Open Access
Volume 02, Issue 06 - 2026

INSR Journal of Multidisciplinary Studies (INSRJMS)
e-ISSN: 3143-0791
Journal homepage: https://insrpublisher.com/insrjms/

Research Article

DOI: 10.5281/zenodo.20792860

Health Effect of Pollution: Focus on Plastic and Greenhouse Gas Emission in Nigeria

*Simon Ajayi Olukotun, PhD

Department of Urban and Regional Planning Lead City University Ibadan, Nigeria.

Submission Date: 28 April 2026 **Published Date:** 22 June 2026

Citation: Olukotun, S. A. (2026). Health Effect of Pollution: Focus on Plastic and Greenhouse Gas Emission in Nigeria. In INSR Journal of Multidisciplinary Studies (Vol. 2, Number 6, pp. 18–25). https://doi.org/10.5281/zenodo.20792860

Abstract

This study examined the impact of plastic pollution and greenhouse gas emissions on human development index (HDI) in Nigeria. Environmental pollution, particularly from plastic waste and greenhouse gases, poses significant threats to public health, yet limited research has focused on how these pollutants jointly affect human welfare outcomes such as health, education, and income. The study employed annual time series data from 1990 to 2025 sourced from the World Bank, the Emission Database for Global Atmospheric Research (EDGAR), and MDPI. The autoregressive distributed lag (ARDL) bounds testing approach was applied to accommodate the mixed order of integration among the variables, with the Augmented Dickey-Fuller test revealing that HDI and plastic leakage were stationary at first difference I(1), while greenhouse gas emissions were stationary at level I(0). The bounds test confirmed a long-run equilibrium relationship among the three variables at the 1% significance level. The parsimonious ARDL error correction model results showed that in the short run, lagged HDI exerted a positive significant effect, while greenhouse gas emissions and lagged plastic leakage exerted negative significant effects on HDI. In the long run, both greenhouse gas emissions and plastic leakage were negative and statistically significant determinants of HDI, with plastic leakage having a substantially larger detrimental impact. The error correction term of -0.387 indicated that approximately 38.7% of deviations from long-run equilibrium are corrected within one period. The study concludes that plastic pollution and greenhouse gas emissions significantly reduce human development in Nigeria, and recommends strengthening recycling infrastructure, enforcing existing environmental laws, and adopting long-term pollution reduction strategies.

Keywords: *Environmental pollution, human development index, Greenhouse gas emission, plastic pollution.*

1.0 INTRODUCTION

Environmental pollution encompassing air, water, land, and waste generation are major problems in Nigeria. Plastic in Nigeria presents a complex duality. It has emerged as a pivotal component across diverse sector such as essential packaging and convenience, economic driver infrastructure innovation, construction industry, transportation and agriculture significantly contributing to the advancement of modern society (Vasopoulos et al., 2023). Plastic unique attributes, including versatility in production, durability, resistance light weight nature, cost effectiveness and transparency have led to large growth in global plastic consumption since their market inception (Ali et al., 2023).

Nigeria is the only country in west Africa that modules plastic resin, the country is said to have produced 486kt of resin in 2018 and 498kt in 2019 (WACA, 2024). The rapidly increased production of disposable plastic production overwhelms the word ability to deal with them (UNIDO, 2021; SMEP, 2024) Nigeria is ranked 9th globally for pollution of waterway and the seas with over 200,000 tons of plastic waste entering Atlantic Ocean annually (Earth org, 2021). Presently there are different sizes of plastic pollution found in the soil water and air ranging from nano plastic to micro plastic, nano plastic has been observed in the air and could protend significant danger for human and animal where they are breathed (morales, 2022; SMEP, 2024). The burning of plastic waste is a common hazardious disposal method in many Nigeria cities releasing toxic fumes (dioxins) that contribute to respiratory problems, cancer and damage the nervous system (Halden Ru, 2010; Theresa-Onaji Bension et al., 2023).

Plastic pollution is a global problem every year 19-23 million tonnes of plastic waste leaks into aquatic ecosystem polluting lakes, river and seas (UNEP, 2024).

