil-fuel-driven development pattern consistent with the EKC hypothesis. However, the ecological footprint significantly constrained economic performance, indicating increasing pressure from resource depletion. The study concluded that although Nigeria's growth remained emissions-dependent, environmental degradation constituted a major constraint to sustainable development. It therefore recommended stronger environmental protection policies, a transition to renewable energy, and sustainable resource management to ensure long-term development in Nigeria.

Keywords: Carbon Footprint, Sustainable Development and Ecological Footprint

JEL Classification: Q56, Q01

1.0 Introduction

Sustainable development in Nigeria involves the pursuit of economic growth that is inclusive, environmentally responsible, and socially equitable (Hauwah *et al*., 2022). The nation has embraced the United Nations' Sustainable Development Goals (SDGs) and assimilated them into its national developmental framework via the National Development Plan (2021–2025). Furthermore, the Nigerian government has ratified the United Nations Sustainable Development

Cooperation Framework (UNSDCF) for the period of 2023–2027 to reinforce its dedication to the realization of the SDGs. Entities such as the Office of the Senior Special Assistant to the President on SDGs (OSSAP-SDGs) are spearheading the coordination and execution across various ministries and states. Recent endeavours, exemplified by the $1 billion agricultural modernization accord between Nigeria and Brazil, aim to foster mechanized and climate-resilient agricultural practices to bolster food security and economic inclusiveness. In addition, the World Bank has sanctioned a $1.57 billion funding package to enhance public services, augment renewable energy capabilities, and advance irrigation infrastructure, which are essential for long-term environmental and social sustainability (World Bank, 2024).

A principal objective of every nation is the attainment of sustainable economic growth and development; as economies expand, the demand for energy escalates, resulting in an amplified carbon footprint. A carbon footprint denotes the aggregate amount of greenhouse gases (GHGs) discharged into the atmosphere as a consequence of human activities, typically quantified in terms of tons of carbon dioxide (CO_2) or its equivalent (Du *et al*., 2024). It encompasses direct emissions from activities such as transportation, energy consumption, and industrial operations, alongside indirect emissions stemming from the production and supply chains of goods and services. With the proliferation of global industrialization, carbon footprints have emerged as a significant contributor to climate change, as the accumulation of these gases, particularly CO_2, intensifies the greenhouse effect, thereby precipitating an increase in global temperatures (Ahmed *et al*., 2022). As part of the international endeavour to mitigate climate change, numerous countries, including Nigeria, are progressively preoccupied with quantifying and diminishing their carbon footprints to comply with global climate accords such as the Paris Agreement, which aims to restrict global warming to well below 2°C above pre-industrial levels (IPCC, 2021).

In Nigeria, the carbon footprint is profoundly affected by the nation's energy sector, which is predominantly dependent on fossil fuels such as oil and natural gas. The country's energy consumption is primarily directed towards power generation and transportation, both of which substantially contribute to GHG emissions. Notwithstanding its considerable renewable energy potential, Nigeria continues to witness limited integration of clean energy alternatives. As per a report by the Nigerian Energy Commission (NEC, 2022), the carbon footprint of Nigeria is aggravated by ineffective power infrastructure and dependence on diesel generators, particularly in off-grid regions (Ekpotu *et al*., 2024). Moreover, deforestation, agricultural methodologies, and waste management practices are also significant contributors to the nation's carbon emissions. Nevertheless, recent initiatives, such as Nigeria's pledge to attain net-zero emissions by 2060 and the advocacy for renewable energy policies, underscore efforts to curtail its carbon footprint.

Despite the nation's considerable potential for renewable energy, particularly in solar energy attributable to its high solar irradiance, investment in large-scale renewable infrastructure has been constrained by a multitude of factors, including significant initial costs, ineffective policy implementation, a deficiency in technical expertise, and inadequate incentives for private sector engagement. The ineffective disposal and management of solid waste further exacerbates carbon emissions. Substandard waste management systems, insufficient recycling infrastructure, and the prevalent practice of open-air burning of waste emit methane (a highly potent greenhouse gas) and an array of harmful pollutants into the atmosphere. Agriculture, a fundamental sector of the Nigerian economy employing over 60% of the workforce, is exceedingly susceptible to the repercussions of climate change, encompassing extreme weather phenomena such as floods and droughts (Amankwah, 2023).

