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Economic growth and Environmental Sustainability in Selected African countries: A panel investigation

Dinyelu, Tochukwu Michael[1], Nteegah, Alwell[2], Nwinee, Barisua Fortune[3]
[1]Emerald Energy Institute (EEI), University of Port Harcourt
[2]Department of Economics, University of Port Harcourt
[3]Department of Finance and Banking, University of Port Harcourt

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Corresponding Author:
Nteegah, Alwell

ABSTRACT
This study examined the effect of economic growth on environmental sustainability among selected African countries. To achieve the objectives of this study economic growth was analysed alongside some control variables - foreign direct investment, credit to the private sector, population growth rate and trade openness to determine their impact on environmental performance index (proxy for environmental sustainability) in the six selected African countries namely: Angola, Algeria, Egypt Ghana, Libya, and Nigeria over the period 1990-2022 using panel analysis. Based on the analysis of the data trend analysis and econometric analysis of panel fixed effect regression econometric technique, some key empirical findings were made. Egypt had the highest environmental performance index (EPI), Direct relationship between the real GDP and environmental performance index (EPI) was visualised in Algeria, Egypt and Libya. Economic growth had a positive and significant impact on the environmental performance index. That FDI and trade openness had positive but marginal effect on environmental performance index while credit to the private sector and population growth rate had negative impact on environmental performance index in the selected countries. Based on the findings, the study recommended increase investment in the real sector and the increase in emission tax in order to sustain the environment in Africa.

KEYWORDS: Economic growth, Environmental Performance Index, Foreign direct investment and Population growth

I. INTRODUCTION

Energy consumption is a crucial catalyst for economic growth and development, fueling industries, transportation, and households globally. Nevertheless, the dependence on fossil fuels and non-renewable energy sources has ensued in substantial environmental repercussions, intensifying problems such as air and water contamination, deforestation, and climate change (environmental degradation).

As the world's populace expands and becomes more industrialized, the need for energy increases, leading to a greater sway on the environment (Haliru, 2023). Wajid, et al (2022) define energy consumption as the utilisation of energy in various activities i.e. power generation, transportation, heating, and industrial processes. Fossil fuels, comprising coal, oil, and natural gas, have traditionally been the primary sources of energy worldwide and most especially less developed countries because of their abundant supply, cost-effectiveness, and high energy concentration. Nevertheless, the process of burning fossil fuels emits greenhouse gases (GHGs) and air pollutants, hence contributing to climate change, air pollution, and public health issues.

The transport industry has a major role in both energy consumption and degradation of the environment, being accountable for a substantial share of worldwide emissions of carbon dioxide (CO_2). The prevalence of petrol and diesel-powered internal combustion engine cars worsens air pollution and urban congestion, leading to adverse impacts on air quality and public health (Kehinde & Devi, 2022). Industrial processes i.e. manufacturing, mining, and construction are substantial energy consumers. They frequently depend on fossil fuels and non-renewable resources to fulfil their energy requirements. The extraction, processing, and utilisation of natural resources result in environmental consequences, comprising habitat destruction, soil erosion, and water contamination. Furthermore, the utilisation of energy in residential and commercial areas, mainly for the purpose of heating, cooling, lighting, and operating appliances, leads to degradation of the environment due to the discharge of greenhouse gases (GHGs) and air pollutants. Buildings and appliances that are not efficient worsen the use of energy and adverse effects on the environment, highlighting the need of energy efficiency measures in decreasing emissions and the depletion of resources.

Abdulkarim (2023) found that the connection between energy consumption and degradation of the environment is influenced by both direct and indirect mechanisms, which operate at different spatial and temporal dimensions. The extraction, production, and combustion of fossil fuels and non-renewable sources of energy have direct consequences, as they release pollutants and greenhouse gases (GHGs) into the environment. Emissions from power plants, industrial facilities, and cars have a substantial sway on the environment at the local, regional, and global levels, leading to issues i.e. air and water pollution, likewise climatic instability. Indirect repercussions arise from the wider socio-economic and technological systems that support energy consumption, comprising alterations in land use, urbanisation, populace expansion, and consumption habits.

Less developed countries depend mainly on fossil fuel for energy their energy needs (industrial production, transportation, household activities among others) due to its availability, cost and the low level of investment in other energy sources like hydro, solar and natural gas despite their availability. This lack of energy diversification has effects both on the economy and environment of a country. It is in the light of this development that this study seeks to examine the effect of fossil fuel consumption on environmental sustainability in selected African countries.

The study covers a period of thirty-three (33) years that is, 1990 – 2022. This time scope is informed by the availability of the data that are required and necessary to conduct a robust analysis in this study. Geographically, the study mainly concentrates on six African countries. These African countries includes: Nigeria, Angola, Egypt, Algeria, Libya and Ghana. The selection criteria are based on the energy production capacity, population size, energy consumption as well as the level of economic activities in these countries. We shall continue our investigation by reviewing related works on the topic, followed by the methodology employed to achieve the purpose of the study, results of data analysis, discussion of findings and concluding remarks and recommendations.

II. LITERATURE REVIEW

The Environmental Kuznets Curve (EKC) hypothesis proposes a curvilinear nexus, curved like an inverted U, between the level of degradation of the environment and the level of economic activities. The EKC hypothesis, named after Economist Simon Kuznets, suggests that environmental degradation initially worsens during the industrialization process and as incomes increase. However, it eventually improves once a certain level of economic growth is achieved. The Environmental Kuznets Curve (EKC) hypothesis posits that there exists a curvilinear link between carbon emissions and income per capita, characterised by an initial increase in pollution during the early stages of economic growth, ensued by a subsequent decline in the later stages.

The fundamental concept behind the Environmental Kuznets Curve (EKC) is that as a nation's industrialization progresses, there exist a corresponding rise in resource extraction and pollution levels due to rising income levels. As individuals experience an increase in their wealth, they become more aware of the importance of environmental quality and are now able and willing to buy greener sources of energy. Consequently, compelling the reduction of pollution emissions after a certain timeframe. This is the method by which the inverted U-shape is achieved. The first proposal of the Environmental Kuznets Curve theory, which suggests an inverted-U form, was put out by Grossman and Krueger in 1991. Beckerman (1992) argues that the most effective approach to decreasing environmental pollution is for the nation to achieve economic prosperity.

