ECONOMIC GROWTH AND ENVIRONMENTAL SUSTAINABILITY IN AFRICA

Jummai Sabo Ogumka
Department of Economics,
Faculty of Social sciences,
Federal University of Lafia
Jummaisabo0084@gmail.com

Freeman Aye-Agele
Department of Economics,
Faculty of Social sciences,
Federal University of Lafia
fayeagele@gmail.com

Salami Abdulganiyu
Department of Economics,
Faculty of Social sciences,
Federal University of Lafia
fayeagele@gmail.com

***Corresponding Author**
Jummai Sabo Ogumka
Department of Economics,
Faculty of Social sciences,
Federal University of Lafia
jummaisabo0084@gmail.com

Abstract

The paper examined the impact of economic growth and environmental sustainability in Africa. The study used secondary annual panel data which span the period 2000 to 2024, the panel data was analyzed with the aid of panel autoregressive distributed lag (P/ARDL) or the Pooled Mean Group (PMG) estimator. The variables employed in the study are environmental performance index (EPI) which is the dependent variable, while gross domestic product per capita (GDPPL), population (POPL), degree of trade openness (DTO), institutional quality index (IQI), labour (L), and capital (K), all serve as the independent variables. The outcome of the findings, revealed that in the long run GDPPL was found to have a positive impact on EPI with a coefficient of 0.0007 and in the short run it exhibited an inverse relationship on EPI, although in both period it was found to be insignificant to EPI, with a p-value of 0.499 and 0.454 respectively. Whereas, in the long run POPL, TDO and K demonstrated a positive impact on EPI, and are all found to be statistically significant. While IQI, and L were found to have a negative impact on EPI in the long run. While in the short run TDO, and IQI exhibited a negative impact and were found to be statistically insignificant to EPI. Furthermore, POPL, L, and K were all having a positive and insignificant effect on EPI in the short run. The paper further put forth the recommendation that government in Africa should prioritize renewable energy adoption and target urban planning, energy efficiency, and governance reforms to amplify long-run benefit while curbing emissions.

Keywords: *GDP per capita, Environmental Sustainability, Pool Mean Group, and Africa.*

1. Introduction

Environmental sustainability has emerged as a critical global imperative in the 21st century, reflects humanity's capacity to maintain ecological balance for present and future generations. The Brundtland Report defines it as development "meeting present needs without compromising future generations" (World Commission on Environment and Development, 2023), encompassing ecosystem integrity, biodiversity conservation, pollution reduction and sustainable resource use. The International Institute for Environment and Development emphasizes integrating economic activity with environmental preservation, social equity and effective governance (Fatima & Carolina, 2017).

Yet unprecedented challenges persist greenhouse gas emissions, ecological degradation and intensifying climate change manifesting in soil decline, deforestation, biodiversity loss and deteriorating air quality (Tenaw & Beyene, 2021). The WHO reports 91% of the global population lives in areas exceeding air quality guidelines (World Health Organization, 2021). Africa faces acute sustainability challenges despite contributing less than 4% of global greenhouse gas emissions. The continent loses 3.9 million hectares of forest annually; biodiversity has declined sharply with the Living Planet Index documenting a 66% average reduction in wildlife populations; and over 600 million Africans lack clean electricity while 900 million depend on biomass and fossil fuels, driving indoor air pollution and premature mortality (Xu & Ding, 2024). Climate change costs Africa $7–15 billion annually, projected to reach $50 billion by 2040 (African Development Bank, 2025). Between 2010 and 2020, Sub-Saharan Africa lost 9.3 million hectares of forest through agricultural expansion and unsustainable logging (Xu & Ding, 2024). Degradation is compounded by water stress, soil erosion, inadequate waste management and pollution from extractive industries, disproportionately affecting vulnerable populations threatening food security, public health and livelihoods. IPCC projections indicate intensifying temperature extremes, altered precipitation, and accelerated desertification (IPCC, 2022).

Economic growth measured by GDP or per capita income reflecting productive capacity and technological advancement (Mohsin, Iqbal, & Iram, 2024) — averaged 4.2% annually in Africa between 2000 and 2019, driven by resource extraction, agriculture, and emerging industrialization (African Development Bank, 2025). However, this growth has coincided with accelerating environmental degradation. Oil-dependent economies like Nigeria and Angola derive 90% of export revenues from petroleum; agricultural expansion drives deforestation and soil degradation. The Environmental Kuznets Curve (EKC) hypothesis posits an inverted U-shaped relationship between income and environmental degradation (Grossman & Krueger, 1995), yet empirical evidence remains mixed, with continued deterioration observed in weak institutional contexts (Kemp-Benedict, 2003; Smulders, 2000).

Critical knowledge gaps persist on the nexus between economic growth and environmental sustainability in Africa’s nations. The World Economic Forum identifies climate change and environmental degradation as leading global risks, with developing regions facing disproportionate impacts (World Economic Forum, 2021), yet research predominantly focuses on developed economies or Asia (Saint Akadiri, Bekun, & Sarkodie, 2019). Africa's rapid population growth, resource abundance, and climate vulnerability create unique dynamics requiring context-specific investigation (Sichigea, Puiu, Circiumaru, & Carstina, 2024). This study examines how economic growth influences environmental sustainability in African countries, incorporating the moderating effects of institutional quality, technological development and policy frameworks. The subsequent sections of this study are structured as follows: section 2 delve into the conceptual clarification, theoretical, and empirical literature. Section 3 details the methodology and data. Section 4 covers data analysis and results presentation, and section 5 covers the conclusion, with policy recommendation.

