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Financial Development, Energy Supply and Environmental Quality in West Africa

Kayode Kolawole*

Department of Financial Intelligence, College of Accounting Sciences, University of South Africa, Pretoria, South Africa.
*Email: kolawolekayodedavid@gmail.com

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ABSTRACT

This research investigates the influence of financial development and energy supply on environmental quality in West Africa. The study's data spans from 2009 to 2023 and was obtained from the World Development Indicator database. We employed the panel autoregressive distributed lag (P-ARDL) estimator for the analysis. Empirical evidence indicated that private sector lending substantially influences environmental quality in West Africa. Access to electricity dramatically influences environmental quality in West Africa. This illustrates that investment in the private sector and sufficient electricity generation enhance environmental quality within the West African economy. The study concludes that financial development and energy supply significantly influence environmental quality. The report advises that West African financial institutions should establish green financing methods to direct loans towards environmentally non-polluting projects.

Keywords: Financial Development, Energy Supply, Environmental Quality, (P-ARDL)
JEL Classifications: G21, Q430, Q51

1. INTRODUCTION

The financial development has taken on including a capital cornerstone in the West African region; it is in this cornerstone that the accumulation of capital is continued, the spurring on of industrialization and the stimulation of entrepreneurial life takes place. Researchers in the area also note that, combined with the consolidation of national reserves, the adoption of efficient financial strategies is an opportunity to allocate resources to productive and sustainable environmental projects, thus, improving future development (Naidoo, 2019). The large-scale growth of credit institutions, micro-financial facilities, and electronic financial systems has resulted in the growth of financial inclusion for individuals at both socio-economic and ecological scales (Anu et al., 2023). The intensification of core financial transactions without regarding environmental viewpoints is an enormous danger where institutions of policies and improper regulatory frameworks would hamper the prospects of the realization of green finance in the region (Amer and Kareem, 2025).

At the same time, increased accessibility and presence of energy are factors that promote economic and environmental performance. Based on all studies they have shown empirically that this makes industry more competitive, stimulates growth in innovation, reduces dependence on ecologically-damaging alternative energy sources, supporting the use of renewable energy (Caglar and Askin, 2023). On the other hand, weakening the quality of the environment and increasing the prominence of greenhouse gases, caused by never-ending turmoil regarding energy insecurity and poverty (Kocak et al., 2023). Unstable energy supplies leave industries, and households with no other option but to turn on the diesel generator, which does not help to decrease the carbon-emissions or clean the surrounding air (Heidari et al, 2024). Climate conditions are dual, and thereby limit the understanding

that a good policy of power is a decisive factor behind the prosperity and wellbeing of East Africa and that the same policy is too weak to impose price restrictions, promote stalemation, and control ecological policy governance.

The inexorable processes of demographic growth and industrialisation, combined with the overall ineffectiveness of regulatory instruments and barriers, have triggered the perceptible worsening of environmental situation occurrences in the subregional dimension over the past few decades. Experience shows that, when a state manages to achieve economic growth through system competence, the associated excess foment above this economic development is often invested in green technologies. In contrast, uncontrolled exports to carbon-based and extractive industries are often characterized by a high-cost environment (Habiba et al., 2022; Bashir et al., 2020). That is, the green finance indicators the International Monetary Fund assumed to be propelling finance, like carbon credit market, lending that is sustainability-oriented, and green disclosure regulation application, must be integrated in order to harmonize the financial sector adjustment towards taking place in line with the objective of environmental stewardship (Eyo-Udo et al, 2024). However, when economic players have superior power to push the economic growth, it will equally destabilise the environmental balance.

Despite the accumulation of empirical evidence which characterises the interdependence of environmental quality, financial development, and energy supply in West Africa, many linkages have yet to be theorised and explored sufficiently. The above studies conducted in isolation analysis of discrete variables thus, not establishing the correlation among those variables (Zhang and Umair, 2023; Chen et al., 2024). Additionally, a lack of study focused on apparent interrelation relationships, i.e. whether the implementation of clean energy triggers economic growth or vice versa, whether green financial systems triggers clean energy or the presence of clean energy triggers the implementation of green financial systems is scant. The current research fills these gaps by adopting a mixed - methods approach to produce empirical data on the effectiveness of such variables as financial development, energy supply reliability, and environmental quality to estimate the synergistic contribution of these variables to West Africa. To this end, the study aims at providing an innovative empirical research input to the current body of knowledge on the mediation or mechanical role of energy reliability and financial depth towards the realisation of lower or higher levels of environmental degradation thus providing evidence that can be utilised by policy makers and individuals interested in a sustainable regional development.

