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Environmental Degradation Determinants and Economic Growth in Ecowas Countries

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Abstract
The study examined environmental degradation determinants and economic growth in ECOWAS countries. The specific objectives were to: Investigate the impact of non-renewable energy consumption on economic growth in ECOWAS countries and examine the impact of industrial sector carbon emissions on economic growth in ECOWAS countries. This study made use of quantitative research design. The sampled six (6) out of fifteen (15) ECOWAS countries were selected based on availability of detailed data on study variables. The study countries were Nigeria, Ghana, Sierra Leone, Cabo Verde, Mali and Senegal out of Benin, Burkina Faso, Gambia, Cote d'Ivoire, Guinea, Liberia, Guinea-Bissan, Niger, and Togo. These variables consist of NREC is non-renewable energy consumption, ISC is industrial sector carbon emissions, TCE is transportation carbon emissions, FDI is foreign direct investment for a period of 1991 to 2022 as defined in our model specification and were sourced from World Bank development indicators. The data collected was subjected to descriptive statistic, correlation matrix, Panel Augmented Dickey-Fuller Unit Root test statistic and Panel Johansen Co-integration test. The method of data analysis was Panel Fully Modified Ordinary Least Square (FMOLS) Approach. The empirical results showed that non-renewable energy consumption (NREC) has negative and significant impact on economic growth in ECOWAS countries because [t-Statistics; -3.4658; P-value (0.0008) < significant value (0.05] and industrial sector carbon emissions (ISC) has negative and insignificant impact on economic growth in ECOWAS countries because [t-Statistic; -1.1588; P-value (0.2490) > its significant value (0.05]. The study recommended that government of ECOWAS countries should implement policies that will encourage the use of carbon capture and storage (CCS) technology involves capturing carbon emission from non-renewable energy consumption and other carbon emission generated by human activities.

Keywords: Environmental Degradation, Non-renewable Energy Consumption and Industrial Sector Carbon Emissions

1. Background of the Study

Economic Community of West African States (ECOWAS), over the years, have tried to develop their economies by shifting gradually from an agrarian economy to an industrialized one. This is not surprising since industrialization has been traditionally considered as the backbone for economic development (Ekundayo & Nwachukwu, 2018) [13]. The increase in economic development has led to global warming with carbon dioxide (CO_2) as the main gas at the center of the debate. Generally speaking, problems with environmental degradation are often linked with process of development and therefore have effects on local, regional, as well as global levels. These effects which are the result of human activities have devastating consequences on the environment and so are harmful to human beings, animals and plants and can be passed on to future generations (Adjei, Hamdiyah & Adzawla, 2022) [4]. In the face of global economic recession environmental degradation poses a great challenge to sustainable development. Ogboru and Anga, (2015) [27] opine that economic development is increasingly resulting in the emission of CO_2, with emission levels reaching 30 percent in the late 20th century. Shi (2003) suggest that high levels of pollutants in the atmosphere could lead to great disruption of the environment and create environmental degradation.

Meanwhile, environmental degradation is one of the factors that significantly contribute to economic growth and development. For instance, Achmad and Nurvita (2018) [1] argued that China's growth and development in recent years has contributed significantly to carbon emissions across the globe. Concerning the issues around the correlation between economic growth and environmental quality in ECOWAS, Alege and Ogundipe (2013) submitted that air pollution (mainly caused by smoke and noise), loss of forest areas, municipal waste problems, habitat destruction, threats to biodiversity, global greenhouse gases and the resource depletion are not unconnected to economic growth. The authors further argued that environmental degradation in Oil producing States in ECOWAS countries (Nigeria and Ghana) could be traced to the era of crude oil discoveries. The oil-induced economic performance has heightened the depth of environmental degradation, especially in the major oil-producing areas in the region of Oil producing States in ECOWAS countries (Nigeria and Ghana). Oil spillage by multinationals operating in the region has resulted in socioeconomic deprivation for farmers and traders without adequate compensation to the affected groups and communities. Despite the growth of natural resource endowment in most African countries, poor institutional quality, absence of accountability and weak rule of law, as well as, endemic corruption have, in most part, been responsible for environmental degradation on the continent (Simulders 2000 cited in Adekunle, *et al*. 2022). Studies on Nigeria have also exhausted these three strands of the literature (Iyabo, Lawal, Olayinka & Akinsola, 2021) [17]. They include, among others, Jaiyeola and Saibu, 2016 [18]; Nhung and Nguyen, 2018 [23]; Hichem and Lassad, 2020 [15]). Although their findings have been largely inconclusive, they have equally been too biased, because they failed to take into account the probable influences of other factors (such as, urbanization, combustible renewable waste) that contribute to CO2 emission in the economy. This study, therefore, extends the previous studies on Nigeria with a focus on re-examining the functional relation and the causal link between environmental degradation and its determinants in ECOWAS countries.

