Ecological Footprint and Inclusive Growth in Nigeria

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Abstract
This study explores the use of ecological footprints for inclusive growth in Nigeria with a focus on the relationship between environmental sustainability and economic equality. This study investigates the consequences of environmental degradation for the equitable distribution of resources and wealth. The study evaluates how environmental depletion affects inclusive growth and examines viable sustainable methods for advancing the economy. The study employed a Vector Error Correction Model (VECM) to determine the long-term relationships between various factors. The study finds that carbon emissions from the manufacturing sector have a negative impact, while carbon emissions from the agricultural sector, transport sector, labour and gross capital formation have a positive impact on inclusive growth. The study recommends that there should be policies to regulate the use of improved technologies that reduce the level of emissions in the production and discharge of waste, which should be enforced in the extractive industries. The government of Nigeria should enforce stricter environmental regulations in the main polluting sectors, as well as conduct periodic environmental impact assessments aimed at erring firms or organisations; they should also bear the full cost of environmental clean-up.

Keywords: Ecological footprint, inclusive growth, environmental sustainability, economic equity, sustainable development policies.

JEL Classification: O44

Introduction

As population increases and cities spread, demand on land, water, forests increases leading to environmental degradation and low biodiversity (Global Footprint Network, 2021). With the expansion of agriculture, the increasing demand for food and environmental degradation through increased deforestation and utilization of fossil fuels is, therefore, intensifying depletion of natural resources and escalation in emission of greenhouses, intensifying climate change. Nevertheless, regardless of these problems with the environment, Nigeria experienced great economic growth – mainly through oil income and development of non-oil industries (Central Bank of Nigeria, 2022). And, these economic gains have not filtered down to all the segments of people; the level of poverty is sadly still excessively high, and in particular, in the rural areas. Bad distribution of resources, services and employment opportunities fuels escalation of social and economic estrangement, which complicates the participation and success on society level for those who are not in better positions.

The interplay between ecological stresses and unequal economic development raises important questions about Nigeria's growth path viability. Economic growth, which can increase living standards, is threatened by an unbridled ecological destruction over the long term. Hence, understanding the link between Nigeria's ecological footprint and inclusion in growth is crucial in formulating strategies geared at achieving economic advancement, while protecting the environment. Research on the nexus between resource consumption and social equity is helpful to the development of sustainable development policies in Nigeria to share growth gains equally without intensifying ecological damage.

Ecological footprint measures humanity's rate of demolishing ecosystems by converting the amount of resource consumption and waste thrown out into biologically productive land (Global Footprint Network, 2021). It measures the number of carbon, farmland, grasslands, woodlands, and marine areas that our consumption is commensurate with. Biocapacity refers to the total ecological output of biomass from ecosystems. Ecological deficit occurs when human ecological balance exceeds the biocapacity available (Omoke et al., 2020). Inclusive growth is a model of economics that ensures that all people have the opportunity according to Chukwunweike, Onuorah & Owonye (2022). It focuses on the manner in which growth occurs and guarantees that growth benefits marginalized groups. Major aspects include the expansion job opportunities for all sectors, guaranteed equal access to markets and the public services and sustainable management of the environment (Chukwunweike et al., 2022).

One of the determinants of inclusive growth actualization is the availability of a sustainable environment free from uncontrolled emission or degradation. Nigeria stands at a critical juncture where economic growth and environmental sustainability intersect. The pursuit of rapid economic development often comes at the cost of environmental degradation, posing significant challenges to achieving inclusive growth Omisore (2018). Despite the nation's rich natural resources and potential for economic expansion, the absence of comprehensive environmental sustainability measures has raised concerns regarding its impact on inclusive growth Ofori et al., (2023). In the pursuit of rapid economic growth in Nigeria, the absence of robust integration of environmental sustainability within its development framework has raised concerns about hindering inclusive growth Ofori et al. (2022). Carbon emissions, the main source of threat to environmental sustainability Raihan and Tuspekova (2022), can affect inclusive growth in various ways. On one hand, carbon emissions can create barriers to inclusive growth by increasing the costs of energy, transportation, agriculture, and other sectors that depend on fossil fuels.