2. Literature Review

2.1 Conceptual Clarification

2.1.1 Economic Growth

Economic growth entail increase in production of capital goods, technology or human capital and it generally corresponds with a rise in national income. It can be measured in nominal or real terms. Total economic growth is traditionally measured in terms gross national product (GNP) or gross domestic product (GDP) (Qudrat-Ullah, & Nevo, 2021). The increase in aggregate production is generally a clear as increase in national income. Also, increase in incomes is motivated by consumers to buy more which will in turn increase their standard of living. It comprises of physical capital, human capital, labour force and technology (Khan, Yu, Sharif, & Golpîra, 2020). Also, GDP is measured in nominal and real value. Nominal GDP is the dollar value of the goods and services in a time period that rely on the volume of what was produced and prices of what was produced. Real GDP captures only the volume of what was produced (Sichigea, Puiu, Circiumaru, & Carstina, 2024). In the context of this paper economic growth refer the process whereby counties income rise over a period of time, which is measured by aggregate total production of goods and services.

2.1.2 Environmental Sustainability

Environmental sustainability can be defined as long time survival of life on earth for present and future generation. This implies that unstainable practice will make our ecosystem to be fragile biodiversity decrease and the result is dangerous to human environment leading disturbed supply chains, rising cost, pressure on industries that depend on natural environments and increase in scare resources (Aladejare, 2020). The quest for a clean environment that can be preserve for the present and future generation However, environmental sustainability is the cure for investing in clean energy, sustainable agriculture and spherical economy will reduce environmental effect by creating employment, strengthens economics and decrease socio disparities. The quest to achieve sustainability is an investment in long-term robust eco-friendly (Alhassan, Kwakwa & Donkoh, 2022).

2.2 Theoretical Framework

This study is anchored on Environmental Kuznets Curve (EKC**)** by Simon Kuznets in 1955, Kuznet opined that economic development initials lead to deterioration in the ecosystem at a certain stage of economic growth. Although, economic growth is vital for every country but some scholars criticize that there is no prove that economic growth can lead to growth in the environment (Yan, Liu, Xiao, & Wang, 2024).

EKC theory suggests an inverted U-shaped relationship between economic development and environmental degradation, deteriorate in the initial stage of economic development and improve at the later stages (Sahoo, & Goswami, 2024) The connection between GDP and sustainable development relates to prosperity distribution and equity. Often, inadequate economic growth results in socioeconomic disparities which can be incompatible with sustainable development (Lu et al., 2025). EKC posits that countries initially experience environmental degradation during initial stage of industrialization, but environmental sustainability recovers once a certain revenue threshold is reached, as societies can afford advanced cleaner technologies and environmental policy. This theory is linked to economic growth and sustainability good for the environment policy that enrich the environment thought productivity. Consequently, it is linked to Africa counties that suffer from environmental degradation. Additionally, Increase in economic growth lead to production of goods and services. This production has negative consequences on the ecosystem such as pollution, which deplete the environment.

2.3 Empirical Review

The relationship between economic growth and environmental sustainability has received serious attention in the recent years. However, there is a paucity of empirical studies in the context of Africa. In spite of the paucity of empirical studies, this study has reviewed relevant empirical literature within the context of Africa and beyond"

Kelly and Newbot (2025) The study examined the relationship between economic growth and environmental sustainability in Sub-Saharan Africa, analyzing 22 samples. It found that economic growth leads to increased environmental degradation, whereas improved electricity control positively affects the ecological footprint. Additional control variables, such as GDP per capita, population density, trade, and foreign direct investment, also contribute to environmental degradation. The study recommends enhancing energy infrastructure sustainably and implementing eco-friendly policies and resource-efficient industrial development to mitigate ecological imbalances.

Zhang, et al., (2022) Investigated the relationship between economic growth and environmental degradation in Henan province, China, utilizing a Vector Autoregression model and various tests, including Granger causality and cointegration. Findings revealed that GDP growth leads to increased exhaust gas production, while SO2 affects wastewater. Additionally, an increase in industrial solid waste and SO2 correlates with a rise in GDP per capita. The early-stage variance decomposition of GDP per capita indicated that perturbations are largely caused by wastewater, exhaust gas, and SO2.

Aladejare (2020) examined the relationship between energy utilization, economic growth, and environmental sustainability in West Africa using symmetric and asymmetric auto-regression distributive lag and Toda-Yamamoto causality models. The study found a long-run asymmetric relationship between energy utilization and environmental sustainability, concluding that the Environmental Kuznets Curve (EKC) hypothesis has only a partial impact; thus, increased energy utilization does not immediately affect environmental sustainability as suggested by EKC.

Alhassan et al. (2022) investigated the interplay between financial development, economic growth, and environmental sustainability in Ghana. The findings revealed a bi-directional relationship between carbon dioxide emissions and financial development, while a unidirectional link was identified between economic growth and environmental sustainability. Additionally, carbon dioxide emissions have a neutral effect on economic growth, with economic growth exhibiting an inverted U-shaped relationship with emissions, supporting the environmental Kuznets curve hypothesis. The study suggests that robust financial instruments are essential for achieving environmental sustainability.

Raihan et al., (2022) Investigated the role of green energy, globalization, urbanization, and economic growth in environmental sustainability in the U.S. from 1970 to 2022 using Autoregressive Distributed Lag (ARDL). Results indicate that increased economic growth and urbanization lead to a rise in CO2 emissions, while renewable energy can mitigate negative environmental impacts through sustainable performance.

Hassan, (2021) The study on economic growth, natural resources, and ecological footprints in Pakistan utilized the autoregressive distributive lag (ARDL) model for estimations and VECM Granger causality for analysis. Findings indicated that accelerated economic growth increases the ecological footprint, then enhances environmental quality, aligning with the Environmental Kuznets Curve (EKC) hypothesis. Recommendations for policymakers included encouraging consumption pattern changes to mitigate resource depletion and investing in agricultural practices and renewable energy for technological advancement.