The concept has established itself as one of the widely accepted observations in the field of environmental and resource economics, as shown by the work of Cole and Neumayer (2005). However, there has been substantial criticism in assent with both theoretical and empirical reasons (Stern, 2003; Cole and Neumayer, 2005). Many scholars interpret the EKC as suggesting that developing nations should not implement environmental policies until they become wealthy. In assent with this interpretation, the environmental issues in these nations will be addressed through policy changes in the future when they have achieved higher levels of economic growth. Consequently, it may be inferred that there is less effort being made to carry out environmental remediation in emerging nations. Recent data (Dasgupta, 2002) challenges these ideas by demonstrating that pollution concerns are really being handled and resolved in emerging nations.

Furthermore, it is probable that the income elasticity of emissions in affluent nations is less than 1, but it is not adverse, as proposed by the Environmental Kuznets Curve (EKC) theory. In nations with slower growth rates, the use of technology that reduces emissions may counterbalance the impact of increasing income per person on emissions. In recent decades, several organisations for economic cooperation and development (OECD) nations have seen substantial declines in emissions per capita. In rapidly developing middle-income nations, the impact of increasing affluence surpasses the influence of technology in mitigating emissions. In general, there exist a robust correlation between economic expansion and pollution. Nevertheless, the interconnections between these two phenomena may be alleviated by several aspects, i.e. transitioning to eco-friendly technology and implementing technical advancements that ensure overall economic advancement and, more particularly, the reduction of pollution. Nevertheless, due to the doubt around the possibility of boundless replacement or technical advancement, there could be constraints on the degree to which these connections can be further relaxed in the future. Previous empirical research had demonstrated the connections between degradation of the environment and economic activities. For instance, Hung and Shaw (2016) found evidence of a simultaneous link between economic growth and environmental quality. In assent with Stem (2014), the Environmental Kuznets Curve (EKC) suggests that degradation of the environment and pollution initially occur during the early stages of economic activities. However, as economic expansion continues, there exist a tendency for environmental resources to improve at a later era.

In a study conducted by Ajudua (2023), it was discovered that an increase in GDP has a substantial relationship with various environmental degradation factors, comprising forest loss, gas flaring, and oil spills. Similarly, Yusuf, et al (2022) found that economic advancement and energy consumption in Nigeria are favourably associated with environmental degradation. In addition, Igbru and Ifurueze (2021) discovered that per capita GDP, utilised as a proxy, had a substantial sway on environmental degradation in Nigeria. Furthermore, the upshots of Ajayi and Ogunrinola (2020) demonstrate that real income per capita, when utilised as a metric for growth, has a noteworthy and affirmative sway on degradation of the environment, both in the short-term and long-term. In assent with Dizaji, Badri, and Shafaei (2016), economic advancement in D8 member nations is favourably correlated with carbon dioxide emissions.

Osuntuyi and Lean (2022) examined whether education matters in economic performance, energy consumption and environmental degradation nexus in diverse countries. The study employs FMOLS, DOLS, ARDL-PMG, CCEMG and heterogeneous panel causality test techniques to investigate the direct and moderating effects of education in the growth-energy-environment linkages in heterogeneous income groups of 92 countries from 1985 to 2018. The findings of this study indicated that economic growth is a long-term solution to environmental deterioration in high and upper-middle-income countries, while the opposite holds for lower-middle-income and low-income countries. In addition, energy consumption is linked with environmental degradation across all income groups. Also, the study found that learning aggravates environmental degradation across all income groups. Moreover, its moderating role ameliorates the adverse effects of energy consumption on environmental degradation in high and upper-middle-income groups but worsens it in the lower-middle-income and low-income groups. The study concluded that education is important for environmental sustainability as it encourages pro-environmental behaviors and attitudes and supports energy-efficient products and investments in green technologies. However, education may also aid energy-intensive activities and dirty technology by supporting lifestyles that are not friendly with the environment. The study therefore suggested that it is important to provide education that promotes better environmental quality.

Rodolfo and Drilona (2022) examined the impact of climate change on states characterized by structural weaknesses, government failure, and lack of institutional basic functions in sub-Saharan Africa (SSA) over the period 1980-2019 using a panel analysis. The fixed effect model revealed that the effect of a 1^{0}C rise in temperature decreases income per capita growth in fragile states in SSA by 1.8 percentage points. Panel quantile regression models that account for unobserved individual heterogeneity and distributional heterogeneity, corroborate that the effects of higher temperature on income per capita growth were negative while the effect of income distribution growth on carbon emissions growth differs across the countries, indicating that higher income distribution growth could help reduce environmental degradation for high-emitter countries.

In another study, Abubakar and Cudjoe (2022) employed Vector Error Correction Model (VECM) to study the environmental effect of energy used in Nigeria using annual time series data from 1990-2018. Our study found a long run positive effect of GDP on CO2 emissions in Nigeria. This result seems to disprove the Environmental Kuznet Curve hypothesis that clean environment exists with an increase in income level. The study also found that the utilization of charcoal has a long run potential of mitigating against CO2 emission while the use of fuel wood has a long run tendency of increasing CO2 emission. The usage of gas oil was found to have a negative effect on CO2 emissions while natural gas utilisation and fuel oil consumption had adverse effects on CO2 emission. Consumption of Hydroelectricity was found to have a negative impact on CO2 emission in the long run in Nigeria. Notwithstanding, the study recommended that investment in hydroelectricity and wood biomass energy consumption could reduce environmental damage in Nigeria. Okon (2021) examined the relationship between per capita GDP and per capita emissions of the greenhouse gas carbon dioxide (CO2) to observe the possible implication of increase in economic activities on environmental degradation in Nigeria by applying the Environmental Kuznets Curve (EKC) analysis approach. To achieve the purpose of the study, time series data spanning the period 2000-2019 was used and the Auto Regressive Distributed Lags (ARDL) approach to co-integration was adopted for the purpose of analysis. Concerning CO2 emission, the anticipated EKCs is not found to exist in this study. The study found a mix effect of economic growth on the environment. This implies that a 'U' shape instead of inverted 'U' shape curve for Nigeria. Furthermore, a 1% change in environment policy in the lag period leads to a decrease in environmental degradation in the short run. Based on this finding, the study advocated the need for a clean revolution in industrial production in Nigeria. In addition, more local and national sustainability efforts are needed on several fronts, especially vis-a-vis water and sanitation, as well as in terms of air quality.