1.1 Statement of the Problem

Greenhouse gases and carbon emissions are the main causes of environmental deterioration worldwide. Researchers and scholars argued that global warming is directly or indirectly associated with the recurrence of the Malaria epidemic, which is again a growing concern internationally (Paramati, Shahzad, & Dogan, 2022; Adewuyi & Adefemi, 2016) [32, 3]. About 80 percent of the world's global warming is due to consumed energy, ∼75% is due to greenhouse gas emissions causing abrupt climate changes (Awosusi, Adebayo, Altunta¸ Agyekum, Zawbaa, Kamel, 2022) [7]. Severe climate changes have caused various diseases and health disparities. The global temperature varies with acute effects on human health (Dogan, Ben, Jebli, Shahzad, Farooq and Shahzad, 2020; Zhao, Ma, Chen, Shang & Song, 2022) [12, 40]. The impact of global warming depends on the human population (host) and infectious agents. It is a gradual process that has serious and harmful consequences with time. The environmental changes trigger and lead to a shift in disease patterns (Khasnis, Nettleman, 2019 [19]; Song, Zhao & Shang, 2020).

Over the past years, mortality and diseases have risen due to environmental pollution but also it is a hurdle in sustainable development (Altarhouni, Danju, & Samour, 2021) [5]. The Malaria outbreaks have befallen many temperate areas of the world. According to the research of the World Health Organization (WHO, 2022) and others, Malaria is a widely spreading infectious disease from Greenhouse gases. In 2020, half of the world's inhabitants were at risk of the infectious disease; Malaria. Approximately 241 million cases of Malaria were informed in 2020 and 227 million cases in the year 2019, while estimated deaths were 6,27,000 worldwide in 2020 (World Health Organization (2022). Additionally, WHO reports that it is expected that the climate conditions may threaten some regions of the world, causing the increasing transmission of Malaria by the year 2050. Escalating environmental degradation has raised the negative influence on health and positive association with institutional quality and health expenses. Institutional quality is important because it has significant benefits for environmental enhancement in many developed economies by reducing Carbon emissions (Lau, Choong & Ng, 2018; Zhao, Mahendru, Ma, Rao, & Shang, 2022) [21, 41].

The major cause of environmental degradation is greenhouse (GHG) and carbon dioxide emissions (Song, Peng, Shang & Zhao, 2022). These emissions are not only harmful to human health but also affect economic activity adversely (Yazdi, Zahra & Nikos, 2019). The findings of the notable studies indicated that environmental degradation negatively influences people's health. Infectious and other respiratory diseases are spread through carbon and Greenhouse gas (GHG) emissions worldwide. Due to this, the world has adverse impacts on human lives by reducing life expectancy. Health is a national asset that plays a significant role in the economy's prosperity. It governs the human capital, an imperative factor for the economy's growth. It is against these problem that this study is being carried out.

1.2 Research Questions

This study sought to provide answers to the following research questions.

1. What is the impact of non-renewable energy consumption on economic growth in ECOWAS countries?
2. What is the impact of industrial sector carbon emissions on economic growth in ECOWAS countries?

1.3 Objectives of the Study

The broad objective of the study was to examine environmental degradation determinants and economic growth in ECOWAS countries. The specific objectives were to:

1. Investigate the impact of non-renewable energy consumption on economic growth in ECOWAS countries.
2. Examine the impact of industrial sector carbon emissions on economic growth in ECOWAS countries.

1.4 Significance of the Study

This study was significant on three major perspectives: Namely theoretical, empirical and policy perspectives. Theoretically, this study will be anchored on the environmental Kuznets Curve (EKC) as a theoretical framework. The hypothesis of EKC is that environmental degradation will first increase with income, and later decline as rising income passes beyond a tipping point. The use of the environmental Kuznets Curve (EKC) as a theoretical framework in this study is a value addition.

Empirically, the primary contributions of this study as regard to literature are discussed as follows: (a) the study incorporated energy consumption from non-renewable energy carbon emissions, transportation carbon emissions, industrial sector carbon emission as main variable to analyze the nexus of emissions-growth-energy that was generally not considered in the energy literature of former studies and this more likely assist to alleviate the omitted variable bias."

In terms of policy, the research work is very important to investigate environmental problems and proffer solutions to them, to evaluate the economic implication of environmental degradation in ECOWAS countries and the relevance governmental agencies in formulating good policies in order to encourage public and private sectors on environmental problems and it control and to properly evaluate the cost and benefit of environmental degradation to the entire economy.

2. Literature Review

2.1 Conceptual Literature

2.1.1 Environmental Degradation

Environmental degradation is the deterioration of the environment through human activities resulting in the depletion of resources, contamination of air, water, and soil, the destruction of the ecosystems and the extinction of flora and fauna (wildlife). This could also be any change or disturbance capable of producing harmful effects on the environment i.e social, economic, technological and institutional activities, and consequently producing results that are undesirable for present and future generations. It occurs when earth's natural resources (water, air, soil) are depleted. Some factors that could affect the environment are urbanisation, population growth, economic growth and activities, intensification of agricultural activities, increase in the use of energy and transportation. Land, air and water are compromised when people exhaust and waste resources or release harmful chemicals. Deforestation also adds to the decay of a safe environment and the effects of environmental degradation are not farfetched as they stare us right in the face (Ogboru & Anga, 2015) [27].

2.1.2 Determinants of Environmental degradation and Economics Growth

Non-Renewable Energy consumption and Environment Degradation

Excessive use of energy due to industrial sector growth poses a great threat to environmental sustainability. Race of economic development compels the nations to use energy which exponentially increased with the passage of time. Higher economic growth necessitates lead to high consumption of energy, which in turn increase carbon emission and cause environmental pollution. Study of Ang (2007) confirms the existence of long run relation between energy consumption and environmental pollution in France.