Carbon emissions can also exacerbate the effects of climate change on vulnerable populations, such as those living in coastal areas, small island states, or arid regions Leal Filho (2021). These effects can undermine human well- being, livelihoods, and social cohesion. On the other hand, carbon emissions can create opportunities for inclusive growth by stimulating technological innovation and market transformation thereby creating new jobs, industries and enhancing productivity and competitiveness Hepburn et al. (2021).

Therefore, there is need for current studies that can account for better economic growth that is inclusive in developing countries, bearing in mind the provisions of the United Nations Sustainable Development Goal Number 4. In the quest of inclusive growth, a sustainable environment has been regarded as paramount for growth to be considered inclusiveness. Carbon emissions are the release of carbon compounds, particularly carbon dioxide (CO_2), into the atmosphere (Li et al., 2022). According to Guo et al. (2022), these emissions primarily originate from human activities, such as burning fossil fuels like coal, oil, and natural gas for energy production, transportation, industrial processes, and deforestation. Carbon emissions contribute significantly to the greenhouse effect, trapping heat in the Earth's atmosphere and leading to climate change. Managing and reducing carbon emissions are crucial steps in addressing climate change and its adverse effects on the environment, ecosystems, and human health. Nigeria stands at a critical juncture where economic growth and environmental sustainability intersect. The pursuit of rapid economic development often comes at the cost of environmental degradation, posing significant challenges to achieving inclusive growth Omisore, (2018). Despite the nation's rich natural resources and potential for economic expansion, the absence of comprehensive environmental sustainability measures has raised concerns regarding its impact on inclusive growth Ofori et al. (2023).

In the pursuit of rapid economic growth in Nigeria, the absence of robust integration of environmental sustainability within its development framework has raised concerns about hindering inclusive growth. Carbon emissions, the main source of threat to environmental sustainability, can affect inclusive growth in various ways. On one hand, carbon emissions can create barriers to inclusive growth by increasing the costs of energy, transportation, agriculture, and other sectors that depend on fossil fuels. Carbon emissions can also exacerbate the effects of climate change on vulnerable populations, such as those living in coastal areas, small island states, or arid regions Filho (2021). These effects can undermine human well- being, livelihoods, and social cohesion. On the other hand, carbon emissions can create opportunities for inclusive growth by stimulating technological innovation and market transformation thereby creating new jobs, industries and enhancing productivity and competitiveness Hepburn et al. (2021). Though carbon emission stimulates economic growth and also can lead to the deterioration of the environment, as noted in Adekoya et al. (2022), institutional quality is a very string and reliable tool to control environmental degradation and stimulate economic growth in Africa.

Empirical review

Based on an empirical evidence on 44 Sub-Sahara African countries over the period 2000 to 2012 and using a GMM technique, Asongu (2017) found a net negative effects CO2 emissions on inclusive human development. Besides, the direction of causality between growth and institutional quality is less certain, and rather could as well run the other way round (Olanrewaju et al., 2020). For instance, Akbar et al. (2021) found from a VAR model in 33 OECD countries from 2006 to 2016 that CO2 emissions significantly escalate the healthcare expenditures.

Renewable energy consumption poses no impact on the quality of the environment. Pata et al. (2021) also revealed that human capital and renewable energy enhance environmental quality, while natural resources stimulate ecological damage. On the other hand, Nathaniel et al. (2021) used the AMG method to investigate the effect of human capital, economic growth, and natural resources rent on EF. Their estimates confirmed that human capital poses a favorable but insignificant impact on EF, while economic growth and natural resources increase the degradation of the environment. On the contrary, Zhang et al. (2021) explored the association among human capital, economic growth, natural resources, and EF in Pakistan from 1985 to 2018. They concluded that human capital and economic factor have a positive, whereas natural resources have a negative effect on EF.