Khan, et a., (2020) The study explored green supply chain management in relation to economic growth and environmental impact across 43 countries using panel Generalized Method of Moments (GMM) estimates. It found that logistics operations consume more energy than fossil fuels and that the greenhouse effect adversely affects environmental sustainability and economic growth. Inadequate transportation infrastructure significantly contributes to emissions harming the ecosystem. The study emphasizes the importance of renewable energy and green practices as strategies to mitigate the negative effects of logistics on the environment.

Zhang, et al, (2022) investigate the interaction between Economic Growth and Environmental Sustainability towered Sustainable Development from the period. The study employed a Vector Autoregression Model between the one-way and two-way relationship analysis, Granger Causality Test, impulse response function. The result showed that growth lead to gas production and that of industrial solid waste (SO_2) will enhance wastewater due to perturbation term. The result from the analysis indicated that economic growth will lead to natural depletion of the ecosystem, the Granger Causality test show that GDP lead to development of exhaust gas production. The policy makers should hasten the use of new energy. Also, there should be environmental protection industries that can help mitigate the control of waste production in the ecosystem.

Literature Gap

Most econometric studies on environmental sustainability focus on regions outside Africa, such as China, Europe, South Asia, and the United States, with a few studies on BRICS and SAARC. Within Africa, empirical contributions are rare; notable studies include Alhassan et al. (2022) on Ghana and Aladejare (2020) on West Africa, which primarily address energy use. Kelly and Newbot (2025) analyze sub-Saharan Africa but are limited by a small sample size. No comprehensive study assesses economic growth, institutional quality, population, trade openness, labor, and capital as determinants of environmental sustainability measured by the Environmental Performance Index (EPI) across a broad range of African countries using the PMG estimator in a Panel ARDL framework. The present study broadens the analysis to encompass 2000-2024, addressing post-millennium development dynamics and institutional changes not previously explored. It identifies a gap in long-run and short-run disaggregated analyses using the PMG method among 43 African countries, confirming or disproving the EKC hypothesis, and establishing a nexus between economic growth and environmental sustainability in Africa.

3.3 METHODOLOGY

3.1 Nature and Sources of Data

The study uses annual secondary panel data which span the period 2000 to 2024 covering a period of 24 years. The sample of selected 43 African countries were covered, due to availability of data on these countries. the countries are, Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central Africa, Chad, Comoros, Congo Democratic, Congo republic, Cote d'Ivoire, Egypt, Equatorial Guinea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Libya, Madagascar, Mali, Mauritania, Mauritius, Morocco, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leon, South Africa, Sudan, Tanzania, Togo, Tunisia, Uganda, Zimbabwe. Environmental performance index (biodiversity, habitat and climate change) serves as the dependent variable; Whereas the independent variables such as gross capital formation as proxy for capital, active labour force economic growth is proxy by per-capita gross domestic product, Population, institutional quality (control of corruption, government effectiveness, regulatory quality and rule of law) and trade proxy by openness to trade are all gotten from World bank world development indicator and World Governance Indicator.

3.2 Variables Description, Measurement and Sources.

Table 1.

Variables	Description	Unit of Measurement
Environmental performance Index (EPI)	Environmental performance index refers to the effectiveness of a country in managing its environmental impacts and achieving sustainable goal.	Metric tons and CHA4 emission.
Gross Domestic Product Per Capita (GDPPC)	GDP per capita refers to a country's economic output divided by its total population.	Annual percentage (%)
Population (POPL)	Annual population growth rate refers to the de facto definition of population, which counts all residents regardless of legal status or citizenship.	Annual percentage
Labour (L)	L refers to active labour force of productive age from 15 and older who produce goods and services during a specified period of time.	Annual Percentage
Capita (K)	K refers to capital which is gross fixed capital formation, it includes land improvements (fences, ditches, drains and so on); plants, machinery and equipment purchases and construction of	Annual Percentage

	infrastructural facilities such as roads, plants, railways, and roads.	
Institutional Quality (IQI)	Institutional quality refers to the efficiency, effectiveness and accountability of institutions in a country or organization.	Index
Trade Openness (TDO)	Trade refers to a country's trade relative to its overall economic activity.	Annual Percentage

Source: Authors compilation, 2025

3.3 Model Specification:

In order to examine the impact of economic growth on environment sustainability in Africa, the study adopted the environmental kuznet curve (EKC) because the EKC is a hypothetical relationship between economic growth and environmental degradation, it suggests that as a country economy grows, environmental degradation initially increases, but eventually decreases as the country becomes wealthier. Also, this study adapted the work of Yurttagular and Kutlu (2017) which was similarly build on the (EKC), the study assessed the relationship between GDP per capita income and carbon dioxide emission (CO2). The model is specified in the functional form as:

CO2 = f(GDPPI, POPL, TOP) (1)

Where;

CO2 represent rate carbon dioxide emission, GDPPI denotes gross domestic product per capita, POPL represent population, and TOP represent trade openness.

The model was modified by introducing Environmental performance index as the dependent variable to replace CO2 emission, because EPI looks at the efficiency of a country in managing its environmental impacts and achieving sustainable goal. Also, Labour, capital and Institutional quality were introduced as part of the independent variables, this is because strong institutions ensure effective governance, which enables the implementation of policies and regulations that promote environmental sustainability. This includes enforcing laws, regulating polluting industries, and providing incentives for sustainable practices.

The functional and econometric forms of the modified model are presented in equation (2) and (3.3) respectively:

EPI = f(GDPPC, POPL, TDO, IQI, L, K)

$$EPI = f(GDPPC, POPL, TDO, IQI, L, K) \quad [3.2]$$

$$EPI_{it} = \beta_0 + \beta_1 GDPPC_{it} + \beta_2 POPL_{it} + \beta_3 TDO_{it} + \beta_4 IQI_{it} + \beta_5 L_{it} + B_6 K_{it} + \varepsilon_{it} \dots \dots (3)$$

Where;

EPI represent environmental performance index as the dependent variable, GDPPC represent gross domestic product per capita, POPL denote population, TDO represent trade openness, and IQI represent institutional quality index. L denotes labour, K denotes gross fixed capital formation as capital.