Furthermore, oil extraction and refining operations, particularly in the Niger Delta region, are significant contributors to extensive gas flaring, representing one of the principal sources of carbon dioxide (CO2) emissions (Ezeokoro *et al*., 2021). A critical issue pertinent to the carbon footprint in Nigeria is its deleterious effect on environmental quality and public health. The extraction and refinement of oil have precipitated widespread soil contamination, water pollution, and deforestation. The persistent occurrence of oil spills in this region has not only ravaged local ecosystems but has also adversely affected communities reliant on agriculture and fishing for their livelihoods (Adebangbe *et al*., 2025). The adverse ramifications of carbon emissions on public health constitute one of the most urgent challenges confronting Nigeria today.

Moreover, Nigeria's carbon-intensive growth trajectory intensifies health burdens and strains infrastructural capabilities, thereby further obstructing sustainable development. The combustion of fossil fuels and industrial activities have engendered significant air pollution in urban centers, such as Lagos and Port Harcourt (Osabohien *et al*., 2025). According to the World Health Organization (WHO, 2023), air pollution in Nigeria accounts for over 114,000 premature fatalities annually, predominantly due to respiratory infections, strokes, and cardiovascular diseases. Additionally, the prevalent utilization of biomass and diesel generators for energy in households and small enterprises not only amplifies emissions but also subjects populations to indoor air pollution. These health repercussions impose a substantial burden on the public health infrastructure and diminish productivity, thereby undermining Sustainable Development Goal 3 (Good Health and Well-being) and Sustainable Development Goal 7 (Affordable and Clean Energy). In light of this, the study critically evaluates the carbon footprint and sustainable development in Nigeria from 1980 to 2024.

This study is warranted by Nigeria's escalating environmental challenges and its ongoing struggle to reconcile economic expansion with ecological stewardship. Nigeria's rapid industrialization, urban sprawl, deforestation, and heavy reliance on fossil fuels have significantly increased greenhouse gas emissions since the 1980s. The research is both timely and policy-relevant, particularly as Nigeria has committed to achieving net-zero emissions by 2060 under the Paris Agreement while still depending heavily on oil revenues to drive development. By examining the historical trajectory of Nigeria's carbon footprint in relation to sustainable development indicators such as energy access, industrial growth, and environmental protection, the study generates critical empirical evidence for informed policymaking. Importantly, the findings extend beyond Nigeria, offering valuable insights for other African countries facing similar structural challenges such as dependence on extractive industries, rapid urbanization, and weak environmental regulation thereby providing a replicable framework for balancing growth with sustainability across the continent. Furthermore, the study enhances public awareness by demonstrating how individual consumption patterns contribute to emissions, encouraging behavioural change and supporting broader climate action efforts within Africa.

2.0 Literature Review

Theoretical Literature

The present study is rooted in the Environmental Kuznets Curve (EKC) theory and the Externalities theory, both of which provide crucial insights into the nexus between carbon footprint and sustainable development.

The EKC hypothesis, initially introduced by Kuznets (1955) in the context of income inequality and represented as an inverted U-shaped curve, has been broadened to describe the association between per capita income and environmental degradation. Under the assumption that environmental quality behaves as a normal good, the demand for better environmental standards increases with rising income levels. Grossman and Krueger (1995) pioneered empirical applications of EKC, showing that at low levels of per capita income, economic growth worsens environmental quality, whereas at higher income levels, economic progress is accompanied by improved environmental standards. This implies that the impact of economic growth on pollution varies depending on the stage of development and the level of income. In the early phase of industrialization and urbanization, resource depletion and pollution intensify, while in later stages, economies tend to adopt cleaner practices and stricter standards (Stern, 2001).

The theory of externalities by Pigou (1920) complements the EKC perspective by emphasizing the unintended costs of production and consumption that spill over to third parties. In economics, externalities particularly negative ones are unintended consequences of economic activities not captured in market prices. With respect to carbon emissions, the adverse health effects and environmental damage resulting from pollution are categorized as negative externalities, since producers in carbon-intensive sectors such as transportation, agriculture, energy, and industry do not internalize these costs. The theory highlights that without corrective policies or regulation, negative externalities persist, causing inefficiencies and reducing social welfare. Nigeria's rising carbon footprint is largely attributed to industries, transport, and energy systems operating without bearing the cost of pollution. Such unchecked emissions hinder progress toward sustainability, exacerbate poverty, and undermine long-term development. Moreover, the theory stresses intergenerational consequences, as today's environmental degradation from deforestation, oil dependence, and unsustainable energy practices imposes climate vulnerability, food insecurity, and ecosystem damage on future generations contradicting the essence of sustainable development.

