JOURNAL OF LIAONING TECHNICAL UNIVERSITY (NATURAL SCIENCE EDITION)
ISSN: 1008-0562

FINANCIAL INCLUSION ANDENVIRONMENTAL SUSTAINABILITY NEXUS IN ECOWAS: A NEW EMPIRICAL EVIDENCE

ONYINYE I. ANTHONY-ORJI
Department of Economics, University of Nigeria, Nsukka, Nigeria

EMMANUEL T. IDEBA
Department of Economics, University of Nigeria, Nsukka

ANTHONY ORJI[1] *
Department of Economics, University of Nigeria, Nsukka, Nigeria

DURU ERASMUS EJIKE
Department of Financial Management Technology/ Entrepreneurship
Federal University of Technology Owerri, Imo State. Nigeria

IFURUEZE PRISCILLA C.
Department of Banking and Finance
Tansian University Umunya Anambra State,

NWAIMO CHILAKA E.
Department of Project Management Technology/ Entrepreneurship
Federal University of Technology Owerri, Imo State. Nigeria,

AMAKO JONATHAN, C.
Department of Taxation,Faculty of Arts, Management &Social Sciences,
University of Agriculture & Environmental Sciences, Umuagwo, Imo State,

ABSTRACT

United Nations Environmental Program (UNEP) pointed out that although Africa makes a small contribution to climate change, it is yet the most vulnerable to its consequences. This vulnerability results from the region's lack of finance to protect itself from the impact of climate change. Hence, this study empirically revisits the debate on the impact of financial inclusion on environmental sustainability in West Africa with emphasis on the 16 ECOWAS member nations. The variables of interest are Total greenhouse gas emissions, commercial bank branches, Depositors with Commercial Banks, Non-renewable energy consumption, Renewable energy consumption, and population. The Westerlund (2007) co-integration test, Panel corrected standard errors (PCSE), and the Common Correlated Effects Mean Group (CCEMG) were utilized to achieve the study's objective. The result reveals that commercial bank branches have a positive and insignificant impact on Total greenhouse gas emissions.In contrast, Depositors with Commercial Banks negatively and significantly impact Total greenhouse gas emissions. Accordingly, the study concludes that financial inclusion positively impacts environmental sustainability in West Africa. As a result, the study suggests that banks in the region switch to green energy across all of their branches. Additionally, initiatives should be made to promote saving and loaning savings to

[1]Corresponding Author *

companies and investors dedicated to environmentally friendly investments and reducing greenhouse gas emissions in the region.

Keywords: Financial Inclusion, Environmental Sustainability, ECOWAS
JEL Codes: B26, D53, E44, F64, O13

1. Introduction

The beauty of West Africa lies in its wide range of landscapes, from its lush rainforests to expansive savannas, arid deserts, and pristine coastlines. However, the beautiful environment of West Africa has constantly been threatened by the activities of residents of the region, which results in greenhouse gas (GHG) emissions. GHGs, which include carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O), among others, can trap heat that keeps the earth warm, which is paramount to the earth's ecosystem (the greenhouse effect). However, excessive trapping of heat by the GHGs resulting from human activities (like fossil fuel consumption, oil and gas extraction, coal mining, waste landfills, and agricultural practices, among others) results in enhanced greenhouse effects, global warming, disruption of the ecosystem and biodiversity, and sea-level rise, among others. Among others, CO2 emissions are the most commonly emitted GHG, and they stay in the atmosphere for about 1,000 years, followed by N2O, which stays for about 120 years, and CH4, which stays for a decade. The life span of CO2 emissions in the atmosphere contributes to global warming as they absorb heat over a long period of time. However, GHG's life span does not determine its global warming potential (GWP). The GWP of a greenhouse gas is determined by its ability to absorb heat. Although methane and nitrous oxide have a shorter life span than carbon dioxide, their GWP is severe in the short run, making them the deadliest contributors to climate change (Musah et al., 2023).

Various international organizations, private sectors, countries, and Non-governmental organizations have constantly pledged their allegiance to the fight against GHG emissions, and notable among them is the United Nations Environmental Program (UNEP), which was established in 1972 to assist countries in transitioning to a low-carbon economy and safe guide the ozone layer. Another effort to address the GHG emissions was the 12 December 2015 conference in Paris, France. The Paris Conference saw the gathering of 196 nations of the globe to discuss and agree on the way forward in addressing climate and environmental issues ravaging the world. The conference resulted in the legally binding international treaty on climate change. In the treaty, the 196 nations agreed to jointly hold the average global temperature increase to 2ºC and pursue efforts to reduce the temperature to 1.5ºC. The Paris Agreement represents a significant milestone in the global response to climate change. It is the first time nations have a legally binding agreement on the fight against climate change. In the agreement, countries communicate their nationally determined contributions (NDCs), which is how they intend to adapt to and mitigate climate change (United Nations Climate Change, 2023).

Furthermore, to unravel the determinants of GHG emissions that result in climate and environmental issues, studies like Musah, Boateng, Kumah, and Adebayo (2022) argued that foreign direct investment (FDI) increases GHG emissions, which degrade the environment, thereby lending voice to the pollution haven hypothesis. Meanwhile, Musah, Gyamfi, Kwakwa, and Agozie (2023) noted that financial inclusion improves the accessibility and affordability of credit, which helps businesses in terms of finance to purchase environmentally friendly materials that induce low carbon emissions. According to Habiba, Xinbang, and Anwar (2022), as financial development advances, businesses have easier access to credit, which enables them to finance the acquisition of energy, such as fossil fuel, to power their facilities. As a result, carbon emissions rise. This assertion is tenable since African enterprises, which exclusively rely on non-renewable energy (coal, petroleum, and natural gas) to produce commodities, have the potential to increase carbon emissions due to the continent's financial development.