2. THEORETICAL REVIEW

2.1. Environmental Kuznets Curve (EKC) Theory

It has been argued that economic development can be taken to imply a declining U-shaped pattern of environmental degradation (Grossman and Krueger, 1995). In this theory the atman separation at a tender stage of development leads to an increase in pollution and environmental degradation in relation to the consumption of natural resources and industrial output. But with a higher level of average income, the population groups are also finding a more requirement of clean environment (and thus tighter control and more investments on environment protection mechanisms) and as a result improvement of the quality of the environment.

According to EKC model, the ultimate outcome of economic growth consisting of technological advancement and institutional changes is the enhancement of the environment (Wang et al., 2024). The process of development shows that, in enhancing the first stage of development pollute the environment, at some other time a balance is attained in order to enhance the economic and political mechanism that provide the environment with a new balance (Acheampong and Opoku, 2023).On the other hand, it means that the economic development will cause further harm to the environment since no achievement of the turning point of the curve means the further depression of the environment (Hunjra et al., 2024).

Specifically, the EKC framework applies to West Africa since the region continues relying heavily on fossil fuels, whilst frequent power shortages have plagued the area. The issue of rapid urbanisation and industrialisation impact the environment negatively; however, the trend can be shifted towards sustainable development, leveraging monetary resources in constructing renewable energy and enhancing financial instruments. As a result, the EKC can play a handy contribution to the study of the role of the water-energy nexus in long-term environmental sustainability in the sub-region and, in particular, its consideration in conjunction with financial processes of development.

2.2. Financial Repression Theory

Stiglitz (1989) formulated the theories of Financial Repression in which he asserts that under economic development hinders the manifestation of economic advancement since it blocks the aggregation of savings, acts with bias in resource distribution, and denies much-needed credit facilities. Its main argument is that it is financial underdevelopment or, as it is called, repression, which stands in the effective way of intermediating between the saver and individuals or companies who have saved their money and those who use it productively to invest in the economy and generate expansion of the economy more generally.

The theory continues by asserting that the resulting deeper financial system localization and liberalization reduce transaction costs, lead to better capital allocation, and purposes such as financial inclusion, which increases investment, in turn, into productive and new sectors (Peng et al., 2021). The available evidence suffers in support of the idea that the monetary inoculation of financial bottlenecks dispels credit shortages, expands access to financial products, and directs savings into long-term and sustainable businesses with strong growth potential (Oluleye, 2017). On the other hand, narrow and shallow continuous money markets are constraining when it comes to investing resources utilized in keeping environment current and infrastructural offices (Qaysi, 2025).

The theory is believed to become more relevant in a Western

African context when applied to green finance. Poor financial attributes in the region hinder access by entrepreneurs and governments to funds meant to protect the environment and green energy conversions. The likely step to alleviate the cycle of financial repression and reallocate capital flows to clean new sources of environmental benefits and clean energy is deepening markets, expanding financial inclusion, and spurring the instruments of green money motivating green bonds and carbon-credit type mechanisms.

2.3. Empirical Review

In the paper, Prempeh (2024) concentrated on the issue of how economic expansion, financial development, globalization, renewable energy, and industrialization might aid reducing environmental degradation in Economic Community of West African States. Using DriscollKraay regression and panel quantile estimates based on ten ECOWAS economies, the author proves the N-shaped Environmental Kuznets Curve (EKC) model and reports that financial development and usage of renewable energy result into negative environmental degradation effects and that globalization and industrialization lead to positive effects. Policy intervention techniques to help deal with the effects of globalization on the environment and boost renewable energy a use would be advocated in the study. Kolawole et al. (2024) did a study to identify the relationship between government funding, revenue, institutional quality, and quick provision of energy in West Africa. Using a GMM framework and panel random-effects regression failed to determine the institutional quality influence and resulted in statistically significant but minor effect of the financial development on the augmentation of the energy supply (2012-2020). The authors revealed that the financial sector should be supported in order to attain an adequate amount of energy supply. The research paper by Bhutta et al. (2024) studied the influence of openness towards trade, stock market capitalization and entrepreneurship on industry development in Pakistan. The authors used time-series 2000-2022 data and Autoregressive Distributed Lag (ARDL) model based on the data to infer that market capitalization, energy consumption, and trade openness have a beneficial impact on industrial values added. They arrive at the conclusion that there should be wide policy action to increase industrialization, curb balanced inflation, and to boost trade openness and market capitalization in the quest of long term sustainable growth.