Empirical Literature

Using a fully modified ordinary least squares, dynamic ordinary least squares and pooled mean group estimators, Ashraf and Javed (2026) studied the role of technological innovation and renewable energy in sustainable development, reducing the carbon footprint of food supply chains. The study found that technological innovation significantly reduces carbon footprint of food supply chains, particularly through improvements in production and distribution efficiency. Renewable energy usage also mitigates emissions, while non-renewable energy sources have the opposite effect. The impact of GDP growth diverges: it reduces emissions in developed countries but exacerbates them in developing ones, reflecting differing levels of technological maturity and infrastructure. Osabohien *et al*. (2025) investigated the interplay between renewable energy, carbon footprint, natural resource depletion, and growth across 45 African economies using the Generalized Method of Moments (GMM). Their findings reveal that greenhouse gas emissions positively and significantly influence economic growth across most African regions except Southern Africa, while resource depletion exerts a negative and significant impact particularly in West, East, and Sub-Saharan Africa. In another study, Al-Marshadi *et al*. (2025) analyzed ecological footprints, global sustainability, and the influence of resource use, financial development, and growth. Their results showed that depletion of natural resources and expansion of financial development worsen ecological footprints, with impacts varying across income groups and regions. While economic growth improved environmental quality in East Asia and the Pacific, resource depletion had a negative influence globally. The EKC hypothesis was only validated in high-income economies, but remained inconclusive across other quantiles and regions.

Focusing on Nigeria, Umar *et al*. (2025) assessed environmental sustainability practices and carbon footprint awareness in Kaduna metropolis. Findings indicated moderate awareness levels, strongly influenced by education, income, and age. Although residents expressed positive environmental attitudes, the practical adoption of low-carbon measures such as waste management, energy conservation, and public transport remained weak due to infrastructural and institutional barriers. Alabi (2023) explored the link between globalization and carbon neutrality in Nigeria over 1980–2022 using the Autoregressive Distributed Lag (ARDL) and Granger causality methods. Results showed a positive relationship between foreign direct investment (FDI) and carbon emissions, with evidence of unidirectional causality running from FDI to emissions. This indicates that higher inflows of foreign capital intensify carbon emissions and greenhouse gas concentrations in Nigeria. Similarly, Aigbedion *et al*. (2024) examined the effect of carbon footprint reduction on Nigeria's economic development using time-series data (1990–2019) and ordinary least squares regression. Their findings demonstrated that total CO_2 emissions significantly reduce economic growth, suggesting that unchecked fossil fuel use undermines Nigeria's developmental progress.

Obayagbona (2023) analyzed the connection between carbon footprint and growth in Nigeria and Ghana from 1990–2020 using Fully Modified Least Squares (FMOLS) and Panel Dynamic Least Squares (PDLS). The study revealed that greenhouse gas emissions and renewable energy consumption negatively affect growth in both countries, while electricity consumption and trade openness had statistically insignificant impacts. The study proposed carbon pricing through taxation of biomass-related emissions (methane, nitrous oxide, and CO_2), as a means of discouraging unsustainable practices such as bush burning. Benjamin *et al*. (2023) examined fossil fuel consumption, CO_2 emissions, and adult mortality in Nigeria using ARDL. Results indicated that while fossil fuel energy consumption reduced mortality in the short run, CO_2 emissions consistently raised adult mortality rates in both short and long terms. The study also found that government health expenditure exhibited an inverted U-shape with mortality, while FDI showed a U-shape relationship. Importantly, a 1% increase in CO_2 emissions raised adult deaths per 1,000 by 0.02642%.