Abid, (2016) found that democracy, government effectiveness, political stability, and control of corruption reduces CO2 emissions and on the other hand, rule of law and regulatory quality increases CO2 emissions. Dhrifi (2019) also found from a panel data from 45 African countries over the period 1995 to 2015 that there is a positive relation between institutional quality on health on one hand, and a negative relationship between environmental degradation and health outcome. Moreover, it was also found that, the direct and negative effects of environmental degradation on health may be decreased by the indirect and positive effects through institutions quality and macroeconomic variables. Knowledge of Ecological Footprint (EF) research is critical in regards to the manner in which resources are used. Sawyerr et al. (2024) scored Ibadan North's EF at 0.43 gha per capita while the main component is energy at 93 percent. From Ambrose and Okoro (2023), household consumption accounts for 12 % of the yearly growth of Nigeria's EF mainly from water and transport use. Nigeria's total ecological footprint 58% more than its biocapacity (Omoke et al, 2020) indicating unsustainable resource consumption. In global figures, the average EF per capita has been reported as 2.75 gha with high income countries exceeding 4 gha. Goldstein et al. (2023) recommended that EF assessments should be customised for various locales to improve urban planning and policy. In China, Zhiying and Cuiyan (2022) found increased consumption to expand EF deficits, which shows ecological effects of urbanisation.

It has been found that there is a dearth of specific ecological footprint information in African urban areas. Sawyerr et al. (2024) managed to fill this gap by using bottom-up methods in Ibadan North. Globally, evaluating EF supports monitoring resource utilization based on availabilities of biocapacity under SDGs. Nevertheless, the maintenance of consistent methodology is difficult, which prevents proper comparisons between nations. Findings from research support that the correlation between EF and growth is inconclusive. Omoke et al. (2020) used Nonlinear Auto-regressive Distributed Lag (NARDL) models between 1971 and 2014 to show that increased ecological footprint went along with the GDP growth, implying resource-based expansion. In their research, they found out that the growth of financial systems enhanced positive effects of EF on growth.

A F1000Research article (2025) examined the connection between financial deepening, national security, and EF in the period of 1995-2022. What they found out however, is that when EF combined with financial deepening contributes to growth, insecurity reduces this positive effect. Sijuwola and Fadogba did a research in 2023 with the use of ARDL, in order to analyze the correlation between carbon emissions and inclusive growth from 1970 until 20. According to their research, short-term emissions increases led to greater inclusivity, while longer-term effects came at a cost to inclusivity. Their analysis suggests that, in the long run, environmental damage could impede equitable development. As pertaining to social inclusion, Ambrose and Okoro (2023) discovered that an increase in household energy consumption tends to result into the unequal distribution of resources and services, which aggravates social differences. According to them, policies should promote the use of energy-efficient technologies in order to reduce EF while promoting equitable welfare.

The EF metric defines sustainability by measuring whether the demand is greater than the available biocapacity. Sawyerr et al. (2024) reported that an ecological footprint of 0.43 gha per capita in Ibadan north signals local sustainability, but this is a warning of impending deficits attributable to energy-intensive actions. As Ambrose and Okoro (2023) pointed out, the different elements of the EF are highly tokent with global considerations on water security, energy consumption and sustainable city-building under the SDGs. Their findings showed that water makes up 58% of EF, which speaks volumes on need for immediate action on Sustainable Development Goals 6 and 11. It was argued by Omoke et al. (2020) that there is need to view the relationship between EF and growth in relation to limitations of resources. They pronounced that sustainable growth implies disentangling the GDP growth from the EF with the aid of green finance and innovative technologies. According to Goldstein et al. (2023), it is important to note that assessment of EF guides the formation of urban resilience strategy such as investing in renewable energy and conservation so as to facilitate SDG 7 and SDG 13. They suggested adopting global EF frameworks to local contexts.

Methodology

Theoretical framework

This study investigates the impact of ecological footprint on inclusive growth in Nigeria, drawing upon the endogenous growth theory as its theoretical foundation. This theory emphasises that advancements in innovation, knowledge, and ecological footprint sustained economic growth and improve overall economic performance. Consistent with the framework proposed by Mankiw, Romer, and Weil (1992), the relationship is specified as follows:

$$Y(t) = K(t)^{\alpha} A(t) L(t))^{1-\alpha} \tag{1}$$

Where Y_i is the output, K_i is the capital, L_i is the Labour, and A is the level of technological progress.