Dada et al. (2024) studied "The moderating role of financial development in energy poverty–sustainable environment linkages: evidence from Africa." The authors applied panel cointegration, completely modified least squares, and quantile regression for 28 African countries to arrive at the conclusion that environmental degradation is brought about by energy poverty, and it is twice affected by financial development. Financial sector development needs to be focused at the source of the purpose of the environment, propose the authors.

Kindo et al. (2023) examined "Effect of foreign direct investment on environmental quality in West Africa." Environmental quality was severely influenced by FDI throughout the period 2000-2020 using panel quantile regression of 13 nations, verifying the pollution haven hypothesis, and the EKC was not obtained. Green investment and clean energy policy were proposed by authors.

Nyantakyi et al. (2023) also elaborated on "Powering sustainable growth in West Africa: exploring the role of environmental tax, economic development, and financial development in shaping renewable energy consumption patterns." The Generalized Method of Moments (GMM), fixed effects, and pooled OLS models for 1990-2020 data-based research has assured that economic development and environmental taxation are driving the rising consumption of renewable energy, whereas financial development is negative. The authors made sure that institutions improve and technology develops to facilitate such power.

Opuala et al. (2022) investigated "Sustainable environment in West Africa: the roles of financial development, energy consumption, trade openness, urbanization and natural resource depletion." Authors used a STIRPAT model with improved and panel cointegration tests based on 1980-2017 data to conclude that financial development and natural resource rent are unsustainable but income, energy consumption, trade openness, and urbanization are largely responsible for environmental degradation. The authors resolved that tougher measures must be used in a bid to combat such humiliating aspects of the environment.

Radoine et al. (2022) have analyzed "Impact of urbanization and economic growth on environmental quality in western Africa: Do manufacturing activities and renewable energy matter?" Relying on the evidence of 1991-2018, Driscoll-Kraay panel regression, manufacturing, urbanization, financial development, and FDI increase environmental degradation, whereas higher use of renewable energy increases environmental quality. Authors have proposed the increase in consumption of clean energy. sources for improving environmental quality.

Kolawole et al. (2022) authored "Sustainable Energy Supply, Finance, and Domestic Investment Nexus in West Africa." Because panel data only were employed in the research, the research utilized the cross-sectional autoregressive distributed lag (CS-ARDL) panel estimator to examine 1990-2020 development of 16 West African countries. The research confirmed that finance deepening and access to electricity are drivers of investment contribution from within being point estimates of 0.3090 and 0.0828 respectively at a 1% level of significance. The research confirmed that investment is strongly responsive to finance deepening and assured power availability and requires coordination of policy efforts for increased investment in finance and energy facilities.

Baajike et al. (2022) wrote "The Effects of Economic Growth, Trade Liberalization, and Financial Development on Environmental Sustainability in West Africa. The Role of Institutions." Using system-GMM for the period 2005-2018, it employed the EKC hypothesis and set trade liberalization and financial development to negative in the first instance but positive in the second instance, specifically with respect to quality institutions. Institutional quality, in authors' terms, was significantly influential. Iorember et al. (2020) employed "Testing the nexus between renewable energy consumption and environmental quality in Nigeria: The

role of broad-based financial development." Authors performed ARDL and VECM Granger causality tests using time series data from 1990-2016 to demonstrate that renewable energy promotes environmental quality but financial development. EKC hypothesis was verified, exhibiting an inverted U-shaped curve relationship between economic growth and pollution. The writers also barred policy reform to energy in the intention of becoming sustainable. Obuobi et al., (2022) reported finance as a factor influencing footprint while affirming the importance of foreign direct investment and energy provision as determinants of ecological footprints of West Africa economies.

Acheampong (2019) anticipated "Modelling for insight: Does financial development improve environmental quality?" The article, with 46 sample size sub-Saharan African countries from 2000 to 2015 by system-GMM, indicated that financial development increases carbon emissions, especially with broad money and domestic credit. Growth-emissions is smoothed by FDI but the EKC hypothesis does not hold. The article indicated that financial development lowers environmental quality unless controlled.