Existing scholarship on carbon footprint and sustainability highlights critical gaps that necessitate further inquiry within the Nigerian context. Regional-level studies (Osabohien *et al*., 2025; Al-Marshadi *et al*., 2025) provide continental perspectives but overlook Nigeria's unique growth-emission dynamics, where fossil fuel dependence continues to drive CO_2, GHG, and NO_2 emissions alongside deteriorating environmental quality (ENCQ). National-level studies (Alabi, 2024; Obayagbona, 2023) often focus on emissions-growth linkages while neglecting broader dimensions such as ecological footprint and its interaction with development outcomes. Micro-level investigations (Umar *et al*., 2025) emphasize awareness and adoption of low-carbon practices but fail to connect these behavioral trends with macro-level indicators such as GDP or EF. These shortcomings justify the need for a holistic, Nigeria-specific study that integrates GDP, environmental quality, CO_2, GHG, EF, and NO_2 into a single analytical framework. Such an approach is vital because Nigeria's current growth path is environmentally unsustainable, with unchecked emissions threatening health, food security, and climate resilience. By bridging the gap between individual behaviours and national policies, this study seeks to generate evidence-based strategies for guiding Nigeria toward a sustainable, low-carbon development trajectory aligned with the SDGs and global climate commitments.

3.0 Methodology

Theoretical Framework

The theoretical model for this study is Environmental Kuznets Curve (EKC) hypothesizes an inverted U-shaped relationship between environmental degradation and economic development. The Environmental Kuznets Curve (EKC) can be expressed mathematically as an inverted-U relationship between environmental degradation (E) and income per capita (Y), typically modeled as:

$$E = \alpha + \beta Y + \gamma Y2 + \varepsilon$$

Where, $\beta > 0$ and $\gamma < 0$. This specification suggests that at low levels of income, increases in Y raise emissions, but beyond a certain threshold, further increases in Y reduce them. To determine the point at which emissions peak, the derivative of E with respect to income Y is taken:

$$\frac{dE}{dY} = \beta + 2\gamma Y$$

Setting this derivative equal to zero gives the turning point:

$$Y^{*} = -\frac{\beta}{2y}$$

This provides the critical income level at which environmental degradation (carbon footprint) begins to decline, which is crucial for assessing Nigeria's sustainable development pathway. In the Nigerian context, the derivative $\frac{dE}{dY}$ represents how incremental changes in economic growth affect carbon emissions. Currently, as Nigeria experiences industrial expansion, urbanization, and dependence on fossil fuels, the derivative remains positive, meaning growth is still strongly associated with rising emissions. The country has not yet reached the EKC's turning point Y^{*}, which suggests that policy and institutional weaknesses prevent economic growth from translating into environmental improvements. This derivative analysis therefore emphasizes that Nigeria remains on the upward-sloping segment of the EKC, where development contributes to environmental stress.

This study reorients the hypothesis by positioning GDP as the subject of the functional relationship, positing that economic output emerges as a function of environmental degradation dynamics, mathematically expressed in a quadratic form as:

$$GDP = \alpha + \beta E + \gamma E^{2} + \boldsymbol{\varepsilon}$$

Model Specification

This research builds upon the framework developed by Al-Marshadi *et al.* (2025), which investigated ecological footprints, global sustainability, and the influence of natural resources, financial development, and economic growth. The modified version of Al-Marshadi et al. (2025) model is stated below:

$$GDP = \beta_0 + \beta_1 ENVQ + \beta_2 CO_2 + \beta_3 GHG + \beta_4 EF + \beta_5 NO_2 + \mu$$

Following Pesaran *et al.* (2001) Autoregressive Distributed lag (ARDL) bounds testing approach, the Model was transformed below:

$$\Delta InGDP_t = \alpha_0 + \sum_{i=1}^{q} \beta_i \Delta GDP_{t-i} \sum_{i=1}^{N1} \gamma_i \Delta In\text{ENVQ}_{t-i} + \sum_{k=1}^{N2} \delta_k \Delta InCO2_{t-k} + \sum_{l=1}^{N3} \psi_l \Delta InGHG_{t-l} + \sum_{m=1}^{N4} \lambda_m \Delta InEF_{t-m} + \sum_{n=1}^{N5} \partial_n \Delta InNO2_{t-n} + \rho InENVQ_{t-1} + \partial GDP_{t-1} + \beta_1 InENVQ_{t-1} + \beta_2 InCO2_{t-1} + \beta_3 InGHG_{t-1} + \beta_4 InEF_{t-1} + \beta_5 InNO2_{t-1} + \mu_t$$