Nigeria currently generates 32 million tons of waste per annum thus accounting for the bulk of the waste generated in Africa (PHC, 2021). Nigeria generates 2.5 million tons of plastic annually and only 10-12% is recycle and the remaining is formed in the land fill river and ocean as pollutant (MDPI, 2025; Babayemi et al., 2018; Obiezu, 2019)

It is increasingly evident especially in recent years that the effect of emission released from global energy production and which is accounted for approximately 76% of the GHG emission is considered to be one of the most air pollutants producing a variety of health effect especially towards the human respiratory system, central nervous system and immune system (Tran et al, 2023). The result of many scientific studies shows that human activities have contributed to the increase in the atmosphere (IPCC, 2021). These contributions include consumption of fossil fuel, deforestation, urban and industrial expansion, over grazing folder increase chemical use in farming, waste burning among others (Aba et al, 2017, IPCC 2021, WMO 2013).

These GHG emission result from a combination of inadequate waste collection, uncontrolled dumping and burning of waste which are the same activates behind plastic leakage (Kaza et al., 2018) carbon dioxide and methane are released into the air when plastic waste which were landfilled finally decomposed. This is released into the atmosphere during the burning of refuse and plastic products thereby trapping radiant heat and cause global warming (Chaildegara et al., 2015) open burning of refuse and plastic products release and plastic product release pollutant such as dioxins, PCBS, and furans which when inhaled can cause health risk specially respiration disorder (Halmlet et al., 2018). Global commitment to GHG reduction is climate change mitigation as evidence in the United Nation sustainable goals (SDGs) which deals with climate change mitigation and natural resources protection. The Paris accord signed in 2016 agreeing to mitigate climate change through lower GHG emission and national level adaptation plans (Castro & Kuntz, 2022).

However, progress towards these goals to date has been limited and emission persist at unmitigated rate (Castro & Kuntz, 2022).

Another landmark development was the endorsement of a resolution for a global treaty on plastic during the 5th United Nation environment Assembly (UNEA - 5) in nairobe Kenya in 2022. The resolution specifically targeted curtailing plastic pollution across marine and terrestrial environment (UNEP, 2022). This development produced a pathway for a global freaty frame work that addresses particle's is life cycle from production to disposal. This resonates with the SDGs by promoting responsible resources utilization while advocating for circular economy practices such as recycling and re-use (Deeney et al., 2023) Other effort by the United Nation include: the givo project in Nigeria, the Ghana clean-up project , the Chinhoyi project in Zimbabwe and the flip flopi project in Kenya (UNep, 2021) the constitution of Nigeria (1999) the national legal order recognize section 20 about the importance of protecting and improving the environment and safe guarding the water, airland, forest and wildlife of Nigeria. Likewise, the state and state ministry of environmental. In addition to policy and regulatory frame work on waste management in Nigeria the federal government of Nigeria promotes sustainable use of plastic as a resource through its life cycle management. It is committed to circular economy in the management of plastic waste. In this regards the Nigeria federal executive council approved the 2018 national policy on solid waste management on 15th July 2020(UNIPO, 2021). This is the most current and comprehensive effort to promote the sustainable use of plastic through life cycle management (UNIPO, 2021).

The national environmental standard and regulations enforcement agency (NESREA) Act (FGN, 2007), empowered the agency to be responsible for enforcing all environmental laws, Guidelines, policies, standard and regulation in Nigeria.

The authority has registered several operators in the extended producer responsibility (EPR) programme including producers' responsibility organization (PROS) recycler and collector with overall objective of the ensuring a decrease in total negative environmental Impact from the product including its packaging (UNIPO, 2021).

1.2 Aim & Objective

Therefore, this research work aimed to examine the impact of plastic pollution and greenhouse gas (TEM) on (HDI) in Nigeria. The study adopted secondary data. The study employed annual time series data between (1990-2025) sourced from the global economy.com. for Nigeria HDI, Emission database for global at atmospheric research (EDGAR) (GHG) and MDPI, (2025) for plastic pollution.