Kırıkkaleli, Adebayo and Kondoz, (2022) [20] conducted a study that investigate the impact of globalization, technological innovation, economic growth on environmental degradation in South Africa, The empirical outcomes establish proof of a connection between CO2 emissions (CO2E) and technological innovation, economic growth, and globalization over time and frequency. Additionally, from the viewpoint of frequency-domain, this paper shows impressive wavelet coherence and robust lead/lag interaction. The empirical findings indicate that technological innovation, globalization, and economic growth depreciate the level of environmental quality in South Africa in the short and medium-term.

Foreign Direct Investment and Environmental Degradation

Oghenekaro and Ifurueze, (2021) [28] investigated the association between environmental degradation and the economic growth in Nigeria using sample from 2011 to 2020. Specifically the study sought to evaluate the effect of foreign direct investment, per capita GDP and population density on the carbon dioxide emission. The data analytical technique was Autoregressive Distributive Lag Model. The result shows 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. Audi and Amjad, (2018) [6] examined the determinants of environmental degradation under the perspective of globalization in the case of selected MENA nations. Specifically, the study sought to determine the environmental degradation (CO2 emissions), energy consumption, globalization index and population density on economic growth (per capita income) over the period of 1980 to 2017.

2.1.3 Economic Growth

Economic growth is the increase in the value of goods and services produced by a country over a period and Real Gross Domestic Product (RGDP) is used as a proxy for economic growth. Real gross domestic product is an inflation-adjusted measure which reflects the value of all goods and services produced by an economy in a given year, usually expressed in base-year prices, and is often graded as constant-price or inflation-corrected GDP. Unlike nominal GDP, real GDP can account for changes in price level and provide a more accurate figure of economic growth (Adu, & Denkyirah, 2017). GDP measures the monetary value of final goods and services—that is, those that are bought by the final user—produced in a country in a given period of time (say a quarter or a year). It counts all the output generated within the borders of a country.

Economic growth is conceptualized as the continuous increase in the per capita national product or net national period over a long period of time (Dwivedi, 2004). This suggests that the speed at which the total output increases must be greater than the speed at which population increases. Igbasan (2017) clarified that another measure of economic growth is that national product should comprise of goods and services that meets the urgent need of a reasonable number of people. He also maintained that economic growth can be ascertained by four important indicators such as national resources, human resources, technological development and capital formation.

2.2 Theoretical Literature

2.2.1 Environmental Kuznets Curve Theory

The Environmental Kuznets Curve Theory was created based on the hypothesis by Kuznets (1995) concerning the income inequality and economic development and was named after it. The Environmental Kuznets Curve considers the relation between different indicators reflecting environmental pollution and per capita income. Although environmental pollution increases in the first stages of economic growth, when higher levels of income are reached, economic growth provides environmental improvement. So the Environmental Kuznets Curve hypothesis proposes a relation between GDP and environmental pollution that appears to be an inverted U shape (Stern, 2003). There is an inverted U relationship or a turning point is reached when EKC hypothesis is accepted. The EKC is accepted if there is a positive relationship between GDP and CO2 on the short run and a negative relationship between CO2 and GDP on the long run.

2.3 Empirical Literature

Busayo and Hooi (2022) [10] evaluated economic growth, energy consumption and environmental degradation nexus in heterogeneous countries. Specifically, the study sought to examine the impact of energy consumption, real GDP, gross primary school enrolment on carbon emission (CO2). The methods of data analysis were Pesaran test, ADF-Fisher test, Breusch-Pagan LM test, Bias-corrected scaled LM test. We employ the Fully Modified Ordinary Least Squares (FMOLS), Dynamic Ordinary Least Squares (DOLS), Pedroni and Kao cointegration tests, Pooled Mean Group (PMG), the PMG estimation uses the cointegration form of the ordinary ARDL model. The findings of this study indicate 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 finds that education's direct effects aggravate 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 recommended 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. It is important, therefore, to provide education that promotes better environmental quality.

Majid and Dahmardeh (2022) [22] conducted a study to evaluate environmental kuznets curve hypothesis with considering ecological footprint and governance quality: Evidence from emerging countries. The aim of this study is to investigate the nexus among the ecological footprint as a multi-aspect indicator of environmental degradation, economic growth, renewable and non-renewable energies, and governance quality within the Environmental Kuznets Curve (EKC) hypothesis framework for two panels of European and Asian emerging countries during 1996–2017. The method of data analysis was generalized panel regression technique. Augmented Mean Group estimation results indicate an inverted U-shape nexus among the economic growth and ecological footprint, which implies validation of the EKC hypothesis in all two panels of countries. The findings indicate the positive impact of non-renewable energy and the negative influence of governance quality on the ecological footprint in all two panels. At the same time, there is evidence of the negative impact of renewable energy on ecological footprint only in European emerging countries. The study recommended that governments and policymakers pay closer attention to implementing non-renewable energy restrictive policies and renewable energy incentive policies. Furthermore, this is important to plan for improving various dimensions of governance quality to achieve better adoption and implementation of environmental policies, especially in the Asian emerging countries where it can lead to a more positive impact on environmental quality according to the results of estimated coefficients.