Equation (2) is a standard Autoregressive Distributed Lag (ARDL) model, which comprise of both long run and short run estimates. The estimates of ∂, λ and Ψ are normalized on ρ and computed as $-\partial/\rho, -\lambda/\rho$ and $-\Psi/\rho$ to yield the long run estimates relationship between sustainable growth and carbon footprint respectively and the constant is computed as $-\alpha/\rho,$ since $\Delta InGDP_t = \Delta InCO2_t = \Delta InENCQ_t = 0$ in the long run. However, the short run estimates are obtained as β_i, γ_j, φ_j and δ_j for composite gross domestic product, and environmental quality respectively. Meanwhile, the variables in difference form can accommodate more than one lag, optimal lag length for the ARDL model is selected using Schwarz Bayesian Information Criterion (SBC). The preferred ARDL model is used to test for co-integration relationship in the model. This approach of testing for co-integration is referred to as Bounds testing as it involves the upper and lower bounds. The test follows an *F* distribution and therefore, if the calculated F-statistic is greater than the upper bound I(1), there is co-integration; if it is less than the lower bound I(0), there is no co-integration and if it lies in-between the two bounds, then, the test is considered inconclusive. Where; GDP = Gross Domestic Product, ENVQ = Environmental Quality, CO_2 = Carbon Emission, GHG = Green House Gas, EF = Ecological Footprint, NO_2 = Nitrous Oxide Emission, μ = Error term

4.0 Results and Discussion of Findings

Interpretation of the Unit Root Test

This confirms that five variables are integrated of order one, I(1), meaning they exhibit unit root behaviour in level but become stationary in their first differenced form. In contrast, the log of greenhouse gas emissions (LGHG) is the only variable that is stationary at level, with its test statistic (-4.4681) more negative than the 1% critical value (-3.635527), indicating that it is integrated of order zero, I(0). This implies that LGHG does not exhibit unit root characteristics and is mean-reverting in its level form. The stationarity results are crucial for determining the appropriate econometric modeling technique such as the ARDL approach which allows for a mix of I(0) and I(1) variables.

Table 1: Unit root test

Variable	Levels	Critical Values	First Difference	Critical Values	Order of Integration	Remark
GDPG	-0.0464	1% = -3.635527 5% = -2.938987 10% = -2.607932	-8.5979	1% = -3.635527 5% = -2.938987 10% = -2.607932	I(1)	Stationary at first difference
CO_2	-1.6482	1% = -3.635527 5% = -2.938987 10% = -2.607932	-6.6616	1% = -3.635527 5% = -2.938987 10% = -2.607932	I(1)	Stationary at first difference
EF	-1.3894	1% = -3.635527 5% = -2.938987 10% = -2.607932	-7.2674	1% = -3.635527 5% = -2.938987 10% = -2.607932	I(1)	Stationary at first difference
ENVQ	-1.7721	1% = -3.635527 5% = -2.938987 10% = -2.607932	-6.0735	1% = -3.635527 5% = -2.938987 10% = -2.607932	I(1)	Stationary at first difference
LGHG	-4.4681	1% = -3.635527 5% = -2.938987 10% = -2.607932	-23.1372	1% = -3.635527 5% = -2.938987 10% = -2.607932	I(0)	Stationary at level
NO2	0.0565	1% = -3.635527 5% = -2.938987 10% = -2.607932	-4.0422	1% = -3.635527 5% = -2.938987 10% = -2.607932	I(1)	Stationary at first difference

Source: Author's Computation from Eview 10

Interpretation of Cointegration Results

The Autoregressive Distributed Lag (ARDL) bounds testing approach was used to examine the short-term dynamics and the co-integration relationship between the dependent variable and the explanatory variables. The result shows that no long run relationship among the variables under study as the F The F-statistic (2.1054) is below the lower bound critical values at all significance levels. Therefore, we accept the null hypothesis of no co-integration among the variables under study.