1.3 Hypothesis of the study

The following hypothesis was tested

- Plastic pollution and greenhouse gas (TEM) Emission have no significant impact on Human development index (HDI) in Nigeria
- Plastic pollution and (TEM) Emission have significante impact on HDI in Nigeria.

1.4 Justification for the study

UNDP (United nation development program) indicates that despite economic growth potential of Nigeria the metric for citizen remains how for instance, HDI for 2024/2025 is estimated at 0.548 placing the country in the low human development categories and ranking it around 161st - 164th out of 193 nations. This index and ranking highlight significant challenge in health. Hence, this research chosed HDI instead of economic development (GDP) which most of the existing research studies focused. The HDI is an indicator of a country welfare. Also, most existing studies focused on one types of pollution source however this study focuses on plastic pollution and Greenhouse gas (TEM) emission due to their tightly associated effect and linkage to each other as well as how each variable has direct and indirect influence on life expectancy, gross national income and education which are the components of HDI.

2.0 METHODOLOGY

2.1. The study Area

The study area is Nigeria, located in the west African continent with a land area of 923,768. It is made up of 36 states including the federal capital territory (figure 2.1) and has an estimated population of 211.4 million (UNFPA, 2021) map of Nigeria.

Map of Nigeria

2.2 Research Design

Quantitative Research design was adopted for the study. This is because according to Queiros et al., 2017 the quantitative approach is typically more objective-minded, expansive and dependable in predicting cause and effect. Since our research is intended to study the causal linkage between level of pollution and degree of human welfare it is necessary and crucial to use measured number-based data. This involves examination and analysis of selected numeric data (HDI, TEM, & plastic). Time series data (1990-2025) were acquired and use for the study the data on dependent variable (HDI) was sourced from united nation report, the first independent variable plastic pollution was sourced from MDPI and the second independent variable was sourced from world bank. The study seeks to explore and examine the impact of pollution (plastic and Greenhouse gas emission) on human development index (HDI) in Nigeria over a period of 1990-2025.

2.3 Model Specification

In line with the topic of this research human development index (HDI) is used to represent health outcomes which represent dependent variable the rationale for choosing this variable is because it affects other variables (Gross National & Education) the TEM and plastic represent independent variable.

The model is as shown below

= health outcomes

= intercept of the model

+ slopes of the independent variable

= greenhouse gas emission

= plastic (Leakage)
= error term

2.4 Technique of Analysis

The research design employed for the analysis is the ordinary least square method. Multiple regression technique is used in determining the effect of pollution on human development index in Nigeria. The study employed the use of econometric view computer software for the estimation of the model's parameter. Autoregressive distributed lag (ARDL) was used because it allows researchers to examine both the short-run dynamics and long-run relationships between variables simultaneously within a single equation.

3.0 ANALYSIS

This section presents the analysis conducted using descriptive statistics, trend analysis, correlation analysis as well as regression analysis on the impact of plastic pollution (Plastic) and greenhouse emission (TEM) on the human development index (HDI) in Nigeria. The results are presented below in tables and charts.

Table 3.1: Descriptive Statistics

	HDI	TEM	plastic
Mean	0.491000	337.4061	1324648
Median	0.482000	337.2634	1338411.
Maximum	0.567000	417.0406	2177861.
Minimum	0.438000	260.8156	534000.0
Std. Dev.	0.042330	31.93671	468827.9
Skewness	0.252155	-0.087162	0.151181
Kurtosis	1.672109	3.458419	2.300135
Jarque-Bera	3.026437	0.360806	0.871852
Probability	0.220200	0.834934	0.646666
Observations	36	36	36

Source: Own Computation from Eviews 12

Where is health outcomes, is greenhouse gas emission (Total greenhouse gas emissions excluding LULUCF (Mt CO2e)) & is plastic not recycle (leakage)

Table 3.1 summarizes descriptive statistics for three variables—Health Outcomes (HDI), Greenhouse Gas Emissions (TEM), and Plastic Not Recycled (plastic leakage). The mean HDI value is 0.491, with a median of 0.482. The fact that the mean exceeds the median suggests a mild positive skew, indicating that while most observations cluster around the medium human development in Nigeria exhibit somewhat higher health outcome values. This is supported by a skewness statistic of 0.255. The HDI values range from a minimum of 0.438 to a maximum of 0.567, with a relatively low standard deviation of 0.042, implying that the sample countries are quite homogeneous in terms of health outcomes, all falling within a narrow band of medium human development. The kurtosis for HDI is 1.672, which is less than 3, indicating a platykurtic (flatter than normal) distribution. However, the Jarque-Bera statistic of 3.026 with a probability of 0.220 fails to reject the null hypothesis of normality at conventional significance levels, suggesting HDI is normally distributed overall.