Model Specification

The objectives of the study drive the model specification in this section, as stated above; this is to examine the impact of ecological footprint on inclusive growth in Nigeria. This study model is derived from the work of Sijuwola and Fadogba (2023) where they examined environmental sustainability and inclusive growth in Nigeria, with little modification from the resultant model is given below;

$$ING_t = f(ECOFTP_t) \tag{2}$$

In expanding ecological footprint, carbon emission from agricultural sector ($CO2AG_t$), carbon emission from manufacturing sector($CO2MA_t$) and carbon emission from transport sector ($CO2TR_t$) will be examined on inclusive growth in Nigeria.

$$ING_t = f(CO2AG_t; CO2MA_t; CO2TR_t) \tag{3}$$

The log-linear form of the model is specified as

$$LING_t = \beta_0 + \beta_1 LCO2AG_t + \beta_2 LCO2MA_t + \beta_3 LCO2TR_t + LAB_t + GCF_t + \varepsilon_t \tag{4}$$

Where ING_t is the dependent variable which is inclusive growth, while $CO2AG$, $CO2MA$, $CO2TR$, LAB and GCF are the independent variables for the model, which are carbon emission from agricultural sector, manufacturing sector and transport sector respectively, labour (LAB) and gross capital formation (GCF) are control variables while the stochastic variable is (ε_t).

Measurement of variables

The definitions and the source of the variables used in the model above were expressed as:

Table 3.1: Measurement of variables and sources

Inclusive growth	$\boldsymbol{ING}$	GDP per person employed (constant 2011 PPP $)	World Development Indicators (WDI)
Agricultural methane emissions	$\boldsymbol{CO2AG}$	(% of total)	World Development Indicators (WDI)
CO2 emissions from manufacturing industries and construction	$\boldsymbol{CO2MA}$	(% of total fuel combustion)	World Development Indicators (WDI)
CO2 emissions from transport	$\boldsymbol{CO2TR}$	(% of total fuel combustion)	World Development Indicators (WDI)
Labour	$\boldsymbol{LAB}$	Total labour force participation rate (percentage of people from 15 to 65 years old)	World Development Indicators (WDI)
Gross capital formation	$\boldsymbol{GCF}$	The stock of private capital used in the production at annual percentage growth rate	World Development Indicators (WDI)

Source: *Author's computation*

Each proxy was based on time series data from 1981 to 2023, and the data was sourced from the WDI database as a secondary source. The study's 43-year timeline runs from 1981 through 2023. Data accessibility and the requirement for consistent start and end dates across all series guided the selection of the data scope. The empirical technique adopted in this study is based on the objectives of the study. This technique is the Johansen test, named after Soren Johansen, is a procedure for testing cointegration of several, say *k*, I(1) time series. This test permits more than one cointegrating relationship so is more generally applicable than the Engle-Granger test which is based on the Dickey–Fuller (or the augmented) test for unit roots in the residuals from a single (estimated) cointegrating relationship. (*Davidson, 2000). Specifying Vector Error Correction Models, The conventional VECM is written compactly as:*

$$\Delta Y_{\mathrm{t}} = \sigma + \sum_{i=1}^{k-1} y_i \, \Delta Y_{\mathrm{t-i}} + \sum_{j=1}^{k-1} \eta_j \, \Delta X_{\mathrm{t-j}} + \sum_{m=1}^{k-1} \xi_m \, \Delta R_{\mathrm{t}-m} + \lambda ECT_{t-1} + \varepsilon_t \qquad (5)$$

ECT_{t-1}= the lagged OLS residual obtained from the long –run cointegrating equation:

$$\Delta Y_t = \sigma + \eta_j X_t + \xi_m R_t + ?_t \quad (6)$$

…and expressed as: $ECT_{t-1} = [Y_{t-i} - \eta_1 X_{t-1} - \xi_1 R_{t-1} \ldots \ldots]$ the cointegrating equation.