Table 2: Results of Co-integration test

Test statistics	Value	K
F-stat	2.1054	5
Critical Value Bounds		
Level of significance	I(0) Bounds	I(1) Bounds
10%	2.22	3.29
5%	2.56	3.68
2.5%	2.88	4.16
1%	3.29	4.79

Source: Author's Computation from Eview 10

Interpretation of Autoregressive Distributed Lag (ARDL)

In the short-run ARDL estimation with GDP as the dependent variable, environmental quality exerts a positive and statistically significant impact, showing how enhancements in ambient conditions such as reduced pollution and preserved ecosystems directly bolster economic output by mitigating healthcare expenditures, and drawing sustainable development which align with the empirical studies on the environmental Kuznets curve (EKC) where quality improvements yield immediate growth dividends. Similarly, carbon dioxide emissions display a positive and significant effect, which reflect the conventional growth-emissions nexus in Nigeria where fossil-fuel intensive industrialization drives short-term GDP expansion. Conversely, the ecological footprint imposes a negative and highly significant drag, highlighting the economic costs of resource depletion and habitat loss through disrupted supply chains, escalated restoration outlays, and diminished natural capital stocks essential for sectoral contributions like agriculture and eco-tourism, thereby signaling a binding constraint on sustainable development trajectories. Greenhouse gas emissions register a positive yet insignificant influence, while nitrous oxide emissions exhibit a negative but insignificant effect. Adjusted R-squared of 0.7220 indicates that the model captures about 72% of factors that affected GDP and F-statistic of 10.4132 validates joint exogeneity, and a Durbin-Watson statistic of 2.1446 ruled out serial correlation.

Table 3: Results of Short-run ARDL Estimate

Dependent Variable: GDP

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LENVQ	1.8107	1.8341	0.9873	0.0156

LEF	-0.7079	0.0621	-5.1871	0.0004
LCO2	0.1235	0.0326	2.4395	0.0073
LGHG	0.1090	0.4381	-0.3783	0.4577
LNO2	-0.0267	0.0874	1.4985	0.6509
C	0.0404	0.8015	-1.5206	0.0282
Adjusted R-squared	0.7220			
F-statistics	10.4132			
Prob(F-stat)	0.0420			
Durbin Watson	2.1446			

Source: Author's Computation from Eview 10

Post Estimation Test

The Breusch–Godfrey Serial Correlation LM test examines whether residuals are autocorrelated up to two lags, and since both the F-statistic probability (0.2519) and the Obs*R^2 probability (0.1902) are greater than 0.05, the null hypothesis of no serial correlation cannot be rejected. This indicates that the model's residuals are not serially correlated, suggesting that the model is adequately specified in terms of error independence and that the estimated coefficients is considered reliable.

Table 4: Serial Correlation

Breusch-Godfrey Serial Correlation LM Test:

Null hypothesis: No serial correlation at up to 2 lags

F-statistic	1.441940	Prob. F(2,31)	0.2519
Obs*R-squared	3.319317	Prob. Chi-Square(2)	0.1902

Source: Author's Computation from Eview 10

The Breusch-Pagan-Godfrey test for heteroskedasticity shows that all the probability values (0.1012, 0.1058, and 0.1160) are greater than the 5% significance level. This means we fail to reject the null hypothesis of homoskedasticity, indicating that the variance of the error terms is constant across observations. In other words, there is no evidence of heteroskedasticity in the model, and the residuals are well-behaved. This outcome validates the reliability of the estimated coefficients, as the standard errors are not biased by unequal error variances, thereby strengthening the robustness of the ARDL model's results and the credibility of its policy implications.