Turning to greenhouse gas emissions, measured as total emissions excluding LULUCF in Mt CO2e, the mean is 337.41 and the median is 337.26. These nearly identical values point to a symmetric distribution, which is confirmed by a skewness of -0.087—effectively zero. The emissions range from a low of 260.82 to a high of 417.04 Mt CO2e, with a standard deviation of 31.94, indicating moderate variability around the mean. The kurtosis of 3.458 is very close to the normal distribution value of 3, suggesting a mesokurtic shape. The Jarque-Bera statistic is only 0.361 with a high probability of 0.835, strongly confirming that TEM follows a normal distribution. In practical terms, this means the sample countries display a typical, bell-shaped spread of emission levels without significant outliers or extreme skewness.

Regarding plastic not recycled, labeled as plastic leakage, the mean is approximately 1,324,648 units (likely tonnes or kilograms, though unspecified) while the median is slightly higher at 1,338,411. This pattern—median exceeding the mean—is unusual and suggests a very mild negative skew, yet the calculated skewness is actually positive at 0.151. This small discrepancy implies the distribution is very close to symmetric, with perhaps a slight elongation toward higher leakage values. The range is substantial, from a minimum of 534,000 to a maximum of 2,177,861, with a standard deviation of 468,828. Relative to the mean, this represents a coefficient of variation around 35%, indicating moderate spread. The kurtosis of 2.300 is below 3, pointing to a somewhat flatter, platykurtic distribution. Crucially, the Jarque-Bera statistic of 0.872 with a probability of 0.647 confirms that plastic leakage also follows a normal distribution. Overall, all three variables meet the normality assumption, making them suitable for parametric statistical tests and linear regression modeling. The sample of 36 observations appears well-behaved, with HDI showing the narrowest relative variation and plastic leakage showing the widest absolute spread.

Table 3.2: Correlation Analysis

	HDI	TEM	plastic
HDI	1		
TEM	0.082	1	
PLASTIC	0.911	0.149	1

Source: Own Computation from Eviews 12

Where is health outcomes, is greenhouse gas emission & is plastic not recycle (leakage)

Table 3.2 presents pairwise correlation coefficients among the three variables. Beginning with the relationship between HDI and TEM, the correlation coefficient is 0.082. Turning to the relationship between HDI and plastic leakage, the correlation coefficient is remarkably high at 0.911. This represents a very strong positive linear relationship, meaning that countries with higher health outcomes tend to have substantially higher levels of plastic that is not recycled, or leakage into the environment. Given that HDI is typically associated with better infrastructure and waste management systems, this positive correlation may seem counterintuitive. However, it could reflect that higher consumption levels associated with better human development also generate more plastic waste, and if recycling infrastructure has not kept pace, absolute leakage volumes remain high. Alternatively, the specific measurement of plastic as total leakage rather than leakage per capita might be driving this relationship, as more populous or more consumption-intensive economies would show up on both higher HDI and higher absolute plastic leakage. Finally, the correlation between TEM and plastic leakage is 0.149. This is a weak positive correlation, indicating little to no linear relationship between greenhouse gas emissions and unrecycled plastic. While both variables relate to environmental degradation, they appear to capture different dimensions of environmental pressure. Emissions are dominated by energy and industrial processes, whereas plastic leakage is a function of waste management systems, consumption patterns, and disposal infrastructure. The weak correlation suggests that reducing emissions does not necessarily go hand in hand with reducing plastic leakage, and policies addressing one environmental problem may not automatically address the other.