The ECT explains that previous period's deviation from LR equilibrium (which is the error) influences short-run (SR) movement in the dependent variable.
Λ = coefficient of the ECT and the speed of adjustment. It measures the speed at which y returns to equilibrium after changes in X and R

$$ECT_{t-1} = [Y_{t-i} - \eta_1 X_{t-1} - \xi_1 R_{t-1} \ldots \ldots], ECT_{t-1} = (ING_{t-i} - \varphi_2 CO2AG_{t-i} + \varphi_3 CO2MA_{t-i} + \varphi_4 CO2TR_{t-i} + \varphi_5 LAB_{t-i} + \varphi_6 GCF_{t-i} + \varepsilon_t \quad (7)$$

Where inclusive growth ING represents the dependent variables, carbon emission from agricultural sector $CO2AG$, manufacturing sector $CO2MA$ and transport sector $CO2TR$ respectively, are independent variable, while LAB and GCF are the vector of the variables. The null hypothesis of the cointegration is tested.

Results and Discussion

Table 2 presents the summary statistics of the variables. It provides key descriptive statistics for various variables, including mean (average) standard deviation, skewness and kurtosis, and Jarque-Bera statistics. From the table, ING, C02AG, C02MA, C02TR, LF and GCF has a mean value of 3.893, 41.63494, 11.99940, 46.61193, 49.6165 and 35.36438 respectively suggested that, on average, all the variables increased at a rate of their mean value between the periods of study with standard deviation far from the mean, indicating that all the variables were susceptible to change within the period. This susceptibility suggests that there is dispersed variation in the variables over the sampled period. Except ING that is closer to the mean, indicating that ING was less susceptible to change between the periods. This further implies that ING has not really recorded significant growth. The minimum value and the maximum value indicated that there are different levels of growth; some parts experience high economic growth, while others record low levels of growth. Furthermore, the Jacque-Bera statistic of the variables is not normally distributed except for emissions from transportation which is not statistically significant, and it shows that it is normally distributed. C02MA and GCF indicate leptokurtic distributions (Kurtosis value above 3**)** while others show platykurtic distributions (kurtosis values below 3). Skewness values are positive for all variables except emissions from transportation C02TR.

Table 2: Descriptive Statistics

Variable	**ING**	**C02AG**	**C02MA**	**C02TR**	**LF**	**GCF**
Mean	3.893	41.63494	11.99940	46.61193	49.6165	35.36438
Maximum	7.333	68.37863	24.50839	54.46346	79.2900	89.38105
Minimum	1.626	28.90700	4.249597	35.38896	23.8550	14.90391
Std. Dev.	2.104	11.59160	4.621942	4.335446	13.5441	18.51950
Skewness	0.525	0.903275	0.819942	-0.159460	0.0649	1.164652
Kurtosis	1.635	2.596172	3.642216	2.964083	2.0884	4.155129
J-B	5.190	5.996722	5.427903	0.180250	24.9038	12.11163
Obs.	42	42	42	42	42	42

Table 3 displays the correlation matrix coefficients for ecological footprint on inclusive growth in Nigeria. The correlation analysis reveals that the covariate regressors exhibit varying degrees of correlation, as indicated by the coefficients ranging from -0.3043 to 0.8772. Once none of the correlation coefficients reaches 0.90, indicating that there is no presence of multicollinearity among the regressors.

Table 3: Correlation Results among the Key Economic Indicators

	C02AG	**C02MA**	**C02TR**	**ING**	**GCF**	**LAB**
C02AG	1					
C02MA	0.7414	1				
C02TR	-0.3043	-0.2419	1			
ING	0.8772	0.4916	-0.1426	1		
GCF	0.1469	0.1294	-0.0923	-0.0231	1	
LAB	0.0723	-0.0291	0.1085	-0.0597	-0.0440	1

Source: *Author's computation*

Tests of stationarity results

Since time series analyses are usually very sensitive to the degree of stationary of the series, it is essential to test the data for unit root. Given that the Augmented Dickey-Fuller (ADF) unit roots test presented in Table 4 revealed that all the variables (carbon emission from agricultural sector, manufacturing sector and transport sector, labour and gross capital formation) are all non-stationary (has unit roots) at levels; but become stationary after differencing once, which shows their level of stability among other series.