Adekunle, *et al*. (2022) conducted a study to analyse of environmental degradation and its determinants in Nigeria: New evidence from ARLD and Causality approaches specially, the study sought to investigate impact of carbon emissions and intensity, transportation infrastructure, population size, technical progress, energy intensity, urbanization level, trade openness, industrial structure on economic growth in Nigeria covering 1977 to 2015. The methods of data analysis were ARDL model estimation and Granger causality test. The empirical result of the study shows that there is a positive relationship between economic growth and environmental degradation (measured by carbon emission). A positive relation was also established between energy consumption and carbon emission. Similarly, this study reported a positive relationship between transport services in the import and export sectors and carbon emission. Through the Granger causality test, the study established a unidirectional causality running from carbon emission to economic growth. Similarly, there was a unidirectional causality running from economic growth to transport services in the export sector. The study recommended that there is an increasing need for the authorities to regulate economic activities that directly and indirectly contribute to systematic environmental degradation in Nigeria.

Iyabo, Lawal, Olayinka and Akinsola, (2021) [17] explored impact of carbon emissions and economic growth in Nigeria. This study tests the environmental kuznet curve (EKC) hypothesis to find evidence of an inverted-U relationship between carbon emissions and economic growth in Nigeria from 1980-2016. Annual time series data was gotten from world development index (WDI). The methods of data analysis were ADF Fisher Chi-square test, Pedroni's co-integration test, Toda Yamamoto Causality Test and Auto-regressive distributive Lag Model ARDL. There is an inverted U relationship or a turning point is reached when EKC hypothesis is accepted. The ekc is accepted if there is a positive relationship between GDP and CO2 on the short run and a negative relationship between CO2 and GDP on the long run. The findings show that Nigeria has not reached a turning point in its level of carbon emissions as economic growth increases. Nigeria is still at the initial stage of growth where carbon emissions accelerate as growth increases. The study recommended that there is need for policies that will broaden the use of renewable energy such as solar, wind energy as energy sources in meeting the energy needs of the fast growing population in Nigeria. There is need to ensure that imported vehicles into Nigeria must meet emission standards to reduce carbon emissions from road transportation. These policies will be instrumental in creating a turning point in carbon emission growth in Nigeria otherwise higher carbon emissions will pose higher risk of future climate change impact in Nigeria and to the rest of the world.

Mouez, Oussama and Lotfi (2021) [25] investigated the relationship between the economic growth and the environmental degradation in Tunisia. The specific objective of the study was to ascertain influence of carbon dioxide (CO2) and sulfur dioxide (SO2) on GDP as the economic indicator during the period of 1961-2004. The data analytical technique was Autoregressive Distributive Lag Model. The empirical results show that there is a long-run cointegrating relationship between the per capita emissions of two pollutants and the per capita GDP. An inverted U relationship between SO2 emissions and GDP has been found. However, a monotonically increasing relationship with GDP is found more appropriate for CO2 emissions.

Furthermore, we assess the causal relationships between the variables using the recent causality tests available in the literature. The causality results support the argument that the relationship between income and pollution in Tunisia is one of unidirectional causality with income causing environmental changes and not vice versa, both in the sort-run and long-run. The study recommended that government of Tunisia should policies that gear towards emission reduction and more investment on pollution abatement expense will not hurt the economic growth and can be a feasible policy tool for Tunisia to achieve its sustainable growth in the long-run.

Syed, Syed, Samia and Nasir (2021) [36] examined associating drivers of economic development with environmental degradation in Western Asia and North African region. Specifically, the study sought to quantifies the Environment Kuznets curve's validity against two different environment proxies, the ecological footprint and carbon emissions for selected seventeen Western Asia and North African countries over the period 1980 to 2017. The study employs the Interactive Fixed Effect (IFE) and Dynamic Common Correlated Effect (D-CCE) to quantify the long-run association among variables in a multiplicative framework. The empirical outcomes indicate that the inverted U-shaped hypothesis is not valid for carbon emission; however, it holds for ecological footprint. The results show that energy intensity and financial development are environment-friendly indicators. Likewise, biomass energy consumption exposes a negative and statistically significant influence on proxies of environmental degradation. Causality findings reveal bidirectional causal links between economic development and its square to emission, biomass energy consumption, and financial development; also, bidirectional causality has been observed from energy intensity to biomass energy in the first model. The study recommended that policymakers should focus on the policy options to increase energy efficiency to get a clean environment.

Olabanji and Adeolu (2020) [29] explored the role of non-renewable energy consumption in economic growth and carbon emission oil producing economies in Africa. Specifically, the study sought to examine investigate the role of non-renewable energy in economic growth and carbon emissions among the top oil producing economies in Africa during 1980–2015. The data analytical techniques were nonlinearity and structural break in unit root and cointegration analysis and non-linear autoregressive distributed lag (NARDL) technique. The study reveals evidence of asymmetric effect of per capita consumption of both petroleum and natural gas consumption on economic growth and carbon emission per capita in all the selected countries except Algeria. In Nigeria, although positive change in the non-renewable energy consumption retards growth, it reduces emission. In the case of Gabon, increase in the consumption of these energy products promotes growth and enhances environmental quality. Consumption of these energy types has negligible impact on environmental pollution in Egypt as it enhances economic growth. While positive change in the non-renewable energy consumption contributes to economic growth in Angola, the effect on carbon emission is mixed across time and energy type. In addition, the influence of negative change in petroleum and natural gas consumption is similar to those observed for positive change in Egypt and Nigeria. It is therefore imperative for policymakers in oil producing economies (in Africa) to explore avenues to invest in, and promote, carbon-reducing technology in production processes in their quest for economic growth if they must continue to increase the consumption of their abundant resources-petroleum and natural gas.