B_0 is the intercept; β_1, β_2, β_3, β_4, β_5, and β_6, are the coefficients of the variables; $\boldsymbol{\varepsilon}$i = error or stochastic term; $_{it}$ represents the time dimension (2000 – 2024).

Apriori Expectation: $\beta1 > 0$, $\beta2 > 0$, $\beta3 > 0$, $\beta4 < 0$, $\beta5 > 0$, & $\beta6 > 0$

Therefore, the panel ARDL model used in this study is presented in equation (4);

$$EPI_{it} = \alpha_0 + \sum_{t=i}^{p}\varphi_1 \Delta EPI_{it} + \sum_{t=i}^{p}{}^{\varphi}{}_2\Delta GDPPC_{it-i} + \sum_{t=i}^{p}{}^{\varphi}{}_3\Delta POPL_{it-i} + \sum_{t=i}^{p}{}^{\varphi}{}_4\Delta TDO_{it-i} + \sum_{t=i}^{p}{}^{\varphi}{}_5\Delta IQI_{it-i} + \sum_{t=i}^{p}{}^{\varphi}{}_6\Delta L_{it-i} + {}^{\varphi}{}_7\, \Delta K_{it-i} + \alpha_1 EPL_{it-i} + \alpha_2 GDPPC_{it-i} + \alpha_3 POPL_{it-i} + \alpha_4 TDO_{it-i} + \alpha_5 IQI_{it-i} + \alpha_6 L_{it-i} + \alpha_7 K_{it-i} + {}^{\varepsilon}{}_t \ldots\ldots\ldots\ldots\ldots(4)$$

Where; EPI, GDPPI, POPL, TDO, IQI, L, K, α_0, ε *and t* have been defined earlier while Δ is change operator. The long-run co-integration will be estimated using Equation (5);

$$EPI_{it} = \alpha_0 + \sum_{t=i}^{p}\varphi_1 \Delta EPI_{it} + \sum_{t=i}^{p}{}^{\varphi}{}_2\Delta GDPPC_{it-i} + \sum_{t=i}^{p}{}^{\varphi}{}_3\Delta POPL_{it-i} + \sum_{t=i}^{p}{}^{\varphi}{}_4\Delta TDO_{it-i} + \sum_{t=i}^{p}{}^{\varphi}{}_5\Delta IQI_{it-i} + \sum_{t=i}^{p}{}^{\varphi}{}_6\Delta L_{it-i} + {}^{\varphi}{}_7\, \Delta K_{it-i} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots(5)$$

The selection of Panel ARDL maximum lag (p q) will be based on the automatic lag length selection. The study will derive the short-run dynamic parameter from Error Correction Model (ECM) estimation, associated with the long-run estimate.

$$EPI_{it} = \alpha_0 + \sum_{t=i}^{p}\varphi_1 \Delta EPI_{it} + \sum_{t=i}^{p}{}^{\varphi}{}_2\Delta GDPPC_{it-i} + \sum_{t=i}^{p}{}^{\varphi}{}_3\Delta POPL_{it-i} + \sum_{t=i}^{p}{}^{\varphi}{}_4\Delta TDO_{it-i} + \sum_{t=i}^{p}{}^{\varphi}{}_5\Delta IQI_{it-i} + \sum_{t=i}^{p}{}^{\varphi}{}_6\Delta L_{it-i} + {}^{\varphi}{}_7\, \Delta K_{it-i} + \delta ECM_{t-1} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots(6)$$

Where;

$\varphi_1 - \varphi_6$ Represents short-run dynamic coefficients converging to long-run equilibrium and δECM_{it-1} represents the speed of adjustment parameter and error correction model originated from the estimated equilibrium relationship.

3.4 PMG Estimation Procedure

Before carrying out the PMG analysis, there are some pre-diagnostic tests that was conducted. This includes; the **Descriptive Statistics Test** which take cognizance of the mean, the minimum, maximum values, Kurtosis, Jaque-Bera, and Skweness. followed by **Correlation Matrix**, after which the **Cross Section Dependence Test** the (CDS) was also conducted to explore whether the variables are cross-sectionally dependent or not. Consequently, the **Panel Unit Root Test** using **CIPS and CD-ADF** was also performed on individual variable to ascertain the order of stationarity. The lag selection will be based on automatic selection, and the **Panel Co-integration Test** for long-run relationship among non-stationary variables using either (Kao, Westerlund or Pedronic) was performed. After the pre-estimation tests, the analysis was accomplished through the **PMG, Dynamic fixed effect.** Subsequently, the **Hausman Test** was carried too.

4.0 Results and Discussion of Findings

Descriptive Statistics

Descriptive statistics enables us to have a glimpse of the nature of the data, by exploring the mean, median, standard deviation, skewness, kurtosis and Jarque-Bera.

Table 2: Descriptive Statistics

	EPI	GDPPL	POPL	TDO	IQI	L	K
Mean	-2.79E-12	1.592174	2.365953	62.12998	1.77E-11	64.19977	20.74638
Median	0.198024	1.919374	2.497022	55.31802	-0.098095	63.83800	20.27835
Maximum	6.916646	91.78137	6.410083	165.0489	7.066705	89.42800	78.00092
Minimum	-3.961895	-49.12786	-2.617432	0.000000	-5.697429	36.18917	-56.26252
Std. Dev.	1.047110	6.072645	0.980383	29.57205	1.894803	11.96802	10.04224
Skewness	2.047957	2.556560	-0.435068	0.747664	0.486689	0.027984	-0.202855
Kurtosis	18.86460	61.15047	5.132190	3.525572	2.865574	2.172528	9.880255
Jarque-Bera	12024.87	152633.0	237.5467	112.5272	43.24789	30.80962	2127.716
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Sum	-3.00E-09	1711.588	2543.399	66789.73	1.90E-08	69014.76	22302.36
Sum Sq. Dev.	1177.576	39605.92	1032.276	939219.4	3855.958	153832.7	108309.3
Observations	1075	1075	1075	1075	1075	1075	1075

Source: Authors Computation using Stata 15.0, 2025.