Table 3.3: VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-560.546	NA	5.00e+10	33.150	33.284	33.196
1	-489.456	125.454*	1.30e+09*	29.497*	30.036*	29.681*
2	-482.300	11.365	1.47e+09	29.606	30.549	29.927
* Indicates lag order selected by the criterion						
LR: sequential modified LR test statistic (each test at 5% level)						
FPE: Final prediction error AIC: Akaike information criterion SC: Schwarz information criterion HQ: Hannan-Quinn information criterion						

Source: Own Computation from Eviews 12

Table 3.3 present VAR lag order selection criteria. The Schwarz Information Criterion selects lag order 1 for the vector autoregression model. This is indicated by the asterisk next to the SC value at lag 1, which is 30.036. This value is smaller than the SC values at lag 0 (33.284) and at lag 2 (30.549). Since the SC, also known as the Bayesian Information Criterion (BIC), is a consistent criterion that penalizes additional parameters more heavily than other criteria such as the Akaike Information Criterion (AIC), its preference for lag 1 carries significant weight, especially with a limited sample of 36 observations as noted in the descriptive statistics. It is worth observing that all five criteria—the sequential modified Likelihood Ratio (LR) test, Final Prediction Error (FPE), AIC, SC, and Hannan-Quinn (HQ)—uniformly select lag 1 as the optimal lag length. This unanimous selection provides strong evidence that a VAR(1) model is appropriate for the Nigerian data. While the AIC sometimes tends to select higher lags to maximize fit, here even the AIC selects lag 1 with a value of 29.497, compared to 29.606 at lag 2. The LR test statistic of 125.454 at lag 1 further confirms that adding the first lag significantly improves the model compared to lag 0, whereas the subsequent LR statistic of only 11.365 at lag 2 indicates that adding a second lag does not provide a statistically significant improvement in explanatory power.

Table 4.4: Unit Root Test Result using Augmented Dickey Fuller (ADF)

Variable	Level		First Difference		Status
	ADF Critical Value	t*	ADF Critical Value	t*	
HDI	-0.144	-3.633	-6.678	-3.646***	I(1)
TEM	-3.043	-2.948**			I(0)
plastic	-1.723	-3.633	-4.089	-3.639***	I(1)
*** p<0.01, ** p<0.05, * p<0.1					

Source: Own Computation from Eviews 12

Where is health outcomes, is greenhouse gas emission & is plastic not recycle (leakage)

Table 4.4 reports the unit root test results for each of the three variables—Health Outcomes (HDI), Greenhouse Gas Emissions (TEM), and Plastic Not Recycled (plastic leakage)—at both level and first difference. The ADF test examines the null hypothesis that a variable contains a unit root, meaning it is non-stationary. Rejecting the null at a given significance level indicates that the variable is stationary. The critical values and the computed t-star statistics are provided for each test, with asterisks denoting statistical significance at the 1%, 5%, and 10% levels. The three variables exhibit mixed orders of integration. TEM is stationary at level, or I(0), while both HDI and plastic leakage are stationary only after first differencing, or I(1). This mixed result has important implications for subsequent econometric modeling. Autoregressive distributed lag (ARDL) model will be used.

Table 4.5: Bound Test

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	5.390	10%	2.63	3.35
k	2	5%	3.1	3.87
		2.5%	3.55	4.38
		1%	4.13	5
*** p<0.01, ** p<0.05, * p<0.1				

Source: Own Computation from Eviews 12

Where is health outcomes, is greenhouse gas emission & is plastic not recycle (leakage)

The bounds test in Table 4.5, conducted within an autoregressive distributed lag (ARDL) framework, is specifically designed to examine the presence of a long-run levels relationship, or cointegration, among variables regardless of whether they are purely I(0), purely I(1), or mutually integrated. The null hypothesis states that there is no levels relationship, meaning no long-run equilibrium relationship exists among the three variables. The test statistic is an F-statistic, reported here as 5.390, with k equal to 2, indicating that two variables are treated as long-run forcing variables in the model. The computed *F*-statistic of 5.390 exceeds the upper bound I(1) critical value at every significance level reported. Specifically, at the 1% level, 5.390 is greater than 5.00; at the 2.5% level, it exceeds 4.38; at the 5% level, it exceeds 3.87; and at the 10% level, it exceeds 3.35. This pattern holds across all thresholds. Therefore, the null hypothesis of no levels relationship is rejected at the 1% significance level, as indicated by the triple asterisks.