Ondaye, Ondze and Imongui (2021) analyzed the influence of economic growth on CO2 emissions in Republic of the Congo over the period 1980-2015 using annual time series and the ARDL methodology. The results show the existence of an inverted U-shaped curve between economic growth and carbon dioxide emissions in Republic of the Congo in the long run. However, the Gross Domestic Product exerted no effect on carbon dioxide emissions in the short term. With respect to the environmental protection policy instruments deployed, Republic of the Congo represents a good example of governance. Thus, the study recommended that the government strengthen environmental protection and renewable energy policies so that economic growth is always achieved without carbon dioxide emissions exceeding environmentally acceptable limits.

Igbru and Ifurueze (2021) investigated the nexus between environmental degradation and the economic growth in Nigeria using sample from 2011 to 2020. The objectives were established to examine the effect of foreign direct investment, per capita GDP and population density on the CO2 emission. After testing stationarity of the variables and the possibility of long run nexus using the Johansen Co-integration procedure, the result showed that per capita GDP and population density have significant effect on environmental degradation but foreign direct investment shows no significant effect on the environmental depletion as was measured by carbon dioxide.

Kahn, et al; (2021) investigated the long-term impact of climate change on economic performance. The result indicated that per-capita real output is negatively affected by constant changes in the temperature, but they do not obtain statistically significant effects for changes in precipitation. The counterfactual analysis implies that a consistent rise in average global temperature by 0.04°C per year, where there is a lack of mitigation policies, reduces world real GDP per capita by more than 7% by 2100. However, when the Paris Agreement is followed, limiting the temperature increase to 0.01°C per annum reduces the loss significantly to about 1 percent. These effects appear to changes substantially across countries depending on the level of temperature increases and vagaries of climate conditions.

Adejumo (2021) also studies the potential effect of climate change on Nigerian economic growth using a time series data (1980-2017). Using the OLS methods, the research work found that annual average rainfall has a significant effect on economic growth both short-run and long-run. Also, there is a high degree of positive and significant relationship between carbon emission, foreign direct investment, gross fixed capital formation and economic growth under investigation. The result also revealed that this relationship between climatic factors and economic growth is more noticeable in the long run. In addition, an inverse relationship was found between forest depletion, population growth and economic growth in the long run. Finally, there is unidirectional causality between annual average rainfall and economic growth in Nigeria. It is therefore recommended that the stakeholders and the general public should build green economy that enables sinking carbon and promotes carbon market in the long-run.

Ogbonna, Ojeaburu and Ehilegbu (2021) investigated the relationship between carbon emission and economic growth in Nigeria for a period ranging from 1981-2018 using carbon dioxide CO2 as proxy for carbon emission and real GDP growth rate as and the proxy for economic growth. Both inferential and dynamic ordinary least Square and bivariate granger causality test were employed to analyze the data. The results showed evidence of autoregressive effect of previous records of gross domestic product on its future value; there is an inverse relationship between carbon emission and gross domestic product. The bivariate granger causality confirms no existence of causality running between the variables. On the basis of the findings, the study concluded that there is an insignificant and negative relationship between carbon emission and Gross domestic product. It also concluded that CO2 and GDP are causally neutral to each other. It therefore recommends that earnest effort should be made by government to reduce greenhouse gas (GHG) in Nigeria by adhering to all relevant protocol and standards. Emissions not connected to the production of industrial and consumer goods should be taxed and avoided completely except the inevitable domestic emissions by practically applying the necessary laws both national and international. Precisely, focus should be shifted to going green in terms of energy generation, ensuring positive multiplier effect of constant power supply and the economics of clean air on the human health and productivity.

Ajayi and Ogunrinola (2020) provided empirical insight into the relationship between growth, trade openness, and environmental degradation in Nigeria. The ARDL bounds test approach was applied on time series data from 1960-2017 to determine if a long run nexus exist among the variables. Employing the Pollution Haven and Environmental Kuznets Curve hypotheses, empirical findings validate the EKC hypothesis in Nigeria in the long-run. All estimated parameters were found to have the expected signs in the short- and long-run, except population, with the expected sign only in the long-run. The analysis proves that trade openness and population aid environmental degradation in the short-run. It reveals that financial development counters environmental degradation in both the short- and long-run, and real income per capita has a positive and significant effect on environmental degradation in both the short- and long-run.

The coefficient of the error correction term suggests that 62.5% of the divergence between actual and equilibrium CO2 emissions is corrected annually. Post-estimation tests employed proves the robustness of the result. The RESET test affirmed the specification of the model and the CUSUM and CUSUM of squares tests confirm the stability of the parameters. Consequently, Nigeria should foster policies that encourage the development and utilization of renewable energy to boost economic development.

Ogundipe, Obi and Ogundipe (2020) investigated the effects of environmental degradation on food security in Nigeria using an annual data for the period 1970-2017. The theoretical framework was based on the Mathusian theory and the environmental Kuznets curve (EKC) hypothesis. The empirical model developed was estimated using the Johansen and vector error correction analysis. The empirical evidence suggested an inverse relationship between food production and environmental degradation implying that food security is threaten with rising degradation of the environment. In the same manner, food production responded inversely to gross domestic product per capita, hence justifying the EKC hypothesis. Since pollution is a rising function of income at the initial development stages, the rising pollution associated with income growth tends to hamper food security. On the other hand, the evidences revealed a positive influence of agriculture land and population growth on food production. However, the effect of the latter (population growth) is negligible suggesting that an increase in population results in lesser proportionate increase in food production, hence confirming the Mathusian theory.

Egbetokun, et al (2019) examined the EKC considering the impact of institutional quality on six variables of environmental pollution [carbon dioxide (CO2), Nitrous Oxide (N2O), Suspended Particulate Maters (SPM), Rainfall, Temperature and Total Green House Emission (TGH)] using the case of Nigeria. The EKC model includes population density, education expenditure, foreign direct investment, and gross domestic investment as control variables, and it was analyzed using the Auto Regressive Distribution Lag (ARDL) econometric technique, which has not been applied in the literature on Nigeria. The results, inter alia, indicate that there is EKC for CO2 and SPM. This implies that the green growth objective can be pursued in Nigeria with concerted efforts. Other environmental pollution indicators did not exert significant influence on economic growth. Therefore, it is recommended that Nigeria's institutional quality be strengthened to limit environmental pollution in light of economic growth.