Table 2 showcase the summary statistics of the effect of economic growth on environmental sustainability in Africa. As presented in the summary statistics table the result established that labour (L) has the highest mean value, with value of 64.1997, this implies that labour practices is focused more in green sectors, eco-tourism, or sustainable agriculture which plays a pivotal role in balancing economic growth with environmental protection. Whereas variable like gross domestic product per capital (GDPPL) has the least mean this suggest that most countries in Africa prioritize economic growth over environmental degradation is not necessarily driven by high consumption patterns as observed in wealthier developed nations, also low GDP per capita indicate that many nations in Africa faces economic challenges, such as limited economic output, poverty, or income inequality. EPI is the only variable seen to exhibit a negative mean -2.791, this implies that overall, the selected

African countries face significant environmental sustainability challenges, such as deforestation, pollution, climate change, or resource depletion.

The higher value of the standard deviation suggested that the data for all the SSA countries included in the panel are strongly dispersed. series such as IQI, and L having kurtosis value less than 3 indicates that they are mesokurtic in nature which indicates that the distribution are more uniform and they have fewer extreme values, while only TDO was seen to be exactly 3 this means that it is platykurtic in nature, this indicates that the series is relatively flat, and showcasing a wider range of trade openness values across African countries. Whereas, GDPPL, EPI, K and POPL exhibited leptokurtic because their values are greater than 3, this high kurtosis values indicates that the distribution has outlier or extreme values.

Table 3: Pairwise Correlation Analysis

Summary	EPI	GDPPL	POPL	TDO	IQI	L	K
EPI	1.0000						
GDPPL	0.0349	1.0000					
POPL	0.2854	0.0119	1.0000				
TDO	0.1098	0.0093	-0.2325	1.0000			
IQI	-0.2159	0.1040	-0.4060	0.2483	1.0000		
L	0.0338	0.0566	0.2204	-0.1319	-0.0228	1.0000	
K	-0.0600	-0.0156	0.2229	0.2680	0.0253	-0.0324	1.0000

Source: Authors Computation using Stata 15.0, 2025.

The table shows the outcome of the correlation matrix, the result demonstrate that the highest correlation coefficient is between IQI and POPL with value of (0.4060), followed by POPL and EPI with value of (0.2854). Although, TDO and GDPPL has the least correlation coefficient of (0.0093). This revealed that there is no possibility of multicollinearity between the panel data set

Table 4 Cross Sectional Dependency Test

Variables	CD-Test	P-Value	CDw+	P-Value
EPI	2.48***	0.000	209.37***	0.000
GDPPL	20.27***	0.000	883.71***	0.000
POPL	17.72***	0.000	1798.76***	0.000
TDO	15.39***	0.000	1556.18***	0.000
IQI	3.66***	0.000	1829.86***	0.000
L	19.69***	0.000	2319.54***	0.000
K	14.88***	0.000	1454.14***	0.000

Note: Null hypotheses states that there is no cross-section dependence or correlation. P-value statistics were considered as test statistics, and ***, **, and * represent 1%, 5%, and 10% significance levels, respectively. *** indicates rejection of the null hypotheses at 1 percent level of significant.
Source: Author's computation using STATA version 15.0, 2025

Table 4 shows the results of the cross-section dependence test. The test established that EPI, GDPPL, POPL, TDO, IQI, L and K have greater positive values with P-values= 0.000, Accordingly, we reject the null hypotheses of no cross-sectional dependence at 1% level of significance. This implies that there is strong presence of cross-sectional dependence among the cross-sectional units. This finding emphasizes the necessity of employing second-generation panel estimators such as CSADF and CIPS, they are specifically designed to account for such dependencies. The result in Table 4 above discloses that common shocks, spatial dependence and degree of integration exist among countries in Africa. It confirms the position that shocks in one country can easily be transmitted to another country within Africa; Thus, African countries are interconnected, and economic or environmental shocks in one country may affect others, Also the shared common factors, such as global economic trends, climate change, or regional policies, affect multiple countries in Africa.

Panel Unit Root Test Result

In agreement with the CSD test, the first-generation panel unit test was considered irrelevant because in spite of the heterogeneity in the African countries, the panel data model shows substantial cross-sectional dependence. When countries in the region are dependent on one another, this implies that the first generation of unit root test fails; henceforth, it is an essential condition to employ the second generation of a unit root. Hence, stationarity properties of the variables are tested with the aid of second-generation panel unit tests using the CADF (Cross-sectionally augmented Dickey-Fuller) and CIPS (Cross-sectionally augmented Im, Pesaran, and Shin) in Table 4.

Table 5: Pesaran CADF and Pesaran CIPS Unit Root Test Results

CADF		**CADF**		**CIPS**	**CIPS**	**Remarks**
Variable	Level	1st Diff	Order of Int	Level	1st Diff	Order of Int
EPI	-4.141 (0.884)	-2.827 (0.000)**	1(1)	-2.013 (-2.11)	-4.644 (-2.11)**	1(1)
GDPPL	-2.402 (0.259)	-3.321 (0.000)**	1(1)	-4.090 (2.11)**	-5.884 (2.11)	1(0)
POPL	-1.772 (1.000)	-2.047 (0.006)**	1(1)	-1.917 (-2.12)	-3.341 (-2.11)**	1(1)
TDO	-2.701 (0.003)**	-3.029 (0.000)	1(0)	-1.891 (-2.11)	-4.777 (-2.12)**	1(1)
IQI	-2.134 (0.893)	-2.721 (0.002)**	1(1)	-2.373 (-2.11)**	-2.366 (-2.11)	1(0)

L	-1.451 (1.000)	-2.772 (0.001)**	1(1)	-1.424 (-2.11)	-3.219 (-2.11)**	1(1)
K	-2.218 (0.741)	-2.894 (0.000)**	1(1)	-1.968 (-2.11)	-4.803 (-2.11)**	1(1)

Note: GDPG, gross domestic product growth rate. TON, trade openness, NONX, non-oil export, FDI, foreign direct investment, LB, labour. INF, inflation, EXCR, exchange rate. GCF, gross capital formation. IQI, institutional quality index. **Critical value**= -***p < 0.01, **p < 0.05, *p < 0.1
Source: Author's computation employing STATA version 15, 2025.