Table 4: Unit root tests result

Augmented Dickey Fuller (ADF)			
Variable	**Level**	**1st Difference**	**Remark**
C02AG	1.9180	-4.7116***	I(1)
C02MA	-0.5428	-6.7272***	I(1)
C02TR	-2.7316	-6.4423***	I(1)
ING	-0.0261	-2.9821**	I(1)
GCF	- 0.8633	- 5.482755***	I(1)
LAB	-0.7680	-4.736003***	I(1)

*** and ** represent significance levels at 1% and 5%, respectively.

Cointegration test results

Table 5 Johansen test of cointegration presents the Trace and Maximum Eigenvalue performed to determine the order of integration; which both indicates that we reject the null hypothesis that none of the variables is cointegrated since p-value 0.0000<0.05, but revealed that there is at most three cointegrating equation or error since p-values is greater than 0.05 for both trace and Max. Eigenvalue i.e the three variables have long run relationship.

Table 5. Test for Johansen Co-integration Using Trace Statistic

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.658670	136.0516	95.75366	0.0000
At most 1 *	0.638776	94.13032	69.81889	0.0002
At most 2 *	0.542672	54.41830	47.85613	0.0107
At most 3	0.236830	23.90646	29.79707	0.2044
At most 4	0.219923	13.36573	15.49471	0.1021
At most 5	0.090034	3.679578	3.841465	0.0551

Trace test indicates 3 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.658670	41.92130	40.07757	0.0307
At most 1 *	0.638776	39.71202	33.87687	0.0090
At most 2 *	0.542672	30.51184	27.58434	0.0204
At most 3	0.236830	10.54072	21.13162	0.6928
At most 4	0.219923	9.686155	14.26460	0.2334
At most 5	0.090034	3.679578	3.841465	0.0551

Max-eigenvalue test indicates 3 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 6 present the results of the normalized cointegration, the signs of the coefficients are reversed in the long-run. Inclusive growth ING is positioned as the dependent variable. Carbon emission from manufacturing sector $CO2MA$ has a negative impact while carbon emission from agricultural sector $CO2AG$, transport sector $CO2TR$ labour LAB and gross capital formation GCF has positive impact on inclusive growth ING on average, *ceteris paribus*. The coefficients are statistically significant at the 1% level except LAB. The null hypothesis of no cointegration is rejected against the alternative of a cointegrating relationship in the model. Once all the variables are cointegrated we can run the Vector Error Correction Model (VECM) (Table 7).

Table 6 Normalized cointegrating coefficients (standard error in parentheses)

LING	LC02MA	LC02AG	LC02TR	LAB	LGCF
1.0000	0.399689 (0.09042)	-1.142566 (0.26726)	-0.912465 (0.26354)	-0.097104 (0.02400)	-0.322145 (0.19479)

Table 7, contains the VECM and its coefficient of one lagged inclusive growth (ING), carbon emission from agricultural sector (C02AG), carbon emission from manufacturing sector (CO2MA), carbon emission from transport sector (CO2TR), labour (LAB) and gross capital formation (GCF) as well as their t-statistic. The cointegrating equation is the error term equation signifying the long run relationship among the variables. Bellow it is short run coefficient, error correction terms and is the adjustment coefficient. The previous period's deviation from long run equilibrium is corrected in the current period as an adjusted speed of 7.7%. A percentage change in LCO2MA is associated with 0.54% increase in ING on average ceteris paribus in the short run, while a percentage change in LC02AG and LCO2TR is associated with 0.25% and 1.68% decrease respectively in ING on average ceteris paribus in the short run while a percentage change in LAB and GCF is associated with 0.26% and 1.15% increase respectively in ING on average ceteris paribus in the short run

Table 7. Vector Error Correction Model

Cointegrating I	CointEq1
LING(-1)	1.000000
LCO2MA(-1)	-0.241585 (0.06825) [-3.53995]
LC02AG(-1)	0.554367 (0.19407) [2.85652]
LCO2TR(-1)	0.193254 (0.21750) [0.88851]
LAB(-1)	-0.020838 (0.01834) [-1.13649]
LGCF(-1)	-1.093278 (0.14323) [-7.63298]
C	-4.270693