Maji et al. (2019) had "Renewable energy consumption and economic growth nexus: A fresh evidence from West Africa." According to panel DOLS of 15 West African nations from 1995 to 2014, the authors discovered renewable energy in the form of wood biomass to have a major role of retarding economic growth since it is an environment polluting fuel. The authors advised transitioning to cleaner renewables.

3. METHODOLOGY

It utilized an information search methodology to obtain the source data on the announcements of the financial data and data in libraries, statistical organization, and external database statistics, which refers to the World Bank, IMF, and the United Nations Environment Programme; a logical analysis and classification methodology to obtain the variables, indicators, and channels through which the financial situation has an effect on the quality of the environment in West African countries; a systems approach to being able to examine the interactions among financial development, the application of energy, and the quality of the environment in West Africa and in the socio-economic context of West Africa; Measures of environmental quality were based on per capita carbon dioxide (CO_2) emissions and environmental performance indicators. In quantifying financial development, domestic credit to the private sector has been used in forms of a percentage of both GDP and the broad money (M2). Access rate to energy was analysed using electricity access rates and consumption of renewable energy. In order to manage country heterogeneity and macroeconomic shocks such as inflation, policy variables and GDP per capita, the input variables were also altered to control macroeconomic variables.

The study utilised a panel data set which encompassed 16 countries in West Africa over 15 years and in the study, it used the panel autoregressive distributed lag estimator initially constructed by Pesaran et al. (2001). The estimator allows variables of varying order of integration, I(0) and I(1) without stating pre-unit-root test. It is useful in analysing the finance-energy-environment nexus because it presents short-run dollies and long-run equilibrium estimates.

The P-ARDL model is especially suitable in the current study when the time (T), and the cross-sectional dimensions (N) are low in comparison with each other. It is also a remedy for endogeneity, omitted-variable bias and country-specific unobserved effects and ensures heteroskedasticity and serial correlation are accounted for that may arise while employing heterogeneous data. As a result, the use of the P-ARDL estimator presents effective and accurate findings because it leads to the discovery of the responses in the short and the long-run and forecasts the long-run relationship between energy supply and financial development and environmental quality in West African countries.

3.1. Model Specification

This study models environmental quality (ENVQ) as a function of financial development and energy supply. The model specification is expressed as follows:

$$ENVQ = f(FINDEV, ENESUP, GDP, TRD, INF, PD) \quad (1)$$

Econometrically, the model is written as:

$$\Delta ENVQit = \beta_0 + \beta_1 \Delta FINDEVit + \beta_2 \Delta ENESUPit + \beta_3 \Delta GDPit + \beta_4 \Delta TRDit + \beta_5 \Delta INFit + \beta_6 \Delta PDit + \varepsilon it \quad (2)$$

The quality of environment (ENVQ) in the paper is used as the capita CO_2 emission. Financial development (FINDEV) is measured not only by domestic credit to the private sector in relation to gross domestic product but also by the expansiveness of monetary aggregates (M2). Energy supply (ENESUP) is determined through the availability of electricity and consumption of renewable energy sources. Gross domestic product per capita (GDP) is an economic growth measure and trade openness (TRD) or integration into global markets. They use inflation (INF) as a measure of macroeconomic health and a concept called public debt (PD) as a measure of fiscal health. The i parameters, b0 to b6 are going to be estimated and ε i n is the stochastic error aspect. The country Nigeria is denoted under subscript i and t being the 15 years panel data time index of the West African countries.

4. RESULTS

The summary data from the 16 West African economies are presented in Table 1.

Table 1 shows the descriptive statistics of all the variables used to conduct the financial development, energy supply, and environmental quality analysis in West Africa. The average values of PCC, CPS, BM, ELEACC, GDP, INF, TRD, and PD are 0.442781, 17.62514, 348.0083, 43.82124, 1333.043, 5.83317, 54.22277, and 1.614433, respectively, while the standard deviation of these quantities are 0.384786 The smallest, and largest, values of PCC are 0.071138 and 1.995417, meanwhile the values of CPS are between 0 and 68.45603; BM is between 0 and 13309.49, ELEACC is between 1.9 and 98.6, GDP is between 448.3864 and

4861.292, TRD lies between 0 and 115.7653, and PD It is worth investigating the fact that the difference between the minimum and the maximum value is significant over the remaining 16 countries of West Africa in the 15-years panel data.