Table 5 reveals the panel unit roots test of the seven variables in level and first difference for individual effect and trend. The table reveals that the variables are stationary at level 1(0) and first difference 1(1). The result further shows that for the Pesaran CADF result only TDO was stationary at level 1(0), while EPI, GDPPL, POPL, IQI, L, and K, were all stationary at first difference 1(1) in the Pesaran.

Similarly, for the Pesaran CIPS result in same table 5 depicts that EPI, GDPPL, POPL, TDO, L, and K were stationary at first difference 1(1), except for IQI which was found to be stationary at level 1(0). This implies that the null (H_0) hypothesis of a unit root process is strongly rejected at 1% significance level. Therefore, the result implies that some variables are non-stationary and are integrated of order one. To account for the cross-section dependence, the panel Westerlund cointegration test was conducted to examine whether long run relationship exist between the dependent variable and explanatory variables. The result of the cointegration test is shown in Table 6.

Westerlund Co-integration Test Results

These mixed orders of stationarity in unit root analysis indicate divergent behaviors of variables in the short run, necessitating a cointegration test. This test assesses if a combination of non-stationary variables can yield a stationary outcome, revealing a stable long-term relationship. Establishing cointegration among variables with a unit root allows for accurate estimation, avoiding spurious results.

Cointegration among the variables in the regression models was assessed using Westerlund's (2007) second-generation tests, which address cross-sectional dependence (CSD) that first-generation tests, like those by Pedroni (1999, 2004), overlook. The use of second-generation tests ensures robustness in the analysis despite CSD and heterogeneity.

is presented in Table 6.

Table 6: Westerlund Co-integration Test Results

	Statistic.	P-Value	Decision
Variance Ratio	4.3295***	0.0000	Co-integration

Notes: The null hypothesis is that the variables are not cointegrated. Under the null hypothesis, all the statistics are distributed as standard normal distributions. ***p<0.01, ** p<0.05, and * p<0.1 are significance level respectively.
Source: Authors' computation Using STATA 15.0, 2025

Table 6 support the presence of cointegration relationships among the variables, as indicated by the rejection of the null hypothesis of no cointegration at 1% significance level. This clearly indicates that when EPI was considered as the dependent variable, the result revealed that GDPPL and the other control variables such as POPL, TDO, IQI, L, and K, has long run relationship with environmental sustainability index at 5% level of significance within the countries in Africa.

Table 7. PMG-ARDL Long-run Estimation Outcomes

D.EPI	Coefficient	Std.Err	Z-stat	P>(Z)
Long-run Coeff				
GDPPL	0.0007	0.001	0.68	0.499
POPL	0.021**	0.010	2.02	0.043
TDO	0.002***	0.000	4.63	0.000
IQI	-0.005	0.005	-1.04	0.300
L	-0.019***	0.002	-7.27	0.000
K	0.001*	0.000	1.66	0.097
Error Correction Coefficient (EC)	-0.135***	0.021	6.19	0.000
Short-run Coefficient				
D.GDPPL	-0.000	0.001	6.19	0.454
D.POPL	0.136	0.044	-0.75	0.759
D.TDO	-0.000	0.000	0.31	0.219
D.IQI	-0.113	0.116	-1.23	0.330
D.L	0.004	0.145	-0.97	0.742
D.K	0.000	0.002	0.33	0.637
Intercept	-0.136***	0.029	-0.47	0.000
Observation	24	24	24	24

Note: Null hypotheses states that there is no significant effect. P-value statistics were considered as test statistics, and ***, **, and * represent 1%, 5%, and 10% significance levels, respectively. ***, **, and * indicates rejection of the null hypotheses at represents 1%, 5%, and 10% respectively.
Source: Authors Computation using Stata 15.0, 2025.

The pooled mean group (PMG) result is showcased in table 7. In the long run gross domestic product per capita (GDPPL) exhibited a positive relationship with environmental sustainability index (EPI) with a coefficient of 0.0007 this implies that a 1% increase in GDPPL will lead to 0.0007% increase in EPI in Africa countries, this conform to the economic apriori expectation. While in the short run the negative coefficient of GDPPL does not conform to the apriori expectation, although in both long run and short run the EPI was found not to be statistically significant to EPI because the corresponding p-value of 0.499 and 0.454 is greater than the critical value of 0.05. Population growth (POPL) in both short run and long run demonstrated a positive coefficient of 0.021, and 0.136 to EPI, this conform to the apriori expectation, and it implies that a one unit increase in POPL will lead to 0.499 and 0.454 increase in EPI. Whereas in the long run POPL has a significant impact on EPI, while in the short run it was found to be insignificant to EPI.