In a similar vein, Derickand and Elisha (2019) examined the Environmental Kuznets Curve (EKC) theory by investigating how economic growth relates to environmental pollution, specifically carbon dioxide emissions (CO2) and combustible renewable waste (CoWaste). The study utilized a panel dataset spanning from 1970 to 2013, focusing on selected West African nations with similar income levels, with the objective to determine whether economic growth leads to a reduction in environmental pollution, and at what income threshold this might occur. The findings of the study showed that in the short term, economic growth significantly contributes to increased CO_2 emissions and CoWaste. However, in the long run, it does not lead to a significant decrease in CO_2 emissions or CoWaste. These results appear to suggest that the EKC does not exist in West Africa, as there is no significant correlation between economic growth and environmental pollution. Additionally, the study identified a very low point at which CO_2 emissions and CoWaste begin to decrease. Nonetheless, the absence of the EKC implies that the relationship between economic growth and environmental deterioration in West African countries cannot be explained by an inverted U-shaped curve. In spite of the key outcomes of the report, the analysis is restricted to a panel dataset spanning from 1970 to 2013. This relatively short timeframe may not capture longer-term trends and fluctuations in the relationship between economic growth and environmental pollution, potentially leading to incomplete or inconclusive findings. Additionally, the study concentrated exclusively on selected West African countries with similar income levels. This sub-regional focus might limit the generalizability of the results to other regions or countries with different economic and environmental dynamics, making it challenging to draw broader conclusions therefrom.

Nwokoro and Chima (2017) carried out a study to examine the impact of environmental degradation on agricultural production and poverty in rural Nigeria. They examined that minimizing the use of natural resources is essential to ensure sustainable environmental conservation. They explained that the continuous pressure placed on the environment exceeding the capacities to which the ecosystem can carry is the major cause of the problem. Their study aimed at addressing the issues of rural poverty and unsustainable agricultural practices, which have a negative impact on the environment and also, highlighted policy implications on sustainable agricultural production in Nigeria.

Dizaji, Badri and Shafaei (2016) investigated the relationship between economic growth and environmental quality in D8 member countries. The study examined the relationship between economic growth and environmental quality in Bangladesh, Egypt, Indonesia, Iran, Malaysia, Nigeria, Pakistan, and Turkey using panel data model in the period 1975 –2012. The results showed that economic growth has a positive effect on carbon dioxide emissions. However, the square GDP per capita has a significant negative effect on carbon dioxide emissions. The study concludes that the Environmental Kuznets Curve hypothesis is confirmed from the group of countries understudy.

Omotor (2016) examined the relationship between per capita income and environmental degradation in the ECOWAS countries using two indicators of environmental quality of

CO_2 and SO_2 emission. The results from both, the fixed and random effect models, support the existence of the Environmental Kuznets Curve in the ECOWAS region for both CO_2 and SO_2.

Azam, et al (2016) inspected the influences of CO_2 emissions, energy use, trade, and human capital on economy growth from 1971 and 2013 for China, the USA, India, and Japan by utilizing panel fully modified ordinary least squares (FMOLS) for checking the association among the study variables. The examined results pointed out that CO_2 emissions and energy consumption negatively and significantly influences the economic growth while trade and human capital positively and significantly influences the economic growth.

Babatunde and Ayodele (2015) examined the empirical linkage between economic growth and climate change in Africa. Using annual data for 34 countries from 1961 to 2009, we find a negative impact of climate change on economic growth. Our results show that a 1°C increase in temperature reduces gross domestic product (GDP) growth by 0.67 percentage point. Evidence from sensitivity analysis shows the two largest economies in the Sub-Saharan Africa (Nigeria and South Africa) play a significant role in ameliorating the negative economic impact of climate change in the region. In addition to impact on Africa, this article provides estimates of the impact of climate change on GDP growth of these 34 countries, which can be valuable in appraising national adaptation plans. We do not find evidence that average long-run temperature changes affect long-run economic growth as measured by 5 year averages.

Leitao (2014) examined the interplay between economic growth, carbon emissions, renewable energy, and globalization within the context of Portugal. To achieve this, the author utilized a range of econometric tests, including ordinary least squares, the generalized method of moments, and Granger causality tests. The study revealed that carbon emissions, renewable energy usage, and globalization all had a positive impact on economic growth. Furthermore, the study provided confirmation for the growth hypothesis.

Alege and Ogundipe (2013) investigated the relationship between environmental quality and economic growth in Nigeria using a fractional cointegration analysis over the period 1970-2011. It seeks to examine the effect of growth on environmental performance by controlling for the role of institutional quality, trade openness and population density. The paper found that early stages of development in Nigeria accentuate the level of environmental degradation. It also finds that weak institutions and unrestricted trade openness increase the extent of environmental degradation due to environmental dumping. Finally, the paper shows that a larger population density enhances the promptness of environmental abatement measures and consciousness for cleaner environment. The study, however, failed to attain a reasonable turning point and hence a non-existence of EKC in Nigeria. The study recommended the need to restrict the importation of emission intensive products, check the activities of multinationals which invest in producing high CO_2 emitting goods in LDCs and exports to home countries. Finally, there is need to strengthen institutional quality to ensure adoption of clean technologies as income rises.

Usenobong and Chuku (2011) carried out a study on "economic growth and environmental degradation in Nigeria: Beyond the Environmental Kuznets Curve". The study contributes to the debate on the existence and policy relevance of the EKC for Nigeria by applying autoregressive distributed lag (ARDL) framework to annual time series data from 1960 to 2008. The traditional EKC model is extended by including (in addition to the level, square and cubed values of the income variable), trade openness as well as the shares of manufacturing, agriculture and service sectors in Nigeria's GDP. Using Co2 emissions per capita to proxy environmental degradation, our findings do not support the existence of the EKC hypothesis. Rather our results show that Nigeria's situation when confronted with data is exemplified by an N-shaped relationship with a turning point at $77.27 that lies below the data set used for the study. Based on these findings, the paper posits that the hypothesized EKC serves as a dangerous policy guide to solving environmental problems in Nigeria. The conclusion is that to ensure sustainability, there exist an urgent need to look beyond the EKC by adopting courageous policy measures of environmental preservation in Nigeria irrespective of the country's level of income.

The review of literature revealed that a lot of studies have been done on the nexus between increase productive activity and the environment. However, there appears to be paucity of literature on cross country studies especially in developing countries. African countries, in their drive to enhance development and reduce poverty have deployed both conventional and unconventional methods in production of goods and services. These have diverse degree of impact on the environment. It is therefore pertinent to examine how the environment has been affected in course of increasing productive activities in the African.