Error Correction:	D(LING)	D(LCO2MA)	D(LC02AG)	D(LCO2TR)	D(LAB)	D(LGCF)
CointEq1	0.077180 (0.02642) [2.92118]	0.930654 (0.43949) [2.11760]	0.035475 (0.08969) [0.39555]	-0.097728 (0.13335) [-0.73288]	1.659851 (2.08585) [0.79577]	0.385301 (0.11315) [3.40509]
D(LING(-1))	0.122090 (0.20690) [0.59010]	-2.592275 (3.44155) [-0.75323]	0.058614 (0.70232) [0.08346]	0.318040 (1.04424) [0.30457]	-4.866664 (16.3340) [-0.29795]	0.543386 (0.88609) [0.61324]
D(LCO2MA(-1)	0.005466 (0.01213) [0.45047]	-0.046458 (0.20185) [-0.23016]	-0.012911 (0.04119) [-0.31343]	0.039453 (0.06124) [0.64419]	1.198131 (0.95799) [1.25067]	-0.010009 (0.05197) [-0.19260]
D(LC02AG(-1)	-0.002532 (0.05301) [-0.04777]	0.400819 (0.88175) [0.45457]	0.190665 (0.17994) [1.05961]	-0.076033 (0.26754) [-0.28419]	-3.905482 (4.18487) [-0.93324]	0.052469 (0.22702) [0.23112]
D(LCO2TR(-1)	-0.016813 (0.03886) [-0.43265]	-0.444883 (0.64640) [-0.68825]	-0.076261 (0.13191) [-0.57813]	-0.066818 (0.19613) [-0.34068]	1.017436 (3.06787) [0.33164]	-0.037203 (0.16643) [-0.22354]

D(LAB(-1))	0.002684	-0.018543	-0.002489	-0.006997	-0.247923	0.002087
	(0.00212)	(0.03534)	(0.00721)	(0.01072)	(0.16774)	(0.00910)
	[1.26312]	[-0.52467]	[-0.34514]	[-0.65251]	[-1.47802]	[0.22940]
D(LGCF(-1))	0.011521	0.191046	0.111782	0.041694	0.014577	0.151464
	(0.03545)	(0.58974)	(0.12035)	(0.17894)	(2.79897)	(0.15184)
	[0.32497]	[0.32395]	[0.92883]	[0.23301]	[0.00521]	[0.99752]
C	0.013056	0.042164	0.008884	-0.004487	0.129176	-0.000817
	(0.00413)	(0.06869)	(0.01402)	(0.02084)	(0.32599)	(0.01768)
	[3.16184]	[0.61387]	[0.63382]	[-0.21529]	[0.39626]	[-0.04622]
R-squared	0.447540	0.203250	0.126321	0.100759	0.163881	0.554679
Adj. R-squared	0.326689	0.028961	-0.064797	-0.095949	-0.019021	0.457265
Sum sq. resids	0.008974	2.483014	0.103403	0.228595	55.93112	0.164600
S.E. equation	0.016746	0.278557	0.056845	0.084520	1.322062	0.071720
F-statistic	3.703243	1.166166	0.660958	0.512226	0.896006	5.694042
Log likelihood	111.2886	-1.169415	62.40239	46.53610	-63.46237	53.10476
Akaike AIC	-5.164432	0.458471	-2.720120	-1.926805	3.573119	-2.255238
Schwarz SC	-4.826656	0.796247	-2.382344	-1.589029	3.910894	-1.917462
Mean dependent	0.014963	0.012144	0.013175	-0.000310	0.012375	0.008506
S.D. dependent	0.020408	0.282681	0.055088	0.080735	1.309665	0.097352

Note: Standard errors in ( ) & t-statistics in [ ]