Furthermore, degree of trade openness (TDO) was found to have a positive coefficient of 0.002 and is statistically significant to EPI in the long run, this conform to the economic apriori expectation. This shows that a one unit increase in TDO will lead to 0.002 percent increase in EPI. Whereas in the short run it was established that TDO has a negative impact on EPI, this does not conform to the apriori expectation and it implies that a unit increase in TDO will lead to a unit decrease in EPI, also it was discovered not to be statistically significant to EPI. Interestingly, institutional quality in both long run and short run was discovered to have a negative coefficient of -0.005, and -0.113 this conform to the apriori expectation. Also, in both period IQI was shown not to be statistically significant to EPI. Labour (L) was found to have a negative impact on EPI with the coefficient of -0.019 in the long run this does not conform to the apriori expectation, although it was seen to be statistically significant to EPI. While in the short run it exhibited a positive coefficient this conform to the economic apriori expectation, though it was found to be statistically insignificant to EPI. Capital (K) in both long run and short run exhibited a positive impact on EPI, this conform to the apriori expectation. Although in the long run it was discovered to be statistically significant to EPI, whereas, in the short run K has an insignificant impact on EPI.

The error correction coefficient is having a negative sign, and its p-value of (0.000) indicates that it is significant; it suggests that any deviations from the long run equilibrium is adjusted at the 13% adjustment speed from the period 2000 to 2024. The EC significant level implies a significant long run co-integration. It also indicates that we can deduce joint causality of the independent variables jointly influence the dependent variable.

Table 8: Hausman Test

	(b) DFE	(B) pmg	(b-B) Difference
GDPPL	0.004	0.007	0.003
POPL	0.052	0.021	0.030
TDO	0.001	0.002	-0.0008
IQI	0.012	-0.005	0.017
L	0.014	-0.019	0.033
K	0.005	0.001	0.003
Chi2(5)	732.22	Prob>chi2	**0.0318****

Note: Null hypotheses states that there is no significant effect. P-value statistics were considered as test statistics, and ***, **, and * represent 1%, 5%, and 10% significance levels, respectively. ***, **, and * indicates rejection of the null hypotheses at represents 1%, 5%, and 10% respectively.
Source: Authors Computation using Stata 15.0, 2025.

The Hausman test in table 9, permits us to have a check to know whether we employed the appropriate estimator in our model. Thus, since the p-value (0.0318) of the Hausman test is below the 5% critical value it infers that the dynamic fixed effect is not the suitable estimator to implement but rather the pooled mean group (PMG) is the suitable estimator we can incorporate in the model. Therefore, based on the Hausman test, the PMG model in which economic growth jointly affect environmental sustainability in Africa is appropriate for estimation.

4.1 Discussion of Findings

The study utilized the Panel ARDL model, specifically the PMG, to assess the long and short run effects of economic growth on environmental sustainability in Africa. It found that in the long run, a positive correlation exists between GDP per capita and environmental sustainability, indicating that growing economies tend to foster increased environmental awareness and better policies, as well as promote cleaner technologies and resource management.

The analysis indicates that economic growth may initially harm the environment, yet lacks a significant correlation with long-term sustainability improvements. For example, Nigeria's substantial oil production results in severe environmental issues like oil spills and deforestation, while South Africa faces pollution and water scarcity, demonstrating that economic growth does not guarantee sustainability. This contradicts findings by Zhang et al. (2022), who reported a negative impact of economic growth on environmental sustainability, including increased exhaust emissions and ecosystem depletion.

The positive impact of population growth on environmental sustainability suggests that it can foster innovation, technological advancements, and more efficient resource use, particularly in Africa. Remarkably, Rwanda exemplifies this by achieving significant strides in sustainability despite rapid population growth through investments in renewable energy, reforestation, and eco-tourism. This view contrasts with Kelly and Newbot's (2025) study, which found that population density negatively affects environmental degradation.

Trade openness positively influences environmental performance indicators (EPI) in the long term by facilitating the transfer of sustainable technologies. For example, Morocco's trade agreement has fostered investments in sustainable agriculture, enhancing eco-friendly practices. However, in the short term, trade openness can result in negative environmental costs, such as increased pollution and resource depletion, as seen in Ghana's gold mining sector. This aligns with Kelly and Newbot (2025), highlighting trade openness's adverse effects on environmental sustainability and degradation. Institutional quality (IQI) negatively impacts environmental protection indicators (EPI) both in the long and short run, suggesting ineffective regulation and enforcement in countries like Nigeria, where corruption undermines environmental policies. Labour's negative impact on sustainability indicates that labor-intensive practices harm the environment, although in the short run, transitioning to a green economy could create jobs in Africa. Capital investment in green technologies positively influences environmental sustainability in both timeframes.

5. Conclusion and Recommendation

The paper analyzes the relationship between economic growth and environmental sustainability in Africa. It identifies a cross-sectional dependency among key factors: GDP per capita, population growth, trade openness, institutional quality, labor, and capital, impacting the environmental sustainability index. Utilizing second-generation unit root tests like CSADF and CIPS, it confirms a long-term relationship between these variables from 2000 to 2024, leading to the adoption of the pooled mean group estimator (PMG).

The PMG regression results indicate that in the long run, GDPPL, POPL, TDO, and k positively impact EPI, although GDPPL is statistically insignificant. IQI and L have an inverse relationship with EPI, with L being significant. In the short run, GDPPL, TDO, and IQI negatively and insignificantly affect EPI, while POPL, L, and K positively and insignificantly impact EPI. The findings highlight the need for African countries to pursue sustainable development, prioritize environmental protection, and raise public awareness about sustainability. Recommendations are provided based on these outcomes.

Recommendations

i. The governments in Africa should prioritize renewable energy adoption and targeted urban planning, energy efficiency, and governance reforms to amplify long-run benefit while curbing emissions.

ii. The governments should invest and create jobs in sustainable sectors, such as renewable energy, sustainable agriculture, and eco-tourism.

iii. To mitigate the negative impacts of trade openness and promote sustainable resource management, the African government needs to implement environmental regulations.

iv. The institutions should be strengthened in order to build capacity and strengthen environmental institutions to improve regulations and enforcement.

REFERENCES

Aladejare, S. A. (2020). Energy utilization, economic prosperity, and environmental quality in west africa: is there an asymmetric nexus?. International Journal of Energy, Environment and Economics, 28(3), 165-191..

Alhassan, H., Kwakwa, P. A., & Donkoh, S. A. (2022). The interrelationships among financial development, economic growth and environmental sustainability: Evide nce from Ghana. *Environmental Science and Pollution Research*, *29*(24), 37057-37070.

Saci, F., & Aliouat, B. (2024). Green Finance and Sustainable Development Goals. *Green Finance and Sustainable Development Goals in Transformations in Banking, Finance and Regulation*, *12*.

Chen, J., Li, L., Yang, D., and Wang, Z. (2023). The dynamic impact of green finance and renewable energy on sustainable development in China. Front. Environ. Sci. 10, 1097181. doi:10.3389/fenvs.2022.1097181

Chen, L., and Huo, C. (2022). The measurement and influencing factors of highquality economic development in China. Sustainability *14* (15), 9293. doi:10.3390/ su14159293

Ostos-Ortiz, O. L., Rentería-Ramos, R., & Cala-Vitery, F. (2022). Evaluation of the impact of the Colombian scientific productivity on the fulfillment of the Sustainable Development Goals. *Journal of Environmental Management & Tourism*, *13*(5), 1512-1519.Procedia Economics and Finance, 26, 806-811.

Guang-Wen, Z., Murshed, M., Siddik, A. B., Alam, M. S., Balsalobre-Lorente, D., & Mahmood, H. (2023). Achieving the objectives of the 2030 sustainable development goals agenda: Causalities between economic growth, environmental sustainability, financial development, and renewable energy consumption. *Sustainable Development, 31*(2), 680-697.

Hassan, S. T., Xia, E., Khan, N. H., & Shah, S. M. A. (2019). Economic growth, natural resources, and ecological footprints: evidence from Pakistan. Environmental Science and Pollution Research, 26, 2929-2938

Hunjra, A. I., Hassan, M. K., Zaied, Y. B., & Managi, S. (2023). Nexus between green finance, environmental degradation, and sustainable development: Evidence from developing countries. Resources Policy, 81, 103371.

Hysa, E., Kruja, A., Rehman, N. U., & Laurenti, R. (2020). Circular economy innovation and environmental sustainability impact on economic growth: *An integrated model for sustainable development. Sustainability, 12*(12), 4831.

Isfat, M., & Raihan, A. (2022). Current practices, challenges, and future directions of climate change adaptation in Bangladesh. *International Journal of Research Publication and Reviews, 3*(5), 3429-3437.

Isfat, M., & Raihan, A. (2022). Current practices, challenges, and future directions of climate change adaptation in Bangladesh. *International Journal of Research Publication* and *Reviews, 3*(5), 3429-3437.

Kelly, A. M., & Nembot Ndeffo, L. (2025). Understanding the nexus: economic complexity and environmental degradation in Sub-Saharan Africa. *Clean Technologies and Environmental Policy, 27(*1), 423-437.

Khan, S. A. R., Zhang, Y., Anees, M., Golpîra, H., Lahmar, A., & Qianli, D. (2018). Green supply chain management, economic growth and environment: *A GMM based evidence.* Journal of Cleaner Production, 185, 588-599.

Mohsin, M., Iqbal, N., & Iram, R. (2024). The nexus between green finance and sustainable green economic growth. Energy Research Letters, 5(3).

Prabhakar, A. (2025). A Sustainable and Inclusive Economic Development: A Global Imperative: A Global Imperative. Journal of Recycling Economy & Sustainability Policy, 4(1), 1-16.

Qi, Y., Bhunia, P., Zhang, T. C., Luo, F., Lin, P., & Chen, Y. (2020). *Environmental degradation and sustainability.* https://onlinelibrary.wiley.com/doi/chapte

Quality In West Africa: Is There An Asymmetric Nexus? International *Journal of Energy, Environment and Economics, 28(*3), 165-191

Qudrat-Ullah, H., & Nevo, C. M. (2021). *The impact of renewable energy consumption and environmental sustainability on economic growth in Africa. Energy Reports, https://scholar.google.com/schola*

Raihan, A., Atasoy, F. G., Atasoy, M., Ridwan, M., & Paul, A. (2022). The role of green energy, globalization, urbanization, and economic growth toward environmental sustainability in the United States. Journal of Environmental and Energy Economics, 1(2), 8-17

Resilience, P. U. T. G. (2025). Chapter Global Prospects and Policies. World Economic Outlook.

Sadiq, M., Fadel, M. E., Mezher, T., & Mayyas, A. (2025). *Interconnectedness of economic growth and environmental sustainability: challenges and strategies. Energy, Sustainability and Society,* https://scholar.google.com/scholar

Saint Akadiri, S., Bekun, F. V., & Sarkodie, S. A. (2019). Contemporaneous interaction between energy consumption, economic growth and environmental sustainability in South Africa: what drives what? Science of the total environment, 686, 468-475.

Sichigea, M., Puiu, S., Circiumaru, D., & Carstina, S. (2024). Insights from the nexus between economic growth and green energy. Heliyon, 10(14).

Tenaw, D., & Beyene, A. D. (2021). Environmental sustainability and economic development in sub-Saharan Africa: A modified EKC hypothesis. Renewable and Sustainable Energy Reviews, 143, 110897.

Xu, Y., & Ding, Z. (2024). Sustainable growth unveiled: Exploring the nexus of green finance and high-quality economic development in China. Frontiers in Environmental Science, 12, 1414365.

Yan, J., Liu, C., Xiao, B., & Wang, S. (2024). Environmental dynamics: *Unraveling the nexus of air pollution, population agglomeration, and sustainable economic development in China. Frontiers in Environmental Science, 12,* 1349419.

Zhang, M., Chen, Y., Lyulyov, O., & Pimonenko, T. (2022). Interactions between economic growth and environmental degradation toward sustainable development. Systems, 11(1), 13.