Table 4.6: Parsimonious Short-Run and Long-Run ARDL-ECM Results

Dependent Variable: HDI		
Bounds Level	**Short-Run**	**Long-Run**
HDI(-1)	0.613 [0.000]***	
TEM	-0.0000017 [0.053]*	-0.0000721 [0.055]*
Plastic	0.0000000217 [0.857]	-0.00000083 [0.000]***
Plastic(-1)	-0.000000036 [0.031]**	
C		0.405 [0.000]***
CointEq(-1)	-0.387 [0.000]***	
R-Square	0.951	
Adjusted R-Square	0.944	
Durbin-Watson Stat	1.948	
Akaike info criterion (AIC)	-6.263	
Schwarz criterion (SIC)	-6.041	
Serial Correlation Test	0.0461 [0.831]	
Normality Test	28.104 [0.524]	
Heteroskedasticity Test	0.621 [0.651]	
Ramsey RESET Test	0.167 [0.686]	
*** p<0.01, ** p<0.05, * p<0.1		

Source: Own Computation from Eviews 12

Where is health outcomes, is greenhouse gas emission & is plastic not recycle (leakage)

Table 4.6 present the parsimonious short-run and long-run ARDL-ECM results. The short-run result revealed that lagged of human development index, greenhouse gas emission and lagged of plastic not recycle are statistically significant in determining human development index in Nigeria but human development index exerts a positive significant effect on human development index in Nigeria while greenhouse gas emission and lagged of plastic not recycle exerts a negative significant effect on human development index in Nigeria. The coefficient on lagged human development index is 0.613

and is statistically significant at the 1% level ($p<0.01$). This positive coefficient means that a percentage increase in HDI in the previous period leads to an increase of 0.613% in current HDI, holding other factors constant. In economic terms, this indicates a strong persistence or inertia in health outcomes in Nigeria. Improvements in human development tend to carry forward into subsequent periods, suggesting that past investments in health, education, or income support continue to yield benefits in the present. The short-run coefficient on contemporaneous greenhouse gas emission is -0.0000017, significant at the 10% level ($p<0.10$). This very small negative coefficient indicates that, in the short run, a percentage increase in emissions (measured in Mt CO_2e) is associated with a reduction in HDI of 0.0000017%. The negative sign, however, carries an important qualitative meaning: even in the short term, higher greenhouse gas emissions are associated with marginally worse health outcomes, possibly through immediate effects such as worsened air quality, heat stress, or disruption to health service delivery. Also, the lagged value of plastic not recycled is -0.000000036, significant at the 5% level ($p<0.05$). This negative coefficient means that a percentage increase in plastic leakage in the previous period reduces current HDI by 0.000000036%. The negative sign implies that unrecycled plastic does not affect health outcomes immediately but rather with a one-period lag, consistent with environmental degradation processes such as water contamination, microplastic ingestion, or blockages of drainage systems leading to waterborne diseases that manifest over time. The lag structure suggests that proper waste management today has delayed but real benefits for human development in the subsequent period.

The long-run analysis revealed that both greenhouse gas emission and plastic not recycle are statistically significant in determining human development index in Nigeria with negative significant effect. The coefficient on greenhouse gas emission is -0.0000721, significant at the 10% level ($p<0.10$). This long-run coefficient is substantially larger in absolute magnitude than its short-run counterpart by a factor of approximately 42. In the long run, a percentage increase in emissions reduces HDI by 0.0000721%. Equivalently, a 100 Mt CO_2e increase in sustained emissions would reduce HDI by 0.00721 points. While still small in absolute terms, the effect is much more pronounced than in the short run. This reveals that the cumulative health damage from greenhouse gas emissions compounds over time. In economic terms, Nigeria faces a long-run trade-off: economic activities that drive up emissions may temporarily boost certain development indicators, but the persistent degradation of environmental quality eventually erodes health outcomes. The negative sign and larger magnitude suggest that ignoring emission reductions leads to a gradual but accelerating decline in human development. The long-run coefficient on plastic not recycled (plastic) is -0.00000083, significant at the 1% level ($p<0.01$). This coefficient is approximately 23 times larger in absolute magnitude than the short-run lagged coefficient (-0.000000036). The negative sign is economically intuitive: plastic leakage contaminates water sources, pollutes agricultural land, harms aquatic ecosystems that support food security, and creates breeding grounds for disease vectors. Over the long run, these effects accumulate and seriously degrade population health outcomes. The high statistical significance at the 1% level reinforces that plastic waste management is not a minor environmental issue but a central determinant of long-term human development in Nigeria.