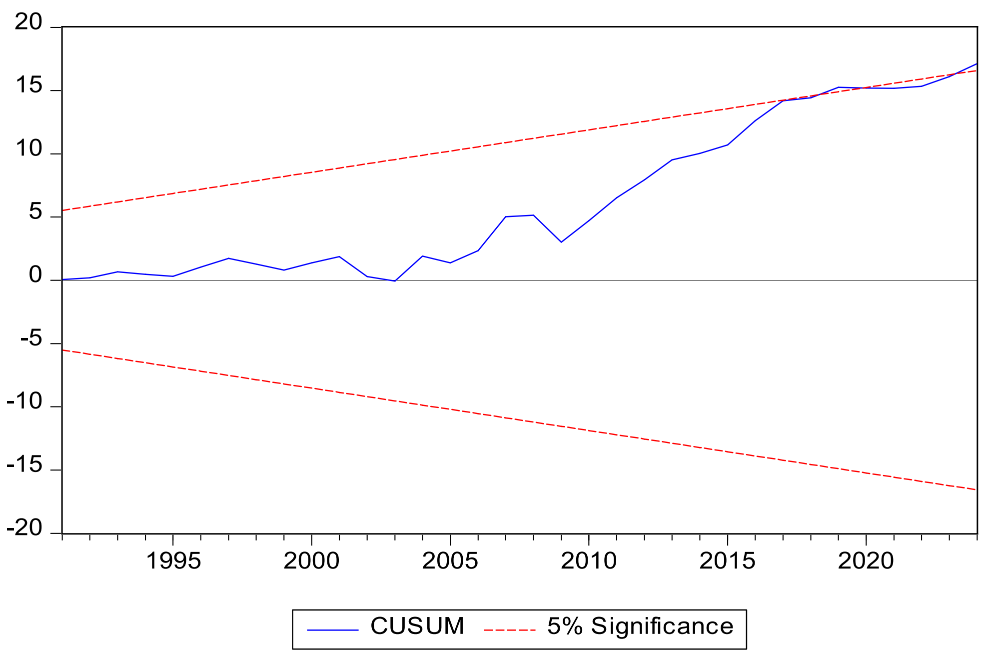
Table 5: Heteroskedasticity

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	4.268560	Prob. F(8,34)	0.1012
Obs*R-squared	21.54684	Prob. Chi-Square(8)	0.1058
Scaled explained SS	21.47268	Prob. Chi-Square(8)	0.1160

Based on the foregoing diagnostic tests, the ARDL model can be considered generally stable. The absence of heteroskedasticity (homoskedastic residuals) confirms that the error variances are constant, which strengthens the reliability of coefficient estimates.

Fig 1: Stability Test



Discussion of the Findings

The finding of this study is consistent with studies such as Osabohien *et al.* (2025) who confirmed that carbon emissions positively drive economic growth in the short run, which reflect the fossil-fuel-dependent growth structure typical of developing African economies. The negative and significant impact of ecological footprint equally supports the broader consensus like Al-Marshadi et al., (2025) that resource depletion constrains sustainable growth. However, the study contradicts Aigbedion *et al*. (2024) and Obayagbona (2023), who reported that CO_2 and greenhouse gas emissions undermine economic growth, as the present findings show a positive growth effect of emissions in the short run. Furthermore, while the Environmental Kuznets Curve (EKC) proposition is supported through the positive impact of environmental quality, this contrasts with evidence from Ashraf and Javed (2026), where sustainable development is driven by technological innovation and renewable energy, thereby revealing a structural weakness in Nigeria's shift toward cleaner and more environmentally sustainable growth.

5.0 Conclusion and Recommendations

In summary, the short-run ARDL results reveal that Nigeria's economic growth is positively influenced by improvements in environmental quality and carbon dioxide (CO_2) emissions, suggesting that the economy is still largely operating within a growth structure consistent with the upward phase of the Environmental Kuznets Curve (EKC), where industrial expansion temporarily coexists with environmental pressure. However, the significant negative effect of ecological footprint indicates that excessive resource consumption and environmental degradation are already imposing measurable constraints on economic performance, thereby threatening long-term sustainability through depletion of natural capital and increased economic adjustment costs. In contrast, greenhouse gas and nitrous oxide emissions show mixed but statistically insignificant effects, implying that their current short-run influence on GDP is limited, though they may still pose latent risks if unaddressed.

Drawing from the empirical results, several policy directions are recommended to guide Nigeria toward a more sustainable development path. Given the positive and significant impact of environmental quality on economic growth, policymakers should prioritize environmental protection measures such as pollution control, reforestation, and ecosystem restoration, as these not only improve public health outcomes but also enhance productive economic capacity. In addition, the positive relationship between carbon dioxide emissions and GDP highlights the continued dependence of Nigeria's growth on fossil-fuel-based activities; therefore, there is a need to gradually transition toward cleaner energy sources by promoting renewable energy investments, improving energy efficiency, and strengthening emission regulation frameworks. Furthermore, the highly significant negative effect of ecological footprint indicates that resource depletion and environmental degradation are already constraining economic performance, making it imperative for government to adopt strict resource management policies, sustainable land-use planning, and conservation strategies to preserve natural capital. Although greenhouse gas and nitrous oxide emissions were statistically insignificant, their potential long-term environmental risks justify proactive mitigation measures, particularly in agriculture, waste management, and industrial processes.

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