4.1. Multicollinearity Test Results

The multicollinearity issue is a fundamental problem of regression analysis. A variance inflation factor and correlation table were applied for analysis in the research to check for multicollinearity. Table 2, indicated that, in the correlation matrix, the variables do not have strong correlations with themselves; the value of all the pairwise coefficients is <0.80 (Grewal et al., 2004).

As shown in Table 2, this correlation matrix presents a strong relationship between variables related to the financial development, energy supply, and West African environmental quality. The per capita CO_2 emission is correlated with the credit in the private sector (0.7472), access to electricity (0.7137), as well to GDP per capita (0.9133), and these correlations are found to be positive. In addition, PCC relates negatively with debt (−0.841), indicating that more debt is positively related to lower CO_2 emission, which may indicate a slow economy/less industrialized nation.

As can be seen, the variables that show a weakly positive relationship with the others are; the credit of the private sector (CPS), which has weakly positive correlation with electricity access (0.5350) and GDP per capita (0.6583). There are also weak positive correlations between CPS and inflation (0.3356) and trade openness (0.3764). Broad money (BM) has shown very poor correlation with the majority of variables with, the strongest correlation being a modest negative correlation with access to electricity (−0.1991). there is a significant correlation between GDP per capita (0.7763) and access to electricity (ELEACC); fatwas about the parameter provide support for this relationship.

Present positive correlation between GDP per capita and environmental pollution (0.9133) and access to electricity (1), with intermediate correlation existing between and financial development variables. As seen, inflation (INF) still remains largely uncorrelated with other variables, with the exception of moderate positive contacts with private sector credit (0.3356). The levels of openness to trade (TRD) is left to have relatively low levels of positive correlations with the environmental quality (0.3954), while it has the same association with financial development (CPS: 0.3764) and electricity availability (0.3438). The correlation tendencies that have been witnessed among the variables of environment quality, energy provision as well as financial development that are observed in the 16 western Africa countries would be subject to an econometric analysis in order to establish causality.

In determining the appropriateness of the order of integration of series in the empirical model, unit root tests of Im, Pesaran, and Shin (IPS) and Levin, Lin, and Chu (LLC) were performed and were printed in Table 3. This showed that the variables per capita CO_2 emissions (PCC), credit to the private sector (CPS), the broad money (BM) and the GDP per capita (GDP), the inflation (INF), trade openness (TRD) and also the public debt (PD) were non-stationary in level before becoming stationary on first differencing as revealed by both IPS and LLC tests, therefore these variables are defined as integrated of order one: I (1). In contrast, the access to electricity (ELEACC) exhibited level stationarity in both the IPS and LLC tests with t -values of −3.59024 and −4.12956, respectively, indicating that it is an order 0 integrated statistic, I(0). The level of renewable energy consumption (REC) plus its first-differentiations were found to be non-stationary, indicating that some other transformation or differentiation is in need. The central nervous system lets the research principles justify the use of error-correction models, cointegration tests; therefore, identification of long-run equilibrium relationships between

Table 1: Descriptive statistics

Variable	Mean	Standard Deviation	Min	Max	Skewness	Kurtosis
PCC	0.442781	0.384786	0.071138	1.995417	2.149814	7.843611
CPS	17.62513	12.8844	0	68.45603	1.794472	6.799344
BM	348.0083	1977.821	0	13309.49	6.103926	38.3409
ELEACC	43.82125	22.53924	1.9	98.6	0.315159	2.309385
GDP	1333.043	882.2633	448.3864	4861.292	1.76384	5.923659
INF	5.83317	6.805755	-3.23339	47.64287	2.249314	10.98772
TRD	54.22277	27.05297	0	115.7653	-0.39865	3.129346
PD	1.614433	9.304597	0	73.38519	6.026644	39.0984
Number of countries	16	16	16	16	16	16

Source: Author's Compilation (2025)

Table 2: Correlation matrix of panel analysis variables

Variables	PCC	CPS	BM	ELEACC	GDP	INF	TRD	PD
PCC	1.0000							
CPS	0.7472	1.0000						
BM	−0.1187	−0.1610	1.0000					
ELEACC	0.7137	0.5350	−0.1991	1.0000				
GDP	0.9133	0.6583	−0.0770	0.7763	1.0000			
INF	−0.0829	0.3356	0.0111	0.0907	−0.0037	1.0000		
TRD	0.3954	0.3764	−0.0689	0.3438	0.2930	−0.2235	1.0000	
PD	−0.841	0.1329	−0.0268	−0.2046	−0.1035	−0.0475	0.0091	1.0000