The error correction term, CointEq(-1), is -0.387 and significant at the 1% level. This negative coefficient confirms that the system corrects disequilibrium: approximately 38.7% of any deviation from the long-run equilibrium is corrected within one period. The high adjusted R-squared of 0.944 indicates that the model explains 94.4% of the variation in HDI. All diagnostic tests are satisfactory: the Durbin-Watson statistic of 1.948 shows no serious autocorrelation, the serial correlation test yields a p-value of 0.831, the normality test yields 0.524, heteroskedasticity yields 0.651, and the Ramsey RESET test yields 0.686, all failing to reject the null hypotheses of no misspecification. The model is therefore well-specified and reliable for policy inference.

4.0 CONCLUSION AND RECOMMENDATIONS

This study examined the impact of plastic pollution and greenhouse gas emissions on the human development index in Nigeria using an autoregressive distributed lag model from 1990 to 2025. The short-run result revealed that lagged of human development index, greenhouse gas emission and lagged of plastic not recycle are statistically significant in determining human development index in Nigeria but human development index exerts a positive significant effect on human development index in Nigeria while greenhouse gas emission and lagged of plastic not recycle exerts a negative significant effect on human development index in Nigeria. Also, the long-run analysis revealed that both greenhouse gas emission and plastic not recycle are statistically significant in determining human development index in Nigeria with negative significant effect.

Based on the findings of the study, the recommendations are presented as:

- **Strengthen plastic recycling infrastructure:** Given that Nigeria currently recycles only 10–12% of its plastic waste, the government should invest significantly in expanding recycling facilities and collection systems to reduce the volume of plastic leakage into the environment.
- **Enforce existing environmental laws and regulations:** The National Environmental Standards and Regulations Enforcement Agency (NESREA) should be fully empowered and adequately funded to enforce all environmental laws, guidelines, policies, and standards, including the Extended Producer Responsibility (EPR) programme.
- **Scale up the Extended Producer Responsibility programme:** The government should register and support

more Producer Responsibility Organizations (PROs), recyclers, and collectors to ensure a measurable decrease in the total negative environmental impact from plastic products and their packaging.

- **Ban or restrict open burning of waste:** Given that open burning of plastic waste releases toxic fumes including dioxins, furans, and PCBs that cause respiratory disorders and other health problems, local and state governments should enforce strict bans on open burning and provide alternative waste disposal methods.
- **Integrate pollution reduction into human development planning:** Since both greenhouse gas emissions and plastic leakage negatively affect HDI in the long run, Nigeria's human development strategies should explicitly incorporate environmental pollution targets rather than focusing solely on health, education, and income.
- **Promote circular economy practices:** The federal government should accelerate the transition to a circular economy by incentivizing reuse, repair, and recycling over single-use plastics, as advocated in the 2018 National Policy on Solid Waste Management approved in July 2020.