Enjema, Molem, Dobdinga, Afuge, and Ngoe (2020) [14] conducted a study to investigate the relationship between urbanization and environmental sustainability in Cameroon. Specifically, the study sought to evaluate the influence of urbanization, trade openness, foreign direct investment and the environment sustainability in Cameroon using time series data from 1991 to 2018. The methods of data analysis were STIRPAT framework, the Principal Components Analysis and Autoregressive Distributed Lag Technique. The models were tested for stationarity by applying the Phillip-Peron test. Results indicated that urbanization and trade openness had positive and significant effects on environmental sustainability in the long-run but negative in the short-run, thus, supporting an inverted U-shaped EKC. The study therefore, recommended that Cameroon revisits its trade policies and urban planning strategies and implement policies that will discourage dirty technology and encourage technological innovations (green) so as to improve energy efficiency which will go a long way to improve environmental sustainability.

Hichem and Lassad (2020) [15] conducted a study to examine impact of renewable energy consumption on carbon dioxide emissions and economic growth in the Kingdom of Saudi Arabia. The specific objectives of the study were examine the relationship between energy consumption, gross fixed capital formation, trade openness, foreign direct investment and real GDP per capita cover the period of 1990 and 2018. The methods of data analysis were ADF Fisher Chi-square test, Pedroni's co-integration test and panel ARDL. The empirical results indicate a unidirectional causal relationship between GDP and energy consumption. A unidirectional causal relationship is between energy consumption and long-term CO2 emissions. The results suggest that carbon dioxide emissions and energy consumption are not driving economic growth. The results also help save the world from natural disasters and conserve the environment under sustainable development policies. It also provides a new perspective on the relationship between energy consumption, economic growth, and carbon dioxide emissions. The study recommended that government of Saudi Arabia can maintain a conservative energy policy and a long-term carbon reduction policy without hindering economic growth.

2.4 Gap in Literature

There is no clear consensus till date in the literature as to whether Environmental Kuznet Curve (EKC) theory obtainable in developing countries especially in ECOWAS countries, this study will bridge the gap by providing clear explanation as regards to cause-effect relationship between environmental degradation determinants and economic growth in ECOWAS countries.

3. Methodology

This study made use of quantitative research design. The second range of coverage by this study is on geographical area which is limited to ECOWAS countries. The sampled six (6) out of fifteen (15) ECOWAS countries were selected based on availability of detailed data on study variables. The study countries were Nigeria, Ghana, Sierra Leone, Cabo Verde, Mali and Senegal out of Benin, Burkina Faso, Gambia, Cote d'Ivoire, Guinea, Liberia, Guinea-Bissan, Niger, and Togo. These variables consist of NREC is non-renewable energy consumption, ISC is industrial sector carbon emissions, TCE is transportation carbon emissions, FDI is foreign direct investment for a period of 1991 to 2022 as defined in our model specification and were sourced from World Bank development indicators. The data collected was subjected to descriptive statistic, correlation matrix, Panel Augmented Dickey-Fuller Unit Root test statistic and Panel Johansen Co-integration test. The method of data analysis was Panel Fully Modified Ordinary Least Square (FMOLS) Approach.

3.1 Model Specification for the Study

The functional form of the model used in this work is specified in equation 5 as

$$RGDP = F\ (NREC, ISC, TCE, FDI) \qquad (5)$$

Where NREC is non-renewable energy consumption, ISC is industrial sector carbon emissions, TCE is transportation carbon emissions, FDI is foreign direct investment. Equation (3.5) was therefore re-written in linear form as follows:

$$GDP = \beta_0 + \beta_1 NREC_t + \beta_2 ISC_t + \beta_3 TCE_t + \beta_4 FDI_t + \mu_t \qquad (6)$$

Where: µt = error term. Specifically, to achieve the objective of this study and based on the perfect linearity of variables, the panel functional relationship in this study is modeled in a linear equation as:

$$RGDP_t = \beta_0 + \beta_{it}\sum_{i=1}^{n} NREC + \beta_{it}\sum_{i=1}^{n} ISC + \beta_{it}\sum_{i=1}^{n} TCE + \beta_{it}\sum_{i=1}^{n} FDI + \mu_{it} \qquad (7)$$

Where: β0 = Constant term, β_1 to β_8 = Regression coefficients, μ_t = Error Term and t is the period. To reduce the outliers among the variables, all variables will be expressed in logarithmic form.

$$LogRGDP_t = \beta_0 + \beta_{it}\sum_{i=1}^{n} LogNREC + \beta_{it}\sum_{i=1}^{n} LogISC + \beta_{it}\sum_{i=1}^{n} LogTCE + \beta_{it}\sum_{i=1}^{n} LogFDI + \mu_{it} \qquad (8)$$

Where: μ_{it} is the error term which denotes other variables that are not specified in the model; i represent the number of countries and t is the number of years. The parameter estimates t >0. The panel data estimation (also known as the longitudinal or cross-sectional time-series data) technique was conducted under the random effect assumption to factor in the possibility of either an autoregressive model with a fixed effect or a random walk with drift. The error term was the standard disturbance term, which varies across years and countries.