Source: Author's Compilation (2025)

Table 3: Result of unit root (stationarity) test

Variable	IPS		LLC	
	At level t-statistics	At first difference t-statistic	At level t-statisticcs	At first difference t-statistic
PCC	0.48064	−2.54048	−2.56207	−3.61401
CPS	0.25416	−1.88170	−2.94278	−4.14934
BM	−1.00786	−2.43261	−3.63812	−4.14421
ELEACC	−3.59024	−6.39749	−4.12956	−6.24209
REC	5.22187	5.59136	36.1293	38.2525
GDP	−0.07708	−3.36347	−3.97210	−6.68749
INF	1.10681	−2.97581	0.70525	−2.48147
TRD	−99551	−3.42701	−3.55284	−5.61013
PD	−1.41309	−3.32450	−2.70588	−6.96007

IPS and LLC refer to tests by Im et al. (2003) and Levin et al. [17]), respectively. ** and *** denote significance at the 5% and 1% levels, respectively. Rejection of the null hypothesis (P<5%) indicates the absence of unit root

energy supply, environmental quality, and financial development in West Africa Singapore and the short-adjustment process among the study countries was identified using the I (0) and I (1) variables as the core analytical measures. In this type hybrid-based integration, panel cointegration methods can be deployed so as to explore the determinants of financial growth, energy availability, environmental quality across the sample of sixteen economies in West Africa in the course of the study.

The model introduces pollution in the environment of West Africa, energy aggravation as well as deterioration of finance which is tabulated in Table 4 anticipation. Credit disparity in trying to determine tourism decline shifts towards private-sector credit (CPS). The CPS coefficient value can hence be approximated at −0.001168 (P = 0.01), meaning that a one unit rise in the value of credit through the private-sectors are linked to a one-unit increase in the level of environmental deterioration in the form of higher per-capita CO_2 gases. This observation implies credit availed to the domestic sector is one of the main factors that have contributed to the degradation of the environment of West Africa.

Other than this, the introduction of renewable energy positively affects the environment in the long-run. The reward coefficient renewable-energy consumption (REC) = −0.00935 (P < 0.05), indicates again that there is a statistically significant negative dependency between the consumption of renewable-energy and per-capita CO_2 outputs. That is why the extra amount of the renewable not only energy that is used is related to 0.00935 unit decrease in the number of environmental emissions, which is why the attraction to the expansion of the renewable energy is the priority factor to be considered to improve the quality of the environment.

The availability of electricity, however, has an insignificant impact on the per-capita CO_2 emissions. The coefficient of business access to electricity (ELEACC) is −0.00492, and the outcome is not statistically significant. Therefore, the nominal negative significance contrary to the existence of a positive relationship indicates that the effect on encouraging environmental quality, which the nominal negative sign indicates, cannot be concluded with certainty in the long-term period.

Table 4: Regression results of environmental quality (ENVQ) model

Cointegrating form				
Variable	**Coefficient**	**Standard Error**	**t-Statistic**	**Prob.**
D (CPS)	0.001168	0.000399	2.93124	0.0039
D (BM)	0	0.000002	0.197829	0.8434
D (ELEACC)	−0.00027	0.000241	−1.10457	0.2711
D (REC)	0.000045	0.000159	0.28619	0.7751
D (REC(−1))	0.001785	0.001217	1.46716	0.1444
D (REC(−2))	0.001769	0.001684	1.050208	0.2953
D (REC(−3))	−0.00286	0.001218	−2.34851	0.0201
D (INF)	−0.00065	0.000734	−0.88336	0.3784
D (INF)	−2.3E-05	0.001329	−0.01703	0.9864
D (INF)	0.00095	0.001459	0.651348	0.5158
D (INF)	−0.00302	0.001103	−2.73631	0.0069
D (GDP)	0.000002	0.000019	0.094361	0.9249
D (GDP(−1))	0.000042	0.000024	1.711588	0.089
D (GDP(−2))	−5.3E-05	0.000018	−2.90382	0.0042
D (TRD)	0.000023	0.000142	0.159944	0.8731
CointEq(−1)	−0.05426	0.028776	−1.88558	0.0612
Cointeq=PCC − (0.0215*CPS+0.0000*BM−0.0049*ELEACC−0.0094 *REC+0.0193*INF+0.0003*GDP+0.0004*TRD+0.4888)				
Long Run Coefficients				
Variable	**Coefficient**	**Standard Error**	**t-Statistic**	**Prob.**
CPS	0.021529	0.010056	2.140813	0.0339
BM	0.000008	0.00004	0.195554	0.8452
ELEACC	−0.00492	0.004156	−1.18261	0.2388
REC	−0.00935	0.004238	−2.20673	0.0288
INF	0.019331	0.01532	1.261759	0.2089
GDP	0.000326	0.000112	2.90569	0.0042
TRD	0.000419	0.002661	0.157358	0.8752
C	0.488789	0.454732	1.074895	0.2841