III. METHODOLOGY

In estimating the effect of economic growth on the environment, the work followed the Kuznet inverted U shape argument that there is increase in environment destruction during the early stage of productive activity and a cleaner environment when economic growth had stabilized. Analytically, the work of Omotor (2016) was useful in the modelling of the environmental sustainability equation but with little modifications. In this study Omotor studied the relationship between per capita income and environmental degradation in the ECOWAS countries using two indicators of environmental quality of CO_2 and SO_2 emission. However, in this study our emphasis is on the effect of real GDP, FDI, credit to the private sector, trade openness and population on Environmental performance index. Given this background, the study specifies an environmental performance index model thus:

$EPI = f(RGDP, FDI, CRED, TROPEN, POPL)$ (1)

Equation 1 is transformed into econometric models as follows:

$EPI_t = \beta_0 + \beta_1 RGDP_t + \beta_2 FDI_t + \beta_3 CRED_t + \beta_4 TROPEN_t + \beta_5 POPL_t + \mu_t$ (2)

Equation 2 is transformed into pool effect model as follows:

$EPI_{it} = \beta_0 + \beta_1 RGDP_{it} + \beta_2 FDI_{it} + \beta_3 CRED_{it} + \beta_4 TROPEN_{it} + \beta_5 POPL_{it} + \mu_{it}$ (3)

Equation 3 is transformed into fixed effect models as follows:

$EPI_{it} = \beta_0 + \beta_1 RGDP_{it} + \beta_2 FDI_{it} + \beta_3 CRED_{it} + \beta_4 TROPEN_{it} + \beta_5 POPL_{it} +$ (4)

$\sum_i^9 = 1\alpha_i idum\varepsilon 1_{it}$

Equation 4 is transformed into Random Effect model as follows:

$EPI_{it} = \beta_0 + \beta_1 RGDP_{it} + \beta_2 FDI_{it} + \beta_3 CRED_{it} + \beta_4 TROPEN_{it} + \beta_5 POPLC_{it} +$ (5)

$\mu t + \varepsilon 1_{it}$

Where:

RGDP = Real Gross Domestic Product, FDI = Foreign Direct Investment, CRED = Credit to the private sector, TROPEN = Trade openness, POPL = Population, GDPPC = GDP per capita, β_0= Regression intercept, $\beta_1 - \beta_6$ = Parameter estimates of the explanatory variables (including the main and control) in each model, $_t$ = time subscript, μ_t = cross-section or firm-specific error component

$\varepsilon 1_{it}$ = combined time series and cross-section error component.

It should be noted that foreign direct investment, credit to the private sector, trade openness and population growth rate are control variables. These variables have serious effect on productive activities and the environment in the long run. The data were sourced from the World Bank Development Indicator, Africa Energy Portal and the International Energy Agency. The data set cover the period 1990 – 2022.

IV. RESULTS

Figure 1 represents the plotted line graph showing the trend in Environmental Performance Index and Economic Growth among the selected countries namely Algeria, Angola, Egypt, Ghana, Libya, and Nigeria. The line graph depicts the environmental performance index in each country from 1990 to 2022. During the bulk of the sample period, Egypt had the highest environmental performance index (EPI), except for a few years when Algeria had a higher EPI than Egypt. Furthermore, Libya consistently had the lowest environmental performance index for most of the study period

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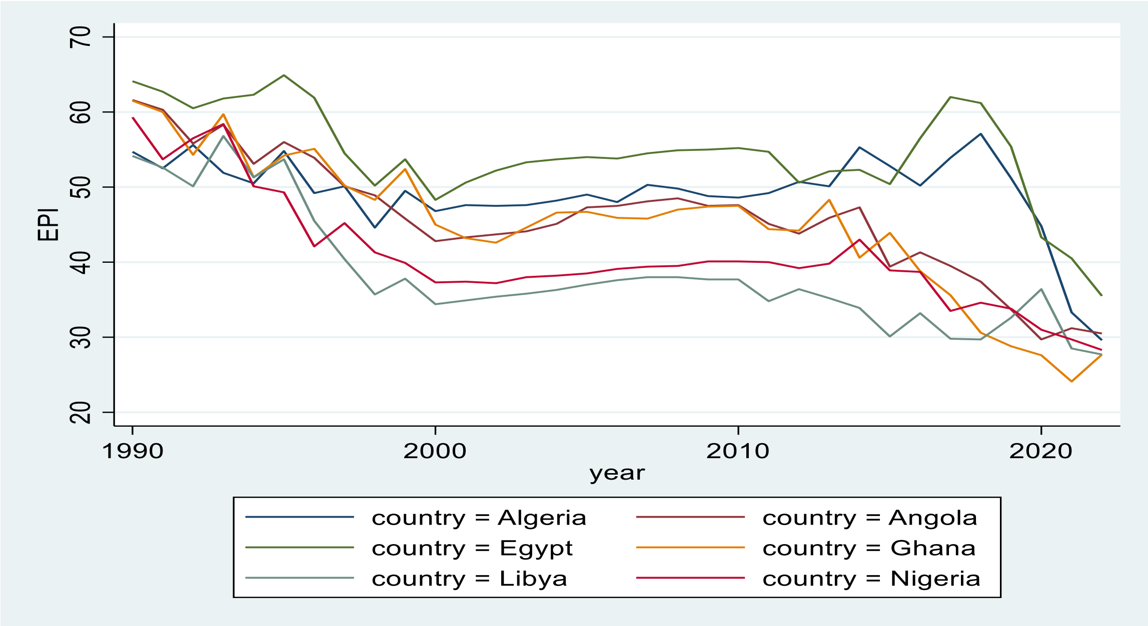

Figure 1: Line graph showing trend in Environmental Performance Index (EPI) among the Selected African Countries

Source: Author's Plot, 2024.