3.2 Methods of Evaluation

3.2.1 Panel Fully Modified Ordinary Least Square (FMOLS) Method

The fully modified ordinary least squares (FM-OLS) regression of Phillips and Hansen (1993) is used in this study to develop new methods for estimating cointegrating coefficients. FM-OLS estimates have a limit distribution that is mixed normal for all the non-stationary coefficients. In its basic form, an FMOLS regression model looks like this:

$$\Delta RGDP_t = \beta_0 + \beta_{it}\sum_{i=1}^{n}\Delta NREC + \beta_{it}\sum_{i=1}^{n}\Delta ISC + \beta_{it}\sum_{i=1}^{n}\Delta EGC + \beta_{it}\sum_{i=1}^{n}\Delta RBC + \beta_{it}\sum_{i=1}^{n}\Delta TCE + \beta_{it}\sum_{i=1}^{n}\Delta FDI + \beta_{it}\sum_{i=1}^{n}\Delta FOREST + \beta_{it}\sum_{i=1}^{n}\Delta UPS + \mu_{it} \qquad (9)$$

Where μ_{it} is a random "disturbance" term. The model is "autoregressive", in the sense that y_t is "explained (in part) by lagged values of itself. It also has a "distributed lag" component, in the form of successive lags of the "x" explanatory variable. Sometimes, the current value of x_t itself is excluded from the distributed lag part of the model's structure.

Justification of Panel Fully Modified Ordinary Least Square (FMOLS) Approach

1. Compared with OLS, the FM-OLS estimator removes asymptotic bias and increases efficiency by correcting both the long run serial correlation in and endogeneity in caused by the long run correlation between u 0 t and u x t.
2. The FM-OLS estimator minimizes the prediction error between the predicted and real values by choosing minimize the sum of squared errors instead of the sum of errors directly.

3.3 Econometric Software for the Work

The study employed e-view version (9) statistical application software to analysis the data because it is user-friendly software.

4. Results and Discussion

Table 1: Descriptive Statistics of the Variables

	RGDP	NREC	ISC	TBC	FDI
Mean	238652.1	99715.84	357350.6	198296.2	20215.43
Median	213911.9	2068.188	1096.260	734.8950	1917.440
Maximum	857019.4	4890270.	4890270.	2133114.	210075.8
Minimum	707.4486	99.00900	94.55000	5.810000	139.3100
Std. Dev.	233590.4	567509.3	942702.9	531127.6	37518.59
Skewness	0.888590	6.815880	2.749839	2.638296	2.786548
Kurtosis	2.939305	50.79449	9.634964	8.464223	11.51237
Jarque-Bera	25.29645	19761.10	594.1535	461.6013	828.1593
Probability	0.000003	0.000000	0.000000	0.000000	0.000000
Sum	45821208	19145440	68611313	38072870	3881363.
Sum Sq. Dev.	1.04E+13	6.15E+13	1.70E+14	5.39E+13	2.69E+11
Observations	192	192	192	192	192

Source: Author's computation from E-view

The table showed descriptive statistics of the variables. In the model estimated in the study, there was one dependent variable and six independent variables. These variables consisted of Real GDP (RGDP) was dependent while non-renewable energy consumption (NREC), industrial sector carbon emissions (ISC), transportation carbon emissions (TCE) and foreign direct investment (FDI) were independent variable respectively. The mean, median, maximum, minimum and sum of each variables were given respectively.

4.1 Correlation Matrix of the Variables

Table 2: Result of Correlation Matrix

	RGDP	NREC	ISC	TBC	FDI
RGDP	1	0.7466	-0.0542	-0.0951	-0.1543
NREC	0.7466	1	-0.0991	-0.1401	-0.1562
ISC	-0.0542	-0.0991	1	0.8508	-0.0359
TBC	-0.0951	-0.1401	0.8508	1	-0.1607
FDI	-01543	-0.1562	-0.0359	-0.1607	1

Source: Author's computation from E-view

This correlation matrix presented a table showing correlation coefficients between sets of variables. Each random variable (X_i) in the table is correlated with each of the other values in the table (X_j). This result of correlation matrix helped to identify which pairs of variables have the highest correlation. This test is to detect whether exact or perfect relationship exist among explanatory variables (multicollinearity). This test presented clear understanding on the assumption of ordinary least square that there is no perfect or exact linear relationship among explanatory variables. The result of correlation matrix showed that every explanatory variable in the study is linearly independent of each other.