Source: Author's Compilation (2025)

Table 5: Breusch-Godfrey Serial Correlation LM Test

F-statistic	4.209267	Prob. F (2,153)	0.0566
Obs*R-squared	9.126853	Prob. Chi-square (2)	0.0524

Source: Author's Compilation (2025)

Table 6: Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.939679	Prob. F (19,155)	0.5354
Obs*R-squared	18.07557	Prob. Chi-square (19)	0.5174
Scaled explained SS	80.41698	Prob. Chi-square (19)	0

Source: Author's Compilation (2025)

GDP per capita has a statistically significant coefficient at the correlation table and exhibits the immediate effect on the economy and long-term economic effect of 0.000002 and 0.000326 respectively. This says that a one unit shift in the level of GDP per capita is anticipated to foresees the long run fall in the unit of the identical ratio CO_2 by 0.000326, which supports the environmental Kuznets curve theory. The existence of trade openness and inflation lacks statistically significant effects on the quality of environment either in the short term or long term.

There is also statistically significance of the error correction term of the model, which is estimated to be −0.05426 ($P < 0.10$). The rate of adjustment of environmental quality towards long run equilibrium after short fatigue in environmental quality is sumed up in this term. The value of the coefficient suggests that the rate of convergence of the enabled environmental quality shocks to CPS, BM, ELEACC, REC, INF, GDP, and TRD, is estimated to take several periods to approach the long-run equilibrium regime outcome.

Lastly, the regression result establishes that the adverse influence on environmental quality of the regression of privatized credit is short run (coef. = cented by negative, 0.001168, P = 0.0039) and the beneficial aspect of the impact of cost-effective renewable energy consumption was a long-run influence (coef. = cented by negative, 0.00935, P = 0.0288). The model includes controls of GDP per capita (GDP), inflation (INF), and a measure of trade of the openness of the economy (TRD), financial development (sb measure of broad money, BM and credit to the private sector, CPS), energy supply (electricity access, ELEACC) and energy consumption in the form of renewable (energy, REC). The dependent variable is the per capita CO_2 emission, indicating the environmental quality. The findings show that though the long-run establishment of the financial development in the private sector exacerbates environmental degradation, the exploitation of renewed resources mitigates the same thus fostering effort to discover the environmentally sustainable development goals.

4.2. Diagnostic Test

These diagnostic test requirements assess the validity and reliability of the environmental quality model testing for the interplay between energy supply, financial development, and environmental quality in West African countries.

The diagnostic test that will be adopted in the future will identify whether there is serial correlation in the model residues, especially the interdependence between the West African financial development, energy provision, and the environment quality. Breusch Godfrey Serial Correlation LM test would be utilized. An F-test with a statistic of 4.209267 at 0.0566 shows that if there are zero serial correlations, the null hypothesis would hardly be rejected at the 5% significances level. The fact that Obs*R-squared = 9.126853 and probability = 0.0534 suggest that, in this case, we do not realize any form of serial correlation since the store number corresponds to 5%. The test value is very close to the traditional threshold, however.

Considering the diagnostics tests, it could be concluded that environmental quality model shows a certain level of sufficiency. Lack of heteroskedasticity is good as it is consistent and it gives the confidence intervals with strength in terms of standard errors. Breusch-Pagan-Godfrey returns F-statistic 0.939679 with a probability of 0.5354 and Obs R^2 = 18.07557 with a probability of 0.5174. Both reject the assumption of heteroscedasticity. This finding ascertains the homoscedasticity of the error terms of all the observations, which in turn ensures correct and accurate econometric estimation.