However, the United Nations Environmental Program (UNEP) pointed out that although Africa makes a small contribution to climate change, it is still the most vulnerable to its consequences. This vulnerability results from the region lacking resources to protect itself from the impact of climate change. To close this gap, the African offices of the United Nations concentrate on helping nations in the region set up a framework for implementing policies geared toward reducing GHG emissions, ensuring food security, providing economic opportunities for youths, and expanding their economies. Through advocacy at the African Ministerial Conference on the Environment (AMCEN) and the United Nations Environment Assembly (UNEA), UNEP strives to achieve its goal by promoting climate and environmental actions as a means for investment opportunities and socioeconomic improvement. In a joint effort to address environmental challenges, the UNEP plan included combined mitigation and adaptation strategies. By combining the mitigation and adaptation strategies, the Paris Agreement's Articles 7 and 9 (which call for "parity between mitigation and adaptation") are addressed in the area (United Nations Environment Program, 2022).

In West Africa, climate change has been a significant concern in addressing food security and malnutrition in the region due to the region’s agricultural sector being under threat by the effects of climate change. Sorgho el ta. (2020) noted that the agricultural sector of West Africa is the most vulnerable and lack the capacity to adapt to climate change due to the region’s agricultural sector being characterized by small-scale farming, lack of access to credit facility and information, changing agricultural calendar, weak organization, and unsustainable ecology. As a remedy, most West African governments embarked on a two-pronged approach, which involves Climate Smart Agriculture (CSA) and Reinforced Promotion Campaign to build resilience in the agricultural sector. In Mali, the development of the microfinance sector to enable them to provide financial support to the limited government fund is seen as a valuable tool in the fight against the effect of climate change. The Mali government also included agro-ecological solutions (i.e., solutions that are in harmony with nature and ecosystems) in its list of ways to reduce greenhouse gas emissions and modify agricultural practices. Meanwhile, the Benin government approaches the fight against climate change by enhancing the knowledge and capacity of human resource personnel in green development and climate resistance. Furthermore, the Mauritania government developed a strategy to include environmental and climate change education within its education system. The comprehensive strategy focuses on providing an overview of the country’s environmental, geographic, and ecological context and establishing research institutes that will focus on providing science-based solutions to the climate issue in the country. The overarching aim of this strategy is to build a sense of responsibility and awareness regarding environmental and sustainability issues among both present and future generations.

However, west African greenhouse gas (GHG) emissions have been rising over the years, as shown in Figure 1 below, with Nigeria, Cameroon, and Ghana being the largest polluters in Figure 2 below, indicating that these efforts have not been successful in reducing the region's GHG emissions.

Figure 1: Aggregate Greenhouse Gas Emissions in West-Africa

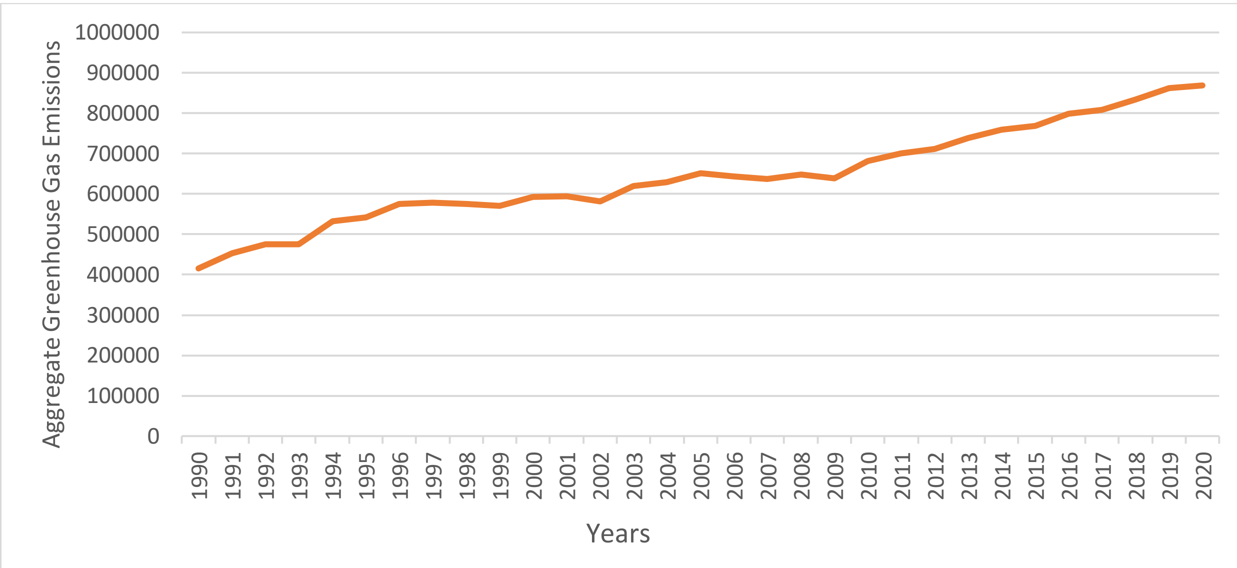
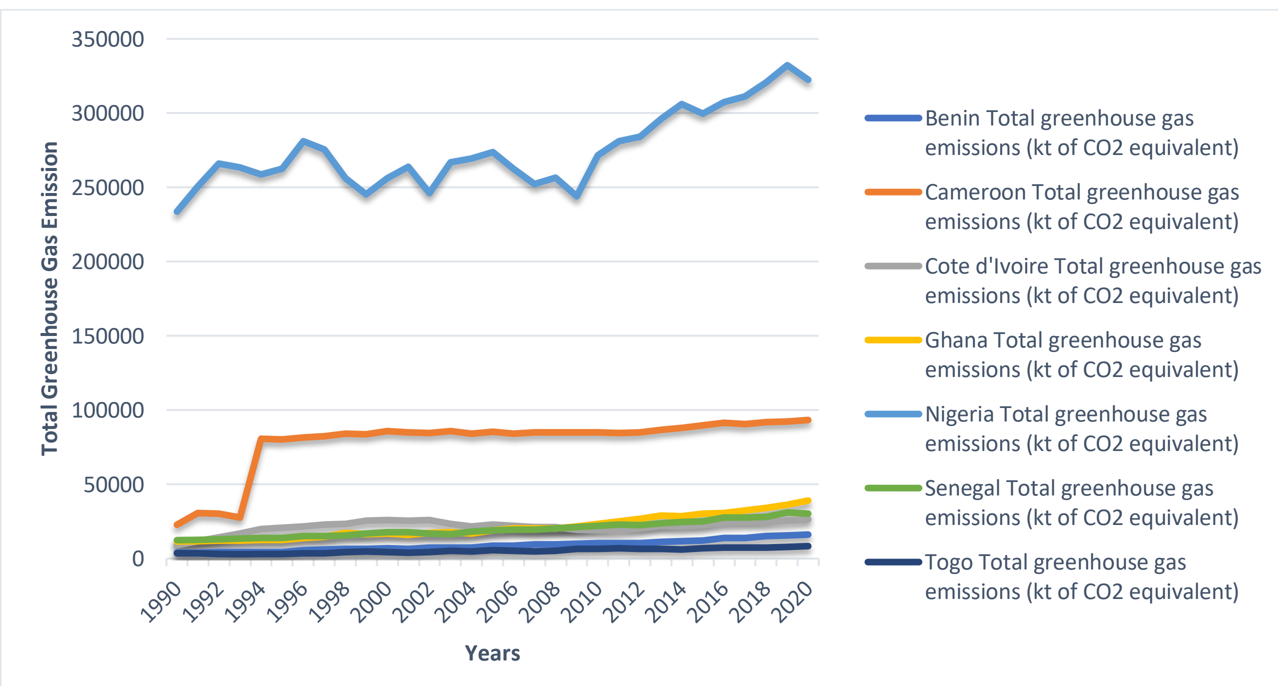


Figure 1: Total Greenhouse Gas Emission in Selected West-Africa Countries



Source: Authors' construct using data from World Development Indicators (WDI)

In accordance with USAID (2019), Nigeria, Cameroon, and Ghana jointly account for 74% of West Africa's GHG emissions, with the Land Use Change and Forestry (LUCF), Energy, and Agriculture sectors being the main drivers of GHG emissions in these countries and the region. Given this undesirable trend, this study aims to contribute to the empirical debate on whether financial inclusion contributes to environmental sustainability in ECOWAS member nations.

2.Literature Review

Numerous studies have investigated how financial inclusion influences environmental sustainability, and each has reached a different conclusion. These studies covered a variety of subjects, some of which were ECOWAS-specific and others which were particular to other regions. Each investigation's findings support or contradict numerous underlying arguments about how financial inclusion and environmental sustainability are related. This section examines ECOWAS- and other region-specific empirical studies.

By employing panel regression analysis, Musah, Gyamfi, Kwakwa, and Agozie (2023) examined the effect of financial inclusion and green investment on GHG emissions in West Africa. The study concludes that financial inclusion and green investment have a monotonic effect on reducing greenhouse gas emissions in West Africa. Ntiamoah el-Ta. (2023) used a panel threshold estimator to examine the point at which West African agriculture will start cutting greenhouse gas emissions. The study concludes that agricultural practices reduce carbon and nitrous oxide emissions below the 3.287 threshold value. Baajike, Ntsiful, Afriyie, and Oteng-Abayie (2022) used pooled ordinary least square to examine how West African environmental health is impacted by economic growth, trade liberalization, and financial development. The empirical findings show that stabilizing the financial industry reduces unpredictable climate change. By using fully modified ordinary least squares, Obuobi, Zhang, Nketiah, Adu-Gyamfi, and Cudjoe (2022) investigated the causal relationships between the demand for renewable energy, financial reforms, economic growth, foreign direct investment, and environmental quality among growing West African economies. The analysis concludes that the region's financial reforms increased the area's ecological footprint. Meanwhile, Musah, Owusu-Akomeah, Nyeadi, Alfred, and Mensah (2022) used the cross-sectional autoregressive distributed lag model to investigate the relationship between financial development and environmental sustainability in West Africa. The study concluded that financial development is detrimental to the sustainability of West Africa's environment. Musah (2022) examined financial inclusion's effect on Ghana's environmental sustainability by employing the Dynamic Autoregressive and Distributed Lag (DARDL) Model. The study reveals that financial inclusion worsens environmental sustainability in the country.

In a different study, the UN's 17 Sustainable Development Goals, which call for eradicating poverty, safeguarding the environment, and providing prosperity for all people by 2030, were examined by Kuada (2019). According to the study, more than financial inclusion may be needed to give the poorest populations in Africa the knowledge and abilities they need to escape poverty. Dada, Ajide, Arnaut, and Adeiza (2023) investigated the effects of financial development and the shadow economy on environmental sustainability in 30 African nations between 1991 and 2017. The study notably shows that the growth of the financial sector and the shadow economy enhance ecological impact based on the augmented mean group estimator. Ogede and Tiamiyu (2023) used panel autoregressive distributed lag to analyze how financial inclusion affects carbon dioxide emissions in Sub-Saharan Africa over the years 2004 to 2017. The study demonstrates that financial inclusion significantly reduces carbon emissions in SSA nations. Meanwhile, Abid, M. (2016) looked into the effect of institutional, financial, and economic changes on CO2 emissions for 25 SSA countries between 1996 and 2010. By employing the Random effect model, the study reveals that financial development does not significantly affect environmental degradation.

Yan el Ta (2023) used panel regression analysis to evaluate factors that can assist developing countries in limiting their atmospheric carbon dioxide releases. The study results showed that financial development hinders and supports the decarbonization goals of lower- and upper-middle-income countries. Similarly, Rehman, Malik, Md Isa, and Jais (2023) investigated the effect of financial inclusion on environmental quality in upper-middle-income, lower-middle-income, and low-income countries using the generalized method of moments regression. According to the study's findings, financial inclusion helps to ensure that environmental quality is improved. Also, Saqib, Ozturk, and Usman (2023) examined how technological innovation, financial inclusion, economic growth, and renewable energy affected emerging economies' ecology by employing advanced panel regression. The study reveals that financial inclusion significantly increases the ecological footprint levels in emerging economies. By employing the difference and system-generalized method of moments, Khan and Ozturk (2021) looked at financial development's direct and collateral effects on CO2 emissions in 88 developing nations between 2000 and 2014. The study finds that financial development lessens the negative effects of pollution emissions. Contrarily, Zhao, F., Zhang, Alharthi, and Zafar (2022) employed the panel quantile regression technique to explore the effects of financial inclusion (FI) and globalization on CO2 emissions in developing nations. According to the study's findings, globalization and financial inclusion both exacerbate the environmental degradation of developing countries. Additionally, the contribution of energy efficiency, green innovation, and financial inclusion to developing and emerging nations' environmental performance was investigated by Singh, Raza, Nakonieczny, and Shahzad, U. (2023). The study finding reveals that financial inclusion enhances a country's ecological footprint, according to the study's quantile regression analysis.

In another study, Zhao, Ozturk, Hafeez, and Ashraf (2023) examined the effect of digital infrastructure and financial structure on carbon emissions in high-polluted Asian economies. The study confirmed that improving financial structure can help reduce carbon emissions in the long run. Similarly, Amin, N., Song, H., & Khan, Z. A. (2022) Looked at the dynamic relationship between financial inclusion, modernization, and environmental sustainability in South Asia. Through panel regression, the study findings reveal that financial inclusion leads to higher CO2 emissions in the South Asian region. The effect of financial inclusion on CO2 emissions in Asia-Pacific Economic Cooperation (APEC) nations was studied by Amin, Song, and Khan in 2022. The study's findings show that financial inclusion and the use of renewable energy greatly support environmental sustainability by lowering CO2 emissions, according to the augmented mean group (AMG) model. Ozkan, Sharif, Mey, and Tiwari (2023) used a dynamic autoregressive and distributed lag model to examine the dynamic effects of green technology innovation, financial development, and trade openness on urban environmental deterioration in China. According to the study, financial development and green technologies positively influence long-term carbon efficiency. Also, by using the panel ARDL model to analyze the effects of financial inclusion on the environment of five developing Asian nations, Liu, Xie, Hafeez, and Usman (2022) found that financial inclusion positively affected CO2 emissions. Meanwhile, in India, Boutabba (2014) examined the relationship between financial development, economic growth, energy consumption, trade openness, and carbon emissions in India. The study reveals a long-run relationship among the variables through the Granger causality test.

Abid, Ceci, Ahmad, and Aftab (2022) adopted a panel threshold model to examine how financial development and green innovation affect environmental sustainability in advanced nations, and they found that there is a strong correlation between the two. Meanwhile, the relationship between financial development, economic development, and environmental quality, as well as the financial development in BRIC economies, was examined by Tamazian, Chousa, and Vadlamannati (2009). In another, Ahmad, Ahmed, Bai, Qiao, Popp, and Oláh (2022) investigated how financial inclusion, technical innovation, environmental openness, and CO2 emissions relate in the BRICS nations. The study found that environmental degradation in the BRICS countries is fueled by financial inclusion using panel regression analysis. The study's panel analysis showed that Higher economic and financial growth levels are associated with less environmental degradation. From 2007 to 2019, Ozturk, I., and Ullah, S. (2022) looked into the impact of digital financial inclusion on economic growth and environmental sustainability in 42 OBRI countries. The study confirmed that while digital financial inclusion boosts economic growth, it also lowers environmental quality due to increased CO2 emissions using panel regression analysis. Panel regression analysis was used by Khan, Murshed, Ozturk, and Khudoykulov (2022) to examine the interaction between increased energy efficiency, the production of renewable electricity, and financial inclusion in promoting environmental sustainability in N-11 (The Next Eleven Countries). According to the study, financial inclusion increases carbon emissions in N-11. The relationship between financial inclusion and environmental sustainability was examined in non-EU nations by Ozili (2023). Using Pearson correlation analysis, the study found a positive relationship between financial inclusion and environmental sustainability. Contrarily, Hussain, Ye, Ye, and Wang (2021) examined the impact of financial inclusion and infrastructure on the ecological footprint in OECD economies by employing the augmented mean group (AMG) and common correlated effects mean group (CCE-MG) estimator. The study proved that financial inclusion is the main reason for environmental degradation in the region. Similar research was conducted by Tian and Li (2022) on the dynamic relationships between financial inclusion, globalization, and CO2 emissions among G20 countries between 2005 and 2018. The study's conclusions demonstrate that globalization and financial inclusion positively impact carbon emissions.

3. Gaps in Literature and Value Added

This study will contribute by giving voice to the scant research on the effect of financial development on environmental sustainability in West Africa. To the best of knowledge, this study is the first to use a more reliable measurement of greenhouse gas emissions (total greenhouse gas emissions) compared to the more restrictive measurement of GHG emissions by carbon emission used as a proxy for environmental sustainability in other studies. Also, it will be the first to combine the use of the Panel corrected standard errors (PCSE) technique, otherwise called cluster-robust standard errors, for the long run estimation and the Common Correlated Effects Mean Group (CCEMG) to determine the robustness and effectiveness of PCSE. Finally, this is the first study that captures the entire ECOWAS member nations in the study of the relationship between financial inclusion and environmental sustainability while controlling for renewable energy consumption, non-renewable energy consumption, and population.

4. Methodology

4.1. Data

This study uses annual secondary data from 15 West African nations, including Benin, Burkina Faso, Cabo Verde, Côte d'Ivoire, The Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, and Togo. The time series spans the years 1990 to 2020 (31 years). The data and its sources are summarized in the table below:

Table 1

VARIABLES	ABBREVIATION	DATA SOURCE
Total Greenhouse Gas Emission	TGE	World Development Indicators (WDI)
Commercial Bank Branches	CBB	World Development Indicators (WDI)
Non-Renewable Energy Consumption	NRE	World Development Indicators (WDI)
Renewable Energy Consumption	REC	World Development Indicators (WDI)
Population	POP	World Development Indicators (WDI)
Depositors with Commercial Banks	DCB	World Development Indicators (WDI)

Authors’ conceptualization (2023)

In this study, Total greenhouse gas emissions (kt of CO2 equivalent) is the dependent variable and a proxy for Environmental Sustainability. Greenhouse gas emissions refer to the release of gases such as carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O), among others, into the atmosphere that contributes to the greenhouse effect and, consequently, global warming and climate change which result to environmental degradation. The unit "kilotons of CO2 equivalent" (kt CO2e) is commonly used to express the total amount of all greenhouse gases emitted, taking into account their global warming potential relative to carbon dioxide

(Watch,2022). A high total emissions level corresponds to a decline in environmental sustainability, while a low level shows environmental sustainability (Murshed, Ozturk, and Khudoykulov, 2022).

Meanwhile, the core independent variables of this study are Commercial bank branches and Depositors with commercial banks. Commercial bank branches are physical locations of resident commercial banks and other resident banks that function as commercial banks that provide financial services to customers and are physically separated from the main office but not organized as legally separated subsidiaries (World Bank 2023). This variable measures the accessibility of financial services in an economy. According to this study, the number of commercial bank branches (per 100,000 adults) reflects how easily accessible and readily available financial services are to all facets of the population. By rational expectation, expanding commercial bank branches will improve the accessibility and availability of financial services to all facets of the population, allowing people and businesses to buy environmentally friendly production materials that improve environmental sustainability. Similarly, Depositors with commercial banks are the reported number of deposit account holders at commercial banks and other resident banks functioning as commercial banks that are resident nonfinancial corporations (public and private) and households (World Bank, 2023). It is reasonable to assume that the growth of depositors with commercial banks will increase the lending options available to individuals and businesses, enabling them to purchase manufacturing materials that are more environmentally sustainable (Ozili, 2023).

Furthermore, Non-renewable energy consumption, Renewable energy consumption, and Population are the control variables of this study. Non-renewable energy consumption refers to using energy sources that cannot be easily replaced within a human lifespan or at a rate that matches their consumption. These energy sources are finite and deplete over time as they are used. Most non-renewable energy sources are fossil fuels: coal, petroleum, and natural gas. This study employs CO2 emission (kt) as a proxy for Non-renewable energy consumption. CO2 emissions are those caused by the combustion of fossil fuels and the production of cement, according to the World Bank (2023). They consist of gas flaring and carbon dioxide created by consuming solid, liquid, and gas fuels. Intuitively, the increase in greenhouse gas emissions caused by the increased usage of non-renewable energy will reduce environmental sustainability.

Meanwhile, Renewable energy consumption refers to using energy sources like the sun and wind that are naturally replenished and do not run out. Renewable energy can be used for electricity generation, space and water heating and cooling, and transportation. In this study, renewable energy consumption is expressed as a percentage of total final energy consumption, which reflects how much renewable energy is used overall. It is reasonable to assume that greenhouse gas emissions decrease as renewable energy consumption rises, making our ecosystem more sustainable. According to the World Health Organisation (2023), “Population refers to all the inhabitants of a country, territory, or geographic area, total or for a given sex and/or age group, at a specific time. In demographic terms, it is the total number of inhabitants of a given sex and/or age group that live within the border limits of the country, territory, or geographic area at a specific time, usually mid-year. The mid-year Population refers to the actual Population on July

1st." It makes sense to assume that as the Population grows, the demand for manufactured consumer goods also grows. As a result, fossil fuel consumption, a necessary input in the production process, grows. This leads to increased greenhouse gas emissions that harm the ozone layer and weaken our ecosystem.

4.2. Summary statistic and correlation analysis

Table 2: Summary statistic

	TGE	CBB	NRE	REC	POP	DCB
Mean	29959.39	4.624215	8725.478	72.15555	18514832	234.3149
Maximum	332247	34.15	119544.1	94.99	2.08E+08	2187.07
Minimum	306.8675	0.14	147	20.78	364563	9.51
Std. Dev.	66619	5.812238	23706.05	19.22975	35602240	349.7077
Jarque-Bera	2842.238	3640.686	3118.928	89.81334	4068.853	3011.418
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Observations	465	465	465	465	465	465

Source: Authors' construct using STATA's output

The variables used in this study are listed in Table 2 above, along with the data's average, spread, and shape. There were 465 observations taken for the descriptive statistics. The average values of the Total Greenhouse Gas Emission (TGE) in ECOWAS nations during the study period are represented by the mean value of 29959.39. This interpretation is similar to how other variables are measured using their respective averages. The range of values is determined by finding the difference between the highest and lowest values in the entire dataset. According to basic calculations, the table does not show any exceptionally unusual data points. The standard deviations also indicate that the variables have some variations. The probability value of the Jarque-Bera (JB) statistic for all variables is less than 0.05, which means that these variables are not normally distributed.

Table 3: correlation analysis

	LTGE	CBB	LNRE	REC	LPOP	DCB
LTGE	1					
CBB	-0.4403	1				
LNRE	0.8505	-0.1461	1			
REC	0.2251	-0.6600	-0.0714	1		
LPOP	0.9557	-0.4960	0.8742	0.3157	1	
DCB	-0.2924	0.9300	0.0129	-0.6049	-0.3288	1

Source: Authors' construct using STATA's output

In table 4.3 above, out of 10 possible outcomes in the correlation among independent variables, there are just two matrix cells with correlation coefficients equal to or greater than 0.8. Thus, there is a correlation between independent variables. Nevertheless, multicollinearity is one of the foremost issues in estimation, according to Blanchard (1987). Multicollinearity results from God's will and is not an issue with statistical methods in general. Thus, we take no action.

4.3. Econometric model

This study proposes the following model to investigate the relationship between financial inclusion and environmental sustainability in ECOWAS nations:

$LTGE_{it} = \alpha_i + \beta_1 CBB_{it} + \beta_2 LNRE_{it} + \beta_3 REC_{it} + \beta_4 LPOP_{it} + \beta_5 LDCB_{it} + \mu_t$... (1)

Where:

α_i = The individual-specific effect for entity i

μ_t= The random or error or stochastic term

i =The cross-section across the panel (15 West Africa countries)

t = The time period across the panel (1990-2020)

β_1, β_2, β_3, β_4, &β_5 = The Regression parameters and slopes of the respective explanatory variables.

All other variables are as defined above.

4.4. Estimation strategy

This study's necessary method included the following steps: (a)Panel cross-section dependence (CSD) test (b) Panel Unit root test (c)Panel co-integration Test (d) Estimation technique: Panel corrected standard errors (PCSE) for long-run estimation and Common Correlated Effects Mean Group (CCEMG) for robust check.

4.4.1. Panel cross-section dependence (CSD) test

In panel data analysis, CSD is important to evaluate for consistent results. The CSD results from unforeseen economic shocks, regional consequences, reciprocal effects, financial interconnectedness, and linkages in the socio-economic systems of the sample nations (Lin & Wu, 2022; Qin et al., 2021). In addition, assessing CSD is necessary for panel analysis to choose appropriate approaches, such as first- or second-generation methods (Jianguo et al., 2022). The presence of CSD ensures that we may continue using second-generation methods like unit root, cointegration, and coefficient estimation. The final version of the Pesaran (2021) CSD test is given in Eq. (2):

$CD_{Test}=2T^{1/2}\frac{1}{\sqrt{N(N-1)}}\sum_{i=1}^{N-1}\sum_{k=1+i}^{N}T_{ik}$---(2)

4.4.2. Panel unit root test

Following the CSD test, this study examines the presence of unit root by employing the Cross-sectional Augmented Im–Pesaran–Shin (CIPS) second generational test proposed by Pesaran (2007). To prevent the estimate of an erroneous regression, it is crucial that time series variables included in a regression model be unit root-free (Gujarati, 2013). CIPS tests the alternative hypothesis that the series is stationary against the null hypothesis, that the series is non-stationary. According to Equations (3) and (4), the CIPS formula is as follows:

$Y_{it}= \alpha_{it}+ \beta_i\, x_{it-1} +\rho_i T+\sum_{j=0}^{n}\theta_{it}\Delta x_{it-j} + \varepsilon_{it}$ ---(3)

CIPS=$\frac{1}{N}\sum_{i=1}^{N} CADF_i$ ---(4)

4.4.3. Panel co-integration test

This study adopts the Westerlund (2007) co-integration to examine the long-run relationships between the variables. This method is essential in addressing the panel's SLH and CSD concerns.

4.4.4. Estimation technique

This empirical study adopts a multivariate regression model. By estimation, this study employs the Panel-corrected standard errors (PCSE) technique, called cluster-robust standard errors, as proposed by A. Colin Cameron and Pravin K. Trivedi. According to Adeleye et al. (2022), the PCSE technique is a second-generational estimation technique that considers potential cross-sectional dependency, autocorrelation, and heteroscedasticity within the same entity (cross-sectional unit) over time. This estimation method is suitable when the number of cross-sectional units is less than the time dimension, i.e., N<T. To estimate a PCSE model, we must first ascertain the cross-section dependency (CSD) to determine if the Panel corrected standard errors are suitable. Furthermore, the study employs the Common Correlated Effects Mean Group (CCEMG) estimator, a method used in panel data analysis to account for unobserved common factors that might affect the dependent variable across different entities (cross-sectional units) over time. It is an approach that combines aspects of fixed and random effects estimators to address issues related to cross-sectional dependence and common factors. This model is employed to determine the robustness and effectiveness of PCSE.

5. Empirical Results

Table 4: CSD, panel unit root, and cointegration tests

Variables	**Pesaran (2004) CD-Test**	**P-value**	**Pesaran (2007)CIPS**		**Pesaran (2007) CIPS**		**integrated Order**
			Level	P-value	First Difference	P-value	
LTGE	38.088	0.0000	0.3832	0.6492	-11.778	0.0000	I(1)
CBB	23.777	0.0000	-0.8318	0.2028	-12.9788	0.0000	I(1)
LNRE	49.154	0.0000	-0.4066	0.3422	-11.9544	0.0000	I(1)
REC	25.549	0.0000	0.9575	0.8309	-11.4328	0.0000	I(1)
LPOP	56.619	0.0000	6.1012	1.0000	-8.6804	0.0000	I(1)
DCB	25.527	0.0000	5.5041	1.0000	-12.9156	0.0000	I(1)
Westerlund (2007) cointegration test							
Variance ratio = 1.7232							
P-value= 0.0424							

Source: Authors' construct using STATA's output

Table 4 above displays the results of the pre-estimation tests. This study failed to accept the null hypothesis of cross-section independence and concluded that the panel is cross-sectional dependent since the p-values of the Pesaran (2004) CD-Test are less than 0.05. This indicates a strong likelihood that a shock in one country in the region of West Africa may spread to another. Also, the table shows that the variables employed became stationary after differencing them once, i.e., I(1). The Westerlund (2007) indicate that there exists a long-term relationship among the variables employed.

Table 5: PCSE and CCEMG Results

	PCSE, Main Analysis			CCEMG, Robustness		
Variable	Coefficient	z-statistic	P-value	Coefficient	z-statistic	P-value
CBB	0.0006348	0.58	0.561	0.0000603	0.02	0.984
LNRE	0.1718037	5.80	0.000	0.265456	4.56	0.000
REC	-0.0006917	-1.17	0.225	0.000169	0.20	0.843
LPOP	0.9608847	24.27	0.000	0.9649763	1.05	0.843
LDCB	-0.0255684	-2.19	0.022	0.017106	1.05	0.291
CONS	-3.079472	-18.26	0.000	-10.11182	-0.73	0.468
R-squared =0.9943 Wald Statistic = 10010.36 P-value = 0.0000				WaldStatistic= 23.04 P-value = 0.0003		

Source: Authors' construct using STATA's output

In Table 5, the PCSE result demonstrates that over time, depositors at commercial banks cut greenhouse gas emissions by an average of 2.55684%. As a result, while controlling for all other factors, an increase in commercial bank depositors will result in a 2.55684% reduction in West Africa's overall greenhouse gas emissions. This is likely explained by the fact that an increase in bank depositors will increase the loan options available to individuals and businesses, enabling them to purchase household and manufacturing materials that are more environmentally sustainable. This finding is consistent with findings from Musah, Gyamfi, Kwakwa, and Agozie (2023) and Baajike, Ntsiful, Afriyie, and Oteng-Abayie (2022), which revealed that financial inclusion reduces GHG emissions in West Africa. However, the result of CCEMG showed an insignificant but positive relationship with total greenhouse gas emissions.

In contrast, Non-renewable energy consumption upsurges Total greenhouse gas emissions in West Africa. The result from PSCE in Table 5 shows that, on average, a percentage increase in Non-renewable energy consumption will increase total greenhouse gas emissions by about 17.18%, holding other variables constant. This result is consistent with the CCEMG result. The high rate of deforestation in West Africa and the region's heavy reliance on fossil fuels as an energy source are the most likely causes of the increase in greenhouse gas emissions in the region. This finding aligns with Djellouli, Abdelli, Elheddad, Ahmed, and Mahmood (2022) findings, who discovered that non-renewable contribute positively to GHGs in West Africa.

Similarly, an increase in population also influences GHG emissions positively. Table 5 shows that in the long run, a percent increase in population will result in a 96.1% increase in Total greenhouse gas emissions on average, holding other variables constant. This outcome has a similar relationship direction to that of CCEMG. Intuitively, the demand for manufactured consumer goods also grows as the population grows. As a result, fossil fuel consumption, a necessary input in the production process, grows. This leads to an increase in greenhouse gas emissions that contribute to environmental degradation.

6. Conclusion and Recommendations

An ongoing discussion in academic centers on how financial inclusion affects environmental sustainability. Therefore, this study adds to the empirical discussion of whether financial inclusion promotes environmental sustainability in ECOWAS countries. Accordingly, the study concludes that financial inclusion positively impacts environmental sustainability in West Africa.

Therefore, the study recommends that banks in the region switch to green energy across all of their branches. Additionally, initiatives should be made to promote saving and loaning savings to companies and investors dedicated to environmentally friendly investments and reducing greenhouse gas emissions in the region.

REFERENCE

Abid, M. (2016). Impact of economic, financial, and institutional factors on CO2 emissions: evidence from sub-Saharan Africa economies. *Utilities Policy*, *41*, 85-94.

Abid, N., Ceci, F., Ahmad, F., & Aftab, J. (2022). Financial development and green innovation, the ultimate solutions to an environmentally sustainable society: Evidence from leading economies. *Journal of Cleaner Production*, *369*, 133223.

Adeleye, B. N., Akam, D., Inuwa, N., James, H. T., & Basila, D. (2023). Does globalization and energy usage influence carbon emissions in South Asia? An empirical revisit of the debate. *Environmental Science and Pollution Research*, *30*(13), 36190-36207.

Ahmad, M., Ahmed, Z., Bai, Y., Qiao, G., Popp, J., & Oláh, J. (2022). Financial inclusion, technological innovations, and environmental quality: Analyzing the role of green openness. *Frontiers in Environmental Science*, *10*, 851263.

Amin, N., Song, H., & Khan, Z. A. (2022). Dynamic linkages of financial inclusion, modernization, and environmental sustainability in South Asia: a panel data analysis. *Environmental Science and Pollution Research*, 1-9.

Baajike, F. B., Ntsiful, E., Afriyie, A. B., & Oteng-Abayie, E. F. (2022). The effects of economic growth, trade liberalization, and financial development on environmental sustainability in West Africa. The role of institutions. *Research in Globalization, 5*, 100104.

Boutabba, M. A. (2014). The impact of financial development, income, energy and trade on carbon emissions: evidence from the Indian economy. *Economic Modelling*, *40,* 33-41.

Dada, J. T., Ajide, F. M., Arnaut, M., & Adeiza, A. (2023). On the shadow economy-environmental sustainability nexus in Africa: the (ir) relevance of financial development. *International Journal of Sustainable Development & World Ecology*, *30*(1), 6-20.

Djellouli, N., Abdelli, L., Elheddad, M., Ahmed, R., & Mahmood, H. (2022). The effects of non-renewable energy, renewable energy, economic growth, and foreign direct investment on the sustainability of African countries. *Renewable Energy*, *183*, 676-686.

Gujarati, D. M (2013). Basic Econometrics (5th ed.) United State of America: Bell and Brain Limited.

Habiba, U. M. M. E., Xinbang, C., & Anwar, A. (2022). Do green technology innovations, financial development, and renewable energy use help to curb carbon emissions? *Renewable energy*, *193*, 1082-1093.

Hussain, M., Ye, C., Ye, C., & Wang, Y. (2021). Impact of financial inclusion and infrastructure on ecological footprint in OECD economies. *Environmental Science and Pollution Research*, 1-8.

Khan, M., & Ozturk, I. (2021). Examining the direct and indirect effects of financial development on CO2 emissions for 88 developing countries. *Journal of environmental management*, *293*, 112812.

Khan, S., Murshed, M., Ozturk, I., & Khudoykulov, K. (2022). The roles of energy efficiency improvement, renewable electricity production, and financial inclusion in stimulating environmental sustainability in the Next Eleven countries. *Renewable Energy*, *193*, 1164-1176.

Kuada, J. (2019). Financial inclusion and the sustainable development goals. In *Extending financial inclusion in Africa* (pp. 259-277). Academic Press.

Lin, S., & Wu, R. (2022). On the nexus between energy efficiency, financial inclusion and environment: Evidence from emerging seven economies using novel research methods. *Economic research-Ekonomska istraživanja*, *35*(1), 6756-6779.

Liu, D., Xie, Y., Hafeez, M., & Usman, A. (2022). The trade-off between economic performance and environmental quality: does financial inclusion matter for emerging Asian economies? *Environmental Science and Pollution Research*, 1-10.

Musah, M., Boateng, F., Kumah, E. A., & Adebayo, T. S. (2022). Financial flows and environmental quality in ECOWAS member states: Accounting for residual cross-sectional dependence and slope heterogeneity. *Environment, Development and Sustainability*, 1-34.

Musah, M., Gyamfi, B. A., Kwakwa, P. A., & Agozie, D. Q. (2023). Realizing the 2050 Paris climate agreement in West Africa: the role of financial inclusion and green investments. *Journal of Environmental Management*, *340*, 117911.

Ntiamoah, E. B., Appiah-Otoo, I., Li, D., Twumasi, M. A., Yeboah, E. N., & Chandio, A. A. (2023). Estimating and mitigating greenhouse gas emissions from agriculture in West Africa: does threshold matter? *Environment, Development and Sustainability*, 1-29.

Obuobi, B., Zhang, Y., Nketiah, E., Adu-Gyamfi, G., & Cudjoe, D. (2022). Renewable energy demand, financial reforms, and environmental quality in West Africa. *Environmental Science and Pollution Research*, *29*(46), 69540-69554.

Ogede, J. S., & Tiamiyu, H. O. (2023). Does Financial Inclusion Moderate CO2 Emissions in Sub-Saharan Africa? Evidence from Panel Data Analysis. *Studia Universitatis Vasile Goldiș Arad, Seria Științe Economice*, *33*(3), 21-36.

Ozili, P. K. (2023). Financial inclusion and environmental sustainability. In *Digital Economy, Energy and Sustainability: Opportunities and Challenges* (pp. 25-39). Cham: Springer International Publishing.

Ozkan, O., Sharif, A., Mey, L. S., & Tiwari, S. (2023). The dynamic role of green technological innovation, financial development and trade openness on urban environmental degradation in China: Fresh insights from carbon efficiency. *Urban Climate*, *52*, 101679.

Ozturk, I., & Ullah, S. (2022). Does digital financial inclusion matter for economic growth and environmental sustainability in OBRI economies? An empirical analysis. *Resources, Conservation and Recycling*, *185*, 106489.

Pesaran, M. H. (2004). General diagnostic tests for cross section dependence in panels. *Available at SSRN 572504*.

Pesaran, M. H. (2007). A simple panel unit root test in the presence of cross-section dependence. *Journal of applied econometrics*, *22*(2), 265-312.

Qin, L., Raheem, S., Murshed, M., Miao, X., Khan, Z., & Kirikkaleli, D. (2021). Does financial inclusion limit carbon dioxide emissions? Analyzing the role of globalization and renewable electricity output. Sustainable Development, 29(6), 1138-1154.

Rehman, A. U., Malik, A. H., Md Isa, A. H. B., & Jais, M. B. (2023). Dynamic impact of financial inclusion and industrialization on environmental sustainability. *Social Responsibility Journal*, *19*(5), 906-929.

Saqib, N., Ozturk, I., & Usman, M. (2023). Investigating the implications of technological innovations, financial inclusion, and renewable energy in diminishing ecological footprints levels in emerging economies. *Geoscience Frontiers*, *14*(6), 101667.

Singh, A. K., Raza, S. A., Nakonieczny, J., & Shahzad, U. (2023). Role of financial inclusion, green innovation, and energy efficiency for environmental performance? Evidence from developed and emerging economies in the lens of sustainable development. *Structural Change and Economic Dynamics*, *64*, 213-224.

Sorgho, R., Quiñonez, C. A. M., Louis, V. R., Winkler, V., Dambach, P., Sauerborn, R., & Horstick, O. (2020). Climate change policies in 16 West African countries: A systematic review of adaptation with a focus on agriculture, food security, and nutrition. *International journal of environmental research and public health*, *17*(23), 8897.

Tamazian, A., Chousa, J. P., & Vadlamannati, K. C. (2009). Does higher economic and financial development lead to environmental degradation: evidence from BRIC countries. *Energy policy*, *37*(1), 246-253.

Tian, Y., & Li, L. (2022). Impact of financial inclusion and globalization on environmental quality: evidence from G20 economies. *Environmental Science and Pollution Research*, *29*(40), 61265-61276.

United nation climate change (2023). The Paris Agreement. Retrieved from https://unfccc.int/process-and-meetings/the-paris-agreement (Accessed 3 October 2023)

United Nation environment programme (2022). Responding to climate change. Retrieved from https://www.unep.org/regions/africa/regional-initiatives/responding-climate-change (Accessed 2 October 2023)

USAID (2019),Greenhouse Gas Emissions in the West Africa Region. Retrieved from https://www.climatelinks.org/sites/default/files/asset/document/2019_USAID_West%20

Africa%20Regional%20GHG%20Emissions%20Factsheet.pdf (Accessed 8 October 2023)

Watch, C. (2020). GHG emissions. *World Resources Institute: Washington, DC, USA*.

Westerlund, J. (2007). Testing for error correction in panel data. *Oxford Bulletin of Economics and statistics*, *69*(6), 709-748.

World Bank (2023). "*Economic Policy & Debt: National accounts: US$ at current prices: Aggregate indicators"* Retrieved from https://databank.worldbank.org/metadataglossary/africa-development-indicators/series/NY.GDP.MKTP.KD (Accessed 25 August, 2021)

World Bank (2023). "*Environment: Emissions"* Retrieved from https://databank.worldbank.org/metadataglossary/ida-results-measurement-system/series/EN.ATM.CO2E.PC (Accessed 25 August, 2021)

World Bank (2023). Financial Sector: Access. *International Monetary Fund, Financial Access Surve.* Retrieved fromhttps://datacatalog.worldbank.org/public-licenses#cc-by (Accessed 25 August, 2021)

World Bank (2023). Financial Sector: Access. *International Monetary Fund, Financial Access Surve.* Retrieved from *https://databank.worldbank.org/metadataglossary/world-development-indicators/series/FB.CBK.DPTR.P3*(Accessed 25 August, 2021)

World Health Organisation (2023), *"Population"*Retrieved from https://www.who.int/data/gho/indicator-metadata-registry/imr-details/1121 (Accessed 25 August, 2021)

Yan, C., Murshed, M., Ozturk, I., Siddik, A. B., Ghardallou, W., & Khudoykulov, K. (2023). Decarbonization blueprints for developing countries: The role of energy productivity, renewable energy, and financial development in environmental improvement. *Resources Policy*, *83*, 103674.

Zhao, F., Zhang, Y., Alharthi, M., & Zafar, M. W. (2022). Environmental sustainability in developing countries: Understanding the criticality of financial inclusion and globalization. *Sustainable Development*, *30*(6), 1823-1837.

Zhao, S., Ozturk, I., Hafeez, M., & Ashraf, M. U. (2023). Financial structure and CO2 emissions in Asian high-polluted countries: Does digital infrastructure matter? *Environmental Technology & Innovation*, *32*, 103348.