4.2 Unit Root Test using Augmented Dickey-Fuller Fisher Test

Table 3: Results of Stationarity (Unit root) test

Variables	ADF-Fisher Chi-Square Statistics	P-Value	Lag Number	Order of integration
RGDP	3.5810	0.0000	1	I (1)
NREC	11.1132	0.0000	1	I (0)
ISC	9.9981	0.0000	1	I (1)
TBC	5.4609	0.0000	1	I (1)
FDI	5.3576	0.0000	1	I (1)

Source: Author's computation from E-view

In the Table 3, the variables that were tested with unit root are shown, the values for Fisher Augmented Dickey-Fuller (ADF) Fisher statistics are presented, the lag level of each variable was identified, and the P-values at 5% level of significant were pointed out. The order of integration of each variable was enumerated, and finally the stationarity position of each variable was also stated. The research work based the level of augment whether the variable was stationary or not stationary on P-value at 5 percent. When Augmented Dickey-Fuller statistic is greater than P-value 5 percent critical value in absolute term, it is concluded that the variable is stationary. The variable Real GDP (RGDP) passed through Unit Root analysis at first differentiation and lag 0, augmented Dickey-Fuller statistic was 3.5810 while the P-value was 0.005 hence it was stationary at first difference. The variable non-renewable energy consumption (NREC) was stationary at first difference and lag 0; its augmented dickey-Fuller statistic was 11.1132 while the P-value was 0.005. The variable industrial sector carbon emissions (ISC) was stationary at first difference and lag 0; its augmented Dickey-Fuller statistic was 9.9981 while the P-value was 0.005. The variable foreign direct investment (FDI) was stationary at first difference and lag 0; its augmented Dickey-Fuller statistic was 5.3576 while the P-value was 0.005. It is now referable to use Hausman test to identify best panel model specification to estimate the parameters.

4.3 Co-integration Test Results

Ho = There is no co-integration (no long run relationship among Variable)

Table 4: Co-integration Test Results

Unrestricted Cointegration Rank Test (Trace and Maximum Eigenvalue)				
Hypothesized	Fisher Stat.*		Fisher Stat.*	
No. of CE(s)	(from trace test)	Prob.	(from max-eigen test)	Prob.
None	102.8	0.0000	548.3	0.0000
At most 1	731.4	0.0000	208.7	0.0000
At most 2	308.9	0.0000	450.0	0.0000
At most 3	231.9	0.0000	333.7	0.0000
At most 4	126.6	0.0000	792.7	0.0000
* Probabilities are computed using asymptotic Chi-square distribution.				

Source: E-view Results

The co-integration results in Table 4 for the model (RGDP, NREC, ISC, TCE) reveals that both trace test and the Max-eigenvalue test indicate 2 co-integrating equation(s) at the 5 percent level of significance. Thus, there is a long-run relationship among the variables (RGDP, NREC, ISC, TCE, FDI). We therefore reject the null hypothesis of no co-integration amongst the variables and accept the alternative hypothesis.

Table 5: Results of Fully Modified Least Squares (FMOLS) Estimation

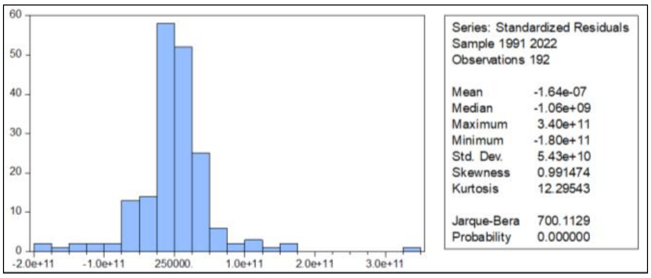
Dependent Variable: LogRGDP				
Method: Panel Fully Modified Least Squares (FMOLS)				
Date: 07/17/23 Time: 08:04				
Sample (adjusted): 1991 2022				
Periods included: 32				
Cross-sections included: 6				
Total panel (balanced) observations: 192				
Panel method: Pooled estimation				
Cointegrating equation deterministics: C				
First-stage residuals use heterogeneous long-run coefficients				
Coefficient covariance computed using default method				
Long-run covariance estimates (Bartlett kernel, Newey-West fixed bandwidth)				
Warning: One more more cross-sections have been dropped due to estimation errors				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LogNREC	-0.007606	0.002194	-3.465893	0.0008
LogISC	-0.003329	0.002872	-1.158823	0.2490
LogEGC	0.094315	0.048235	1.955318	0.0531
LogFDI	-0.290805	0.088166	-3.298398	0.0013
R-squared	0.963026	Mean dependent var		305613.6
Adjusted R-squared	0.958656	S.D. dependent var		251984.4
S.E. of regression	51236.49	Sum squared resid		2.89E+11
Long-run variance	1.40E+08			

Source: E-view Results

The Panel Fully Modified Least Squares (FMOLS) model specification was carried out to examine parameters estimates. In testing this hypothesis, non-renewable energy consumption (NREC), industrial sector carbon emissions

(ISC), transportation carbon emissions (TCE), foreign direct investment (FDI), were regressed against Real GDP (RGDP). The result of the regression analysis represents the model for investigating environmental degradation determinants and economic growth in ECOWAS countries. The empirical result showed that the coefficient of non-renewable energy consumption (NREC) has negative significant impact on Real GDP (RGDP) because [P-value (0.0008) was less than its significant value (0.05]. The empirical result showed that the coefficient of industrial sector carbon emissions (ISC) has negative and insignificant impact on Real GDP (RGDP) because [P-value (0.2490) was greater than its significant value (0.05]. The transportation carbon emissions (TCE) has positive and significant impact on Real GDP (RGDP) because [P-value (0.0000) was less than its significant value (0.05]. The foreign direct investment (FDI) has negative and significant impact on Real GDP (RGDP) because [P-value (0.0013) was less than its significant value (0.05]. Again, our empirical result showed that the R-squared (R^2) is 0.9630.