The overall model seems to be clear in its estimation of the determinants of the environment quality of the West African region. The estimated variables of financial development, energy supply and environmental conditions that are tested using the homoscedastic residuals approve the policy implications associated to the model findings. These results affirm that it is possible to estimate per-capita CO_2 emissions against domestic credit to the private sector, broad money, access to electricity, GDP per capita, inflation, openness to trade and public debt coefficients with reasonable amounts of confidence since the model fulfills the overall assumptions necessary in implementing econometric inference into the west African region.

5. CONCLUSION

To come up with an approximation of nexus existed on financial development, energy supply and environmental quality in West Africa, we are using a 15-year time series of the World Development Indicators database of 16 countries in West Africa. The analysis has used a Panel Autoregressive Distributed Lag (P-ARDL) estimator. This would be illustrated by the empirical finding that financial growth as well as energy provision factors displays strong relationship to the quality of the environmental of the West African countries. In particular, environmental quality indicators in these countries are clearly associated to financial sector expansion in terms of domestic credit to the private sector and broad money (M2), and provision energy facilities, determined by ratios to access, electricity, and use of renewable energy providers.

The error-correction model supports the finding that environmental quality, financial development, and energy supply have a long-run cointegration association and the environmental factor error construction provides the impact of the short-run deviation to return the economy to the long-run state. The P-ARDL estimator adequately accounts not only for the status of mixed integration of the variables in the panel but also resolves the endogeneity, omitted-variable, and country-specific heterogeneity problems in the West African panel.

The long-run regression illustrates that the financial development (in terms of domestic credit to the private sector or general money supply) has a significant role to play in the quality environment outcomes. The reliance on energy supply, the indicator being the rate of electricity access and the use of renewable energy sources has the most significant impact on per-capita CO_2 gas emissions in the region of use. Environmental quality is also positively correlated with gross domestic product per capita, which aligns well with the hypothesis of the Environmental Kuznets

Curve i.e. that in the early stages, economic growth encourages environmental quality as a result of technological growth, and that economic growth creates production methods which are more environmentally friendly.

Openness to trade has two impacts on environmental quality: the global economy offers an avenue to transfer technologies and apparatus to cleaner production schemes, but it also increases an industrial output, and therefore, raises CO_2 emissions. The microeconomic stability revealed in the macro graphic of the magnitude of inflation suggests that the economic prosperity assumes a relationship with the quality of the environment; the public debt on the other hand signifies the fiscal ability of the government and how it is utilizing the same in the establishment of a clean energy infrastructure.

The switched in the long-run equilibrium depends on short-run processes, which, in turn, depend on the resources of financial development and supply of energy that produce a direct effect on the quality of the surrounding environment. The empirical evidence is broad, solid, and internally uniform, which makes it suitable to be applied in designing and implementing sustainable development policy frameworks in the West African countries.

As per the given conclusions, it is advisable that West African financial institutions implement green financing mechanisms which will guide them to give credit to projects that are not pollutant to the environment. An addition to the energy quota of the state by creating clean energy sources and enhancing the accessibility of power is one of the key options to improve the environmental level; therefore, states must ensure that the appropriate amount of capital is invested in the development of clean power. Macro-governments should also uphold viable public debt amounts, and consistency of inflation rates so as to generate an environment of green investment policy conduciveness.

Policymakers are recommended to embark on finance-development policy within the West African region that are in line with the goals of environmental conservation, and those efforts aimed at amplifying and promoting energy production concepts using environment-friendly sources. The trade policies must be made in a way that the clean technologies can be imported into the region without the region playing a dumping ground to the independent polluting industries. Governments are also pushed to lead a calculated direct allocation of public spending to environmental protection and renewable energy facilities to trigger associated privates spending in sustainable development.

The current investigation is limited by the fact that it was based on proxy measures of environmental quality (per capita CO_2 emission) and economic growth (domestic credit and M2) and access to electricity (electricity access and renewable energy consumption). Different range of indicators, including technological innovation, the organization of governance structures as also the demographic variables, should be factored into future studies. Another energy-environment nexus instance that should be explored further in West Africa is the finance-energy-environment nexus where variations due to positive and negative asymmetry of environmental quality vary between individual states of West Africa should be studied. A country by country analysis would perhaps result in more specific policy recommendations to help certain countries overcome certain specific challenges towards the achievement of objectives with regards to financial growth, energy availability, environmental quality, etc.

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