Based on line graph presented as Figure 2, Nigeria has the greatest economy in terms of real GDP among the nations included in the analysis. Furthermore, the gross domestic product (GDP) of Algeria, Egypt, and Nigeria consistently exceeded that of Angola, Ghana, and Libya from 1990 to 2022. Finally, the line graphs illustrate that Libya saw greater volatility in economic growth over the specified timeframe

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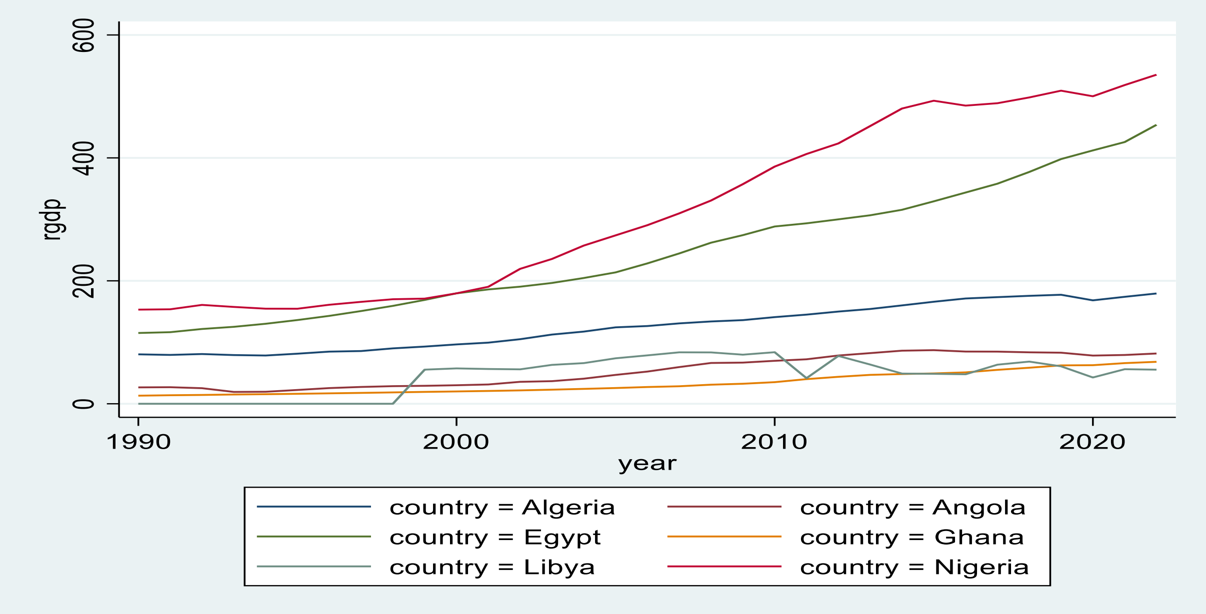

Figure 2: Line graph showing trend in Real Gross Domestic Product (RGDP) among the selected African countries. Source: Author's Plot, 2024.

Figure 3 shows a direct relationship between the real GDP and environmental performance index (EPI) in Algeria, Egypt and Libya from 1990 to 2022. While a high real GDP was accompanied by a high EPI in Algeria and Egypt, a low real GDP was accompanied by a low EPI in Libya. However, this relationship does not hold true for Angola, Ghana, and Nigeria. While EPI was high despite the low real GDP in Angola and Ghana, EPI was low despite the high real GDP in Nigeria. Therefore, one can infer a positive or negative relationship between real GDP and EPI. We will undertake a quantitative analysis utilising the panel data regression econometric technique to examine the nature relationship between real GDP and the EPI.

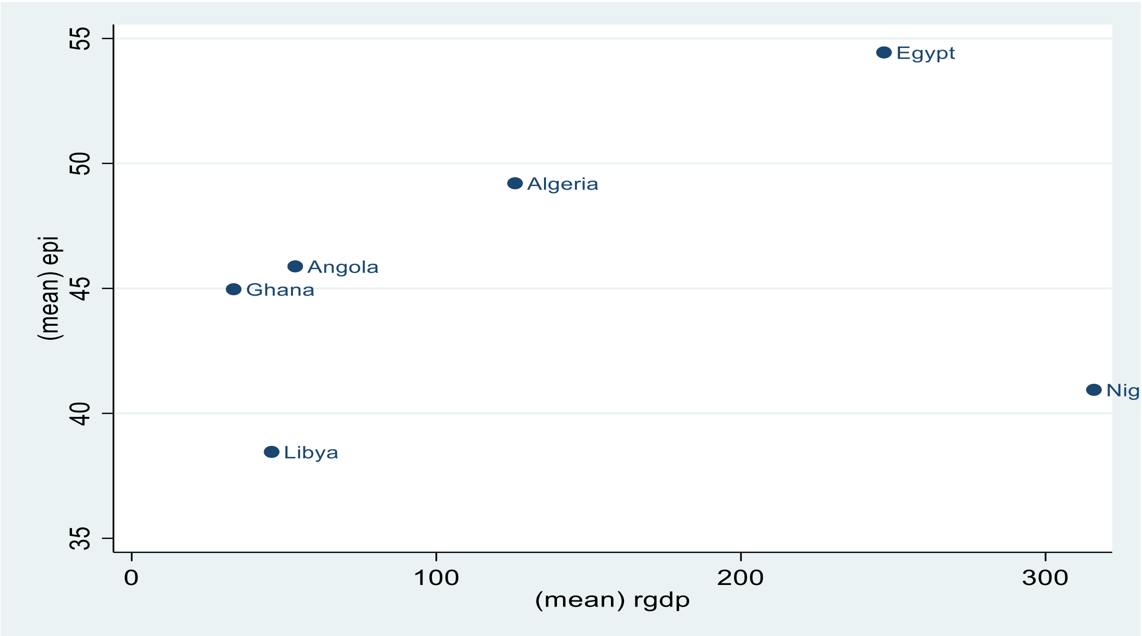

Figure 3: Scatter plot showing the relationship between Real GDP (RGDP) and Environmental Performance index (EPI) in the Selected African Countries
Source: Author's Plot, 2024.

Table 1 presents a concise overview of the dataset, based on the number of observations (N = 198), the number of cross sections (i.e., countries) (n = 6), and the time period covered (T = 33). This table displays the summary statistics including the means, standard deviations (overall, between nations, and within countries), minimum and maximum values, skewness, and kurtosis. Statistical characterization of the variables is essential for examining the distribution and variability of the variables under study. This is done to avoid the potential issues that may arise when working with time series and cross-section data. All the variables display considerable variation both between and within countries. This suggests that the use of panel estimation techniques, which allows the identification of the various parameters of interest, is reasonable. For example, while the mean statistic is computed to be 45.65, the overall, between and within standard deviation statistics for environmental performance index are 9.14, 5.73, and 7.48 respectively. This implies that, on average, the selected countries performed below average with respect to environmental performance, and that although there is variation in their performance index, it cannot be said to be a huge one. Moreover, the skewness and kurtosis statistics are -0.14 and 2.25. This implies a left-skewed (since the skewness statistic is negative) and platykurtic (fewer and less extreme outliers) (since the kurtosis statistic less than 3) distribution. The skewness and kurtosis (in exception of hydro energy consumption) statistics of all the variables are all positive and greater than 3.