4.4 Econometric /Second Order Test
4.4.1 Histogram Normality Test



Sources: E-view 9.0 Version

Fig 1: Presents Normality test for each of the Distribution

Jarque-Bera (JB) test is statistics that compute both skewness and Kurtosis. Skewness shows the degree symmetry (normal distribution). The normal measurement is zero/0. Kurtosis is a statistics that compute degree of peakedness. The normal measurement is three/3. A distribution is skewed if one of its tails is longer than the other. A skewed distribution can be positive or negative. Positive skewed distribution means that it has a long tail in the positive direction. Negative skewed distribution means that it has a long tail in the negative direction. The null hypothesis is that there is no skewness and Kurtosis in the model. We reject the null hypothesis because the Jarqua-Bera statistics (700.1129) is greater than probability value (0.000). We reject null hypothesis and accept the alternative that there is no skewness and Kurtosis in the model. The skewness is normal because the value was 0.9914. The model of the study produced positive skewed distribution meaning that it has a long tail in the positive direction. The kurtosis was 12.2954 meaning that the degree of peakedness was high that normal value of three (3). This implies that the standardized residuals from the estimated model in the regression framework is normally distributed, which is consistent with the OLS assumption.

Test of Hypotheses

The results for the various hypotheses testing are presented in the section.

Test of Hypothesis one

H_{O1} Non-renewable energy consumption has no significant impact on economic growth in ECOWAS countries.

In testing this hypothesis, non-renewable energy consumption (NREC) was regressed against real GDP. The empirical result showed that the coefficient of non-renewable energy consumption (NREC) has negative and significant impact on economic growth in ECOWAS countries because [t-Statistics; -3.4658; P-value (0.0008) < significant value (0.05]. The null hypothesis was rejected and alternative hypothesis was accepted.

Test of Hypothesis two

H_{O2} Industrial sector carbon emissions have no significant impact on economic growth in ECOWAS countries.

In testing this hypothesis, industrial sector carbon emissions (ISC) was regressed against real GDP. The empirical result showed that the coefficient of industrial sector carbon emissions (ISC) has negative and insignificant impact on economic growth in ECOWAS countries because [t-Statistic; -1.1588; P-value (0.2490) > its significant value (0.05]. The null hypothesis was accepted and alternative hypothesis was rejected.

5. Summary of Findings

The following are the major findings of the study**:**

Non-renewable energy consumption (NREC) has negative and significant impact on economic growth in ECOWAS countries because [t-Statistics; -3.4658; P-value (0.0008) < significant value (0.05]. Non-renewable energy consumption has 76 percent negative and significant impact on economic growth in ECOWAS countries. A percent change in non-renewable energy consumption result to 76 percent decrease in economic growth in ECOWAS countries.

Industrial sector carbon emissions (ISC) has negative and insignificant impact on economic growth in ECOWAS countries because [t-Statistic; -1.1588; P-value (0.2490) > its significant value (0.05]. Industrial sector carbon emissions have 33 percent negative and insignificant impact on economic growth in ECOWAS countries. A percent change in industrial sector carbon emissions result to 33 percent decrease in economic growth in ECOWAS countries.

5.1 Conclusion

The study aimed at examining the impact of environmental degradation determinants on economic growth in ECOWAS countries from the periods 1991 to 2022. This study concludes that non-renewable energy consumption, industrial sector carbon emissions, transportation carbon emissions (TCE), foreign direct investment (FDI), are environmental degradation determinants that affects economic growth in ECOWAS countries. Non-renewable energy consumption and industrial sector carbon emission have negative and insignificant impact on economic growth in ECOWAS countries while deforestation (FOREST) and urban population size (UPS) have positive and significant impact on economic growth in ECOWAS countries.

The study provided empirical evidence that fail to support the position of Environmental Kuznets Curve theory that environmental degradation determinants have positive influence with economic growth and later environmental degradation determinants decline as rising national income passes beyond a tipping point. The Environmental Kuznets Curve considers the relation between different indicators reflecting environmental pollution and per capita income. Although environmental pollution increases in the first stages of economic growth, when higher levels of income are reached, economic growth provides environmental improvement. So the Environmental Kuznets Curve hypothesis proposes a relation between GDP and environmental pollution that appears to be an inverted U shape (Stern, 2003). There is an inverted U relationship or a turning point is reached when EKC hypothesis is accepted.

5.2 Recommendations of the Study

Based on the findings of this study, the following recommendations were made.

1. Government of ECOWAS countries should implement policies that will encourage the use of carbon capture and storage (CCS) technology involves capturing carbon emission from non-renewable energy consumption and other carbon emission generated by human activities at its sources example; household gas emission or industrial facilities—and storing it permanently underground in geologic formations, such as depleted oil and gas reservoirs. Policymakers should focus on increasing the proportion of biomass energy consumption in total energy use to establish a sustainable future. Biomass energy consumption in terms of renewable energy rises environmental quality; hence, with increasing economic development.
2. Government of ECOWAS countries should raise public awareness to industrial sectors in order to reduce environmental pollution and make significant structural reforms. Likewise, people become more aware of environmental concern and follow environmental laws and regulations with a better income. This awareness and structural change diminish environmental degradation in turn because environmental contamination.

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