Diagnostic Tests

This section concluded with the presentation and discussion of the results of the post-estimation (diagnostic) tests. It is important to test the results of the adopted models for validity. Only then can the results be said to be reliable and suitable for policy recommendations and implementations. Based on the probabilities of these tests, Table 8 shows that the null hypotheses of these tests are rejected. For autocorrelation and heteroskedasticity tests, the rejection of their null hypotheses of no autocorrelation in the errors and homoscedastic error variances respectively implies that the residuals are serially uncorrelated, and their variances are all equal. With the null hypothesis of the linearity test being that the model is not correctly (linearly) specified, the rejection of the hypothesis clearly demonstrates that the models have the right functional forms. Finally, the null hypothesis of non-normal distribution of the residuals is also resoundingly rejected. In general, the satisfactory reports obtained from the diagnostic tests provide the confidence that the model estimates are true, and can be relied on for suitable policy actions.

Table 8: Diagnostic Tests Results

	Chi	Probability
Autocorrelation	0.8558	0.4392
Heteroskedasticity	0.1984	0.6587
Linearity	4.6232	0.0428
Normality	1.7950	0.4075

Discussion of results

The study examined inclusive growth and macroeconomic variables in Nigeria. A models was instituted to achieve the study objectives as macroeconomics variable of ecological footprint, independently regress against inclusive growth. The model was to look at the impact of ecological footprint on inclusive growth in Nigeria, the result shows that, there is a positive influence of ecological footprint on inclusive growth in Nigeria. This result shows that the impact of ecological footprint on inclusive growth is positive and rising. Showing that at initial level of growth, rising income leads to increase in environmental pollution but as income continues to increase a threshold will be attained when rising income will bring about decrease in the environmental pollution. This depicts an inverted U-shaped curve implying that the economy is growing out of pollution. This shows that increase in wealth makes the nation more technologically advanced and use sophisticated tools to make emissions have a positive effect on the economy by reducing the rate of emissions. The emissions from agriculture are curbed by using advanced agricultural mechanisms for agricultural practices which helps to improve the productivity of the nation. Results from Asongu et al. (2017) broadly show that ICT can be employed to dampen the potentially negative effect of environmental pollution on economic growth. Egbetokun et al. (2019) also indicate that there is EKC for carbon dioxide (C02) and Suspended Particulate Maters (SPM). This implies that the green growth objective can be pursued in Nigeria with concerted efforts. This concludes that the ecological footprint can serve as a positive influence for inclusive growth if its negative effects can be reduced.

Conclusion and Recommendations

In recent times, the Nigerian economy has been recognised as one of the fastest-growing economies in Africa and the world, in terms of having a nominal Gross Domestic Product (GDP) of about US$568 billion and an average annual growth rate of 6.2% (World Development Indicator, 2015). However, despite this apparent economic strength and growth, the benefits have not been widely shared among the population. In lieu of this, the study examines inclusive growth, and ecological footprint in Nigeria. Hence, it is concluded that there is long run relationship that exist among the variables. The null hypothesis of no cointegration is rejected against the alternative of a cointegrating relationship in the model. Once all the variables are cointegrated, VECM was estimated.

The study test for the statistical significant of the data using VECM, the result shows that the Carbon emission from manufacturing sector $CO2MA$ has a negative impact while carbon emission from agricultural sector $CO2AG$, transport sector $CO2TR$ labour LAB and gross capital formation GCF has positive impact on inclusive growth ING on average, *ceteris paribus*. The coefficients are statistically significant at the 1% level except LAB at 5%. To test the validity of the study also, the post estimation test shows that the variables are free from all form of error. The study found out that increase in ecological footprint as a result of decrease in agricultural, manufacturing and transportation emission leads to increase in inclusive growth. Based on these findings, the study strongly recommends that there should be policies to regulate the use of improved technologies that reduce the level of emission in production and discharge of wastes should be enforced in the extractive industries. The government of Nigeria should enforce stricter environmental regulations in the main polluting sectors, as well as, periodic environmental impact assessment aimed at erring firms or organizations and they should also bear the full cost of environmental clean-up. This is in support of the work Omoke et al. (2020) Sijuwola and Fadogba (2023) noted that increased ecological footprint went along with the GDP growth, implying resource-based expansion.

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