Table 1. The results of summary statistics for selected variables (N =198; *n* = 6 countries; *T* = 33)

Variables	Mean	Overall Std. Dev	Between Std. Dev.	Within Std. Dev.	Min	Max	Skewness	Kurtosis
EPI	45.65	9.14	5.73	7.48	24.1	64.9	-0.14	2.25
RGDP	143.49	130.57	116.00	75.06	13.17	535.336	1.39	4.08
TROPEN	61.24	24.70	20.19	17.38	16.35	152.55	0.99	3.97
CRED	18.41	12.27	9.21	8.37	3.66	56.14	1.38	4.47
FDI	2.17	4.72	1.35	4.55	-10.72	40.17	3.60	26.94
POPL	52.74	52.22	53.90	17.13	4.24	218.54	1.39	4.11

Table 2. The results of summary statistics for selected variables (N = 6 countries; T = 33)

	Levels				
	Constant		**Constant and Trend**		
Variables	Test Statistic	5% Critical value	Test Statistic	5% Critical value	**Decision**
lnepi	-2.35*	-2.07	-2.40	-2.68	Non-Stationary
tropen	-2.39*	-2.07	-2.46	-2.68	Non-Stationary
cred	-2.38*	-2.07	-3.13*	-2.68	Stationary
fdi	-2.73*	-2.07	-3.25*	-2.68	Stationary
lnpopl	0.50	-2.07	1.50	-2.68	Non-Stationary
	First Difference				
	Constant		**Constant and Trend**		
Variables	Test Statistic	5% Critical value	Test Statistic	5% Critical value	**Decision**
D.lnepi	-6.12*	-2.07	-6.14*	-2.68	Stationary
D.lnrgdp	-6.17*	-2.07	-6.09*	-2.68	Stationary
D.tropen	-5.56*	-2.07	-5.61*	-2.68	Stationary
D.lnpopl	2.91*	-2.07	-2.97*	-2.68	Stationary

The results of the Im, Pesaran and Shin (IPS) panel unit root test conducted on each of the variables are presented in Table 2. The test was conducted under the constant and constant and trend random walk conditions. The decision rule is based on the comparison of the test statistic with the 5% critical value under each of the random walk assumptions. The null hypothesis is rejected when the test statistic is greater than the 5% critical value under both of the random walk assumptions. The results presented showed that while *cred*, and *fdi* were all stationary at level; *lnepi*, *lnrgdp*, *tropen*, and *lnpopl* only became stationary after first differencing. The stationarity of the panel data variables validates their incorporation into the model for the purpose of estimating the relationship between the dependent and independent variables.

Panel Cointegration Test

The panel regression model specified to examine the impact of economic growth on environmental degradation- with environmental performance index as dependent variable. The panel cointegration test result presented in Table 3 shows that we cannot fail to reject the null hypothesis of no cointegration between the variables in each of the models tested. The results show that at no point did all the test statistics for the respective models prove to be statistically significant. Though some of the test statistics proved significant for the environmental performance index model, it was not sufficient to decide that a cointegrating relationship exists between the variables in each of the models. Hence, the econometric technique adopted for estimating the models ignores the estimation of an error correction term.

Table 3: The results of Pedroni (2004) test of cointegration for Environmental Performance index model ad estimated

Modified Phillips-Perron t Stat. [p-value]	**Phillips-Perron t** Stat. [p-value]	**Augmented Dickey Fuller t** Stat. [p-value]	**Comment**
-0.30[0.38]	-5.60*[0.00]	-2.36[0.01]	No Cointegration

Note 1: * signifies significance at 5% levels of significant errors respectively. Note 2:
Source: Authors’ computation, 2024

Table 4: The results of models estimated to examine the impact of economic growth on environmental degradation.

Independent variables	Dependent variable = Environmental performance Index				
	Fixed Effect		**Random Effect**		**Hausman Test**
	Coefficient	P-value	Coefficient	P-value	chi2 (p-value)
Lnrgdp	0.1953**	0.019	-0.1164***	0.000	103.18***
Fdi	0.0051	0.217	0.0030	0.607	(0.000)
Cred	-0.0018	0.110	0.0058***	0.000	
Tropen	0.0004	0.542	0.0003	0.789	
Lnpopl	-0.9100***	0.000	0.1157***	0.000	
const.	6.2240***	0.000	3.7927***	0.000	
R^2_W	0.5152	-	0.0073	-	
R^2_B	0.2682	-	0.5142	-	
R^2_O	0.0691	-	0.2307	-	
F-stat.	31.03***	0.000	-	-	
Wald	-	-	45.29***	0.000	

Note 1: *, **, and *** signifies significance at 10%, 5%, and 1% levels respectively. **Note 2:** R^2_W = R-squared within; R^2_B = R-squared between; and R^2_O = R-squared overall.
Source: Author’s computation, 2024.

Table 4 presents the results of the panel regression study examining the impact of economic growth on environmental degradation. The dependent variables used in this research are the environmental performance index. The Hausman test indicates that fixed effect models are the best suitable for interpretation due to the statistically significant test statistics (103.18 and 113.79) at the 1% significance level (p-value < 0.01). Hence, going forward, the interpretation of the result will be solely based on the fixed effect models. Firstly, the result of the fixed effect model estimated to examine the impact of economic growth on the environmental performance index shows that the coefficient (i.e., 0.1953) of the natural log of real GDP (*lnrgdp*) appeared with a positive sign. This implies that economic growth had a positive impact on the environmental performance index in all the selected countries. The p-value (i.e., 0.019) shows that the coefficient of economic growth is statistically significant at the 5% level of significant error. Moreover, the coefficients (i.e., 0.0051, -0.0018, 0.0004, -0.9100) of the control variables appeared with both positive and negative signs. This implies that while foreign direct investment and trade openness have a positive impact on the environmental performance index, credit to the private sector and population have a negative impact on the EPI. However, only population proved to be statistically significant at 1% level of significant error. While the within R-squared and between R-squared statistics were computed as 0.5152 and 0.2682, respectively, the overall R-squared is computed as 0.0691. This suggests that the model, on average, explains 51.52% of the variation within the panel variables, 26.82% of the variation between the panel variables, and 6.91% of the variation in the entire panel data. The computed F-statistic (i.e., 31.03) and its p-value (i.e., 0.000) imply that the dependent variable is significantly explained by the independent variables in the model. Thus, the entire model is statistically significant.

Lastly, the post-estimation diagnostic test results for the two models estimated to examine the impact of economic growth on environmental degradation are presented in Table 5. From the results presented in Table 5, we observe that we failed to reject the null hypotheses in all the tests conducted. This is so because while the p-values of the test statistics for heteroscedasticity, autocorrelation, Ramsey RESET omitted variables, and normality test were all greater than 0.05, the stability test statistics (i.e., 0.7162 and 0.5301) were less than the 5% critical value (i.e., 0.9479). Moreover, the recursive CUSUM plot presented in figures 4 shows that the plot fell within the 5% critical area. Hence, we conclude that the models passed all the post-estimation tests.

Table 5: The results of post-estimation diagnostic tests for the models estimated to examine the impact of economic growth on environmental degradation.

Dependent variable = Environmental performance Index

Tests	Test Statistic	Test of significance		Comment
		P-value	5% critical value	
Heteroscedasticity	0.24	0.6242	-	Fail to reject null hypothesis
Autocorrelation	3.221	0.0727	-	Fail to reject null hypothesis
Stability (Recursive)	0.7162	-	0.9479	Fail to reject null hypothesis
Omitted variables	1.92	0.1287	-	Fail to reject null hypothesis
Normality	0.1862	0.3941	-	Fail to reject null hypothesis

Note 1: * signifies significance at 5% levels of significant errors respectively.
Source: Authors' computation, 2024.

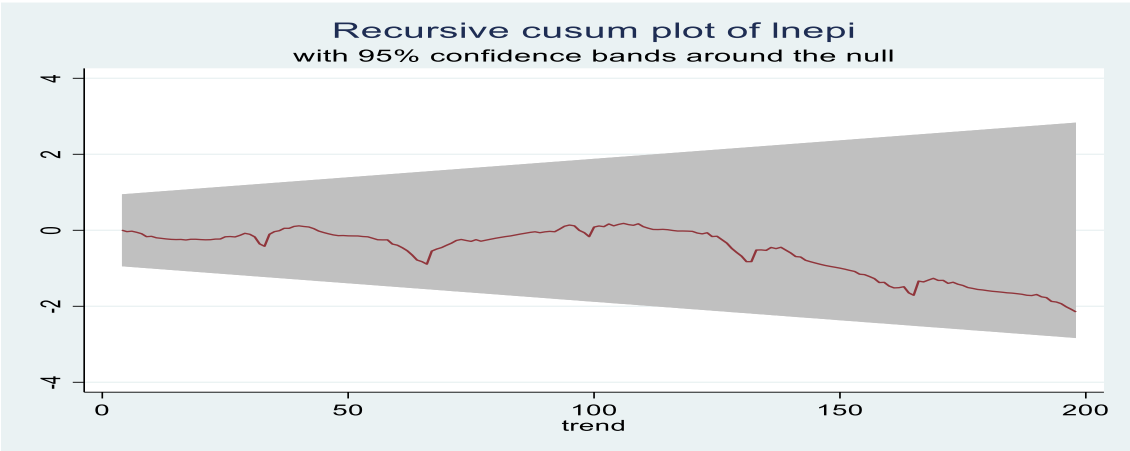

Figure 4: Recursive cumulative plot of EPI model estimated to examine the impact of RGDP
Source: Author's computation, 2024.

V. DISCUSSION OF FINDINGS

Significant findings have emerged from the data analysis to examine the effect of economic growth on environmental degradation among selected countries in Africa. The result shows that economic growth has the expected positive and significant impact on environmental performance index. This implies that increase in economic growth improves environmental performance in Nigeria. Population growth rate was found to have significant negative implication on environmental performance index which implies that increase in population retarded environmental performance.

Nigeria has witnessed stunted economic growth and very high population growth rate over the years. These might have contributed to the low environmental performance index. As at 2022, Nigeria's economic growth grew at about 3.10% while the national population growth rate was 2.4%. The rising population growth rate and the fluctuating GDP growth have further worsened poverty and environmental performance in the country.

EPI combines 58 parameters that cut across 11 categories such as climate change mitigation, air pollution, waste management, sustainability of fisheries and agriculture, deforestation and biodiversity protection. The 2024 report ranks Nigeria 141 with 37.5 score. This implies that Nigeria has very low environmental performance index hence low environmental sustainability. The findings of the study on the impact of economic growth on environmental sustainability does not conforms with findings from studies by numerous authors like Ajudua (2023), Igbru and Ifuruze (2021) and Derickand and Elisha (2019). These studies show that growth in several developing countries is not sustainable with the environment. Increase in production output is usually accompanied by environmental degradation in most developing economies and even some developed or emerging economies. The positive effect of trade openness on environmental performance deviated from earlier study by Ajayi and Ogunrinola (2020) while the negative effect of population growth conforms with the study by Ajayi and Ogunrinola (2020). This implies that population growth has serious implication on environmental performance in Africa.

VI. CONCLUDING REMARKS

This study examined the effect of economic growth on environmental sustainability among selected African countries. To achieve the objectives of this study economic growth was analysed along with foreign direct investment, credit to the private sector, population growth rate and trade openness to determine their impact on environmental performance index (proxy for environmental sustainability) on the six selected African countries namely: Angola, Algeria, Egypt Ghana, Libya, and Nigeria over the period 1990-2022 using panel analysis. Based on the analysis of the data trend analysis and econometric analysis of panel fixed effect regression econometric technique, some key empirical findings were made. Egypt had the highest environmental performance index (EPI), Direct relationship between the real GDP and environmental performance index (EPI) was visualised in Algeria, Egypt and Libya. Economic growth had a positive and significant impact on the environmental performance index. That FDI and trade openness had positive but marginal effect on environmental performance index while credit to the private sector and population growth rate had negative impact on environmental performance index in the selected countries. Based on the findings, the study recommended increase investment in the real sector and the increase in emission tax in order to sustain the environment in Africa.

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