Reference

1. Aba, S. C., Ndukwe, S. O., Amu, C. J., & Blayeri, K.-P. (2017). The role of trees and plantation agriculture in mitigating global climate change. *African Scholarly Science Trust, 17*(4). https://doi.org/10.18697/alfand.80.15500
2. Acheampong, A. O. (2018). Economic growth, CO_2 emissions and energy consumption: What causes what and where? *Energy Economics, 74*, 677–692.
3. Babayemi, O. J., Ogundiran, M. B., Weber, R., & Osibanjo, O. (2018). Initial inventory of plastic imports in Nigeria: Basis for more sustainable management policies. *Journal of Health and Pollution, 8*(38), 1–7.
4. Borrelle, S. B., Ringma, J., Law, K. L., Monnahan, C. C., Lebreton, L., McGivern, A., Murphy, E., Jambeck, J., Leonard, G. H., Hilleary, M. A., & Eriksen, M. (2020). Predicted growth in plastic waste exceeds efforts to mitigate plastic pollution. *Science, 369*(6510), 1515–1518.
5. Castro, B., & Kuntz, C. (2022). Land tenure insecurity and climate adaptation: Socio-environmental realities in Colombia and implications for integrated environmental rights and participatory policy. In M. B. Holland, Y. J. Masuda, & B. E. Robinson (Eds.), *Land tenure security and sustainable development*.
6. Deeny, M., Greer, R., Yan, X., Dooley, C., Yates, J., Rotla, H. B., & Kadiyala, I. (2023). Human health effects of recycling and reusing food-sector consumer plastics: A systematic review and meta-analysis. *Journal of Cleaner Production, 397*, 136567. https://doi.org/10.1016/j.jclepro.2023.136567
7. Halden, R. U. (2010). Plastics and health risks. *Annual Review of Public Health, 31*, 179–194.
8. Kaza, S., Yao, L., Bhada-Tata, P., & Van Woerden, F. (2018). *What a waste 2.0: A global snapshot of solid waste management to 2050*. World Bank.
9. Lebreton, L., & Andrady, A. (2019). Future scenarios of global plastic waste generation and disposal. *Palgrave Communications, 5*(1), 6.
10. Nathaniel, S., & Khan, S. (2020). The nexus between urbanization, renewable energy, trade, and ecological footprint in ASEAN countries. *Journal of Cleaner Production, 272*, Article 122709.
11. Obiezu, T. (2019). Nigerian recyclers reduce plastic waste by exchanging trash for cash. *Voice of America*. Retrieved from https://www.voanews.com
12. PricewaterhouseCoopers (PwC). (2021). *Nigeria sustainability outlook 2021* (pp. 17–18).
13. SMEP. (2024). *Impacts of plastic pollution on human health: Insights from the SMEP program*.
14. Stern, D. I. (2017). The environmental Kuznets curve after 25 years. *Journal of Bioeconomics, 19*(1), 7–28.
15. Tran, H. M., Tsai, F. J., Lee, Y. L., Chang, J. H., Chang, L. T., Chang, T. T., & Chang, H. C. (2023). The impact of air pollution on respiratory diseases in an era of climate change: A review of the current evidence. *Science of the Total Environment, 898*, 166340. https://doi.org/10.1016/j.scitotenv.2023.166340
16. United Nations Development Programme. (2022). *Human development report 2022*. United Nations Development Programme.
17. United Nations Environment Programme. (2020). *Plastic pollution: Hotspotting and shaping action—Regional results from Eastern and Southern Africa, the Mediterranean, and Southeast Asia*. United Nations Environment Programme.
18. United Nations Environment Programme. (2021). *From pollution to solution: A global assessment of marine litter and plastic pollution*. United Nations Environment Programme.
19. United Nations Environment Programme. (2023). *Plastic pollution*. https://www.unep.org/plastic-pollution
20. United Nations Population Fund. (2021). *World population dashboard: Nigeria*. https://www.unfpa.org/data/world-population-dashboard
21. United Nations Industrial Development Organization. (2021). *Study on the plastic value chain in Nigeria: Sustainable alternative packaging and recycling technologies to reduce plastic leakages to the environment*.
22. West Africa Coastal Areas Program. (2024). *Realizing the circular economy potential of plastics in Nigeria*. West Africa Coastal Areas Program.
23. World Meteorological Organization. (2013). *A WMO information note: A summary of current climate change findings and figures*. World Meteorological Organization.
24. Zafar, M. W., Zaidi, S. A. H., Sinha, A., Gedikli, A., & Hou, F. (2019). The impact of globalization and financial development on environmental degradation. *Environmental Science and Pollution Research, 26*, 33765–33782.