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Powering Sustainable Development: The Role of Clean Energy in Transforming West Africa

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ABSTRACT

This study examined the impact of clean energy consumption on sustainable development in West Africa, drawing on Endogenous Growth Theory for the period from 2000 to 2023. Using panel methodology, the research analysed data from 16 West African countries, examining variables such as Electricity Consumption (EC), Air Quality Indicator (AQI), Foreign Direct Investment (FDI), and Gross Fixed Capital Formation (CF) on life expectancy (LEXP) and sustainable consumption and production (SCP). The findings showed that EC significantly positively affected LEXP and SCP, whereas AQI produced mixed results. FDI had a negative impact on SCP, mainly due to the pollution-heavy nature of some industries, while CF had limited effects on both LEXP and SCP. The study recommended expanding clean energy infrastructure, especially through renewable energy projects and rural electrification, to improve health outcomes and sustainability. It also called for stricter environmental regulations to ensure FDI supports sustainability goals, fostering both economic growth and environmental health.

Keywords: Clean Energy, Sustainable Development, Africa, West Africa, Sustainable Development Goals
JEL Classifications: Q400; Q420; Q430

1. INTRODUCTION

Sustainable development represents a critical global priority, emphasizing the interconnected objectives of economic growth, social inclusion, and environmental protection. In Africa, achieving this balance is particularly vital given the continent's unique development trajectory, marked by high poverty levels, environmental vulnerability, and untapped economic potential (Ajibola et al., 2025; Aust et al., 2021; Wu and Zhai, 2023). As a fundamental component of the United Nations 2030 Agenda for Sustainable Development, sustainable development integrates economic, social, and environmental dimensions, offering an all-inclusive structure to achieve long-term global well-being (Sun et al., 2020; Gogu et al., 2021; Kumba and Olanrewaju, 2024). The adoption of the Sustainable Development Goals (SDGs) by all 193 UN member states highlights the commitment to fostering sustainable progress (Hametner and Kostetckaia, 2020).

The urgency to address sustainable development challenges has amplified global policy discussions, with the SDGs serving as a blueprint to ensure inclusive growth and environmental sustainability (Ozili and Iorember, 2024). Among these efforts, the transition to clean energy emerges as a pivotal strategy to mitigate climate change, alleviate energy poverty, and promote environmental conservation. Energy consumption has long been recognized as a key driver of sustainable development. Globally, research highlights diverse relationships between energy consumption and development outcomes, yet consensus

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on these relationships remains elusive (Wang et al., 2022). However, despite significant progress globally, the impact of clean energy on sustainable development in Africa, particularly in West Africa, remains insufficiently explored. While some studies have examined clean energy's relationship with variables such as economic growth, industrial development, and carbon emissions (Maji et al., 2019; Awodumi and Adewuyi, 2020; Okoye et al., 2021), relatively few have investigated its specific effects on SDG 3 and SDG 12 in the West African context.

Prior studies on sustainability and clean energy in Africa have contributed significantly to the discourse on governance, resource management, and environmental protection. Scholars such as Mutiiria et al. (2020), Asongu and Nnanna (2020), and Liyanage et al. (2021) have highlighted progress in addressing these challenges across Africa. However, much of the existing research is limited to sub-Saharan Africa or specific countries, leaving a gap in understanding how clean energy consumption shapes sustainable development outcomes across the broader West African sub-region (Da Silva et al., 2018; Kwakwa et al., 2021; Alola et al., 2021).

This research seeks to address these gaps by examining the impact of clean energy consumption on sustainable development in West Africa, with a focus on SDG 3 and SDG 12. SDG 3 emphasizes improving health and well-being, which is directly influenced by access to cleaner energy sources that reduce indoor air pollution and associated health risks. SDG 12, on the other hand, advocates for sustainable consumption and production patterns, requiring a transition toward energy-efficient practices and reduced environmental degradation. By assessing the role of clean energy in advancing these two goals, this study aims to provide critical insights into how sustainable energy transitions can foster inclusive and environmentally responsible development across the sub-region.

2. LITERATURE REVIEW

Qudrat-Ullah and Nevo (2021) estimated the effects of renewable energy consumption and environmental sustainability on economic growth in Africa using panel data for 37 African countries and employing the system Generalized Method of Moments estimation technique. This study revealed that renewable energy adoption leads to an increase in economic growth in Africa both in the long run and short run. The study further showed that environmental sustainability through a reduction of emissions may not be Africa's priority towards achieving an all-inclusive development at present because the coefficient of CO_2 emission in the study is not statistically significant. It was recommended that African governments intensify efforts to develop the renewable energy sector, especially using policy instruments, while also harnessing the already mature non-renewable industry for more rapid growth in the continent and the attainment of Agenda 2063.

Alola et al. (2021) investigated the impact of clean energy, economic expansion and technological innovation on sustainable development in selected Sub-Saharan African countries, which are often affected by significant energy deficits and technological setbacks. The study focused on the relationship between these factors and the Human Development Index (HDI), utilizing panel econometrics strategies to analyze data from 2000 to 2016. The empirical results revealed a long-run equilibrium relationship between HDI, economic growth, access to clean energy and technological innovation. Specifically, the findings indicated that economic expansion and technological innovation significantly enhanced HDI in both the short and long run. A 1% increase in economic growth was found to increase HDI by 0.040% in the short run and 0.017% in the long run. This suggested that sustainable economic growth leads to improvements in literacy rates, income levels and life expectancy. However, the study also found that access to clean energy initially had a negative impact on HDI in the short run, but its effect became statistically positive in the long run. The research underscored the complex dynamics between clean energy access and human development in Sub-Saharan Africa, highlighting the potential for long-term benefits despite short-term challenges.

Aderemi et al. (2022) carried out a study on the nexus between clean energy supply in Nigeria and industrial development between 1990 and 2019. The study made use of an ex-post facto research design employing the Canonical Cointegrating Regression and Granger Causality which revealed that the contribution of clean energy supply is negatively significant to the manufacturing value added in the country. In achieving the Sustainable Development Goal (SDG 7), the study suggested that clean energy supply should be explored for future industrial development in Nigeria by policymakers.

Wang et al. (2022) examined the impact of various renewable energy sources on economic growth at the state level within the framework of sustainable development goal 7 (SDG-7), which emphasizes clean, affordable and modern energy systems. The study utilized annual panel data from selected Asian countries and applied augmented mean group (AMG) and common correlated effects mean group (CCEMG) methods for analysis. The findings revealed that the consumption of renewable energy sources significantly contributed to economic prosperity in these regions. The study recommended that policymakers focus on expansionary fiscal policies to promote the use of environmentally friendly power generation technologies.

Gyamfi et al. (2022) investigated the effects of trade flow, economic growth, natural resources, clean energy and urbanization on consumption-based carbon emissions (CCO_2) in Sub-Saharan Africa from 1990 to 2018. Utilizing second-generation techniques such as the CS-ARDL model, the study found that trade flow, income, natural resources and urbanization positively impacted CCO_2 emissions. Specifically, the interaction between trade and income also contributed to increased emissions. Conversely, clean energy was shown to have a negative impact on CCO_2 emissions. Causality analysis revealed feedback causality between CCO_2 emissions and income, clean energy and urbanization, while a one-way causality was observed from natural resources rent to CCO_2 emissions. These findings suggest that adopting eco-friendly measures, particularly increasing clean energy use, could help Sub-Saharan African countries achieve environmental sustainability.

Islam et al. (2022) investigated the impact of renewable and non-renewable energy consumption on sustainable development in

ASEAN countries, considering the roles of financial development and institutional quality from 1980 to 2018. Using pooled mean group (PMG) regression and verifying results with fully modified ordinary least squares (FMOLS), dynamic ordinary least squares (DOLS) and canonical cointegration regression (CCR) techniques, the study found that renewable energy had a significantly positive effect on sustainable development, while non-renewable energy had a significantly adverse impact. Institutional quality and financial development were also found to negatively affect sustainable development. The study highlighted the importance of promoting renewable energy and managing non-renewable energy sustainably while improving institutional quality in ASEAN countries. It recommended policies to strengthen institutional frameworks and enhance the adoption of renewable energy to support sustainable development goals.

Aneja et al. (2024) analyzed the impact of economic growth, clean energy and green innovation on environmental sustainability in G-20 nations from 1992 to 2018. The study addressed the challenge of balancing economic growth with environmental quality, given rising environmental issues like climate change, global warming and resource degradation. The authors employed the cross-sectional autoregressive distributed lag (CS-ARDL) model to examine the long-run relationship between economic growth, technological innovations, natural resource depletion, renewable energy consumption and environmental degradation. The findings confirmed the Environmental Kuznets Curve (EKC) hypothesis for the selected G-20 nations, indicating that economic growth initially leads to environmental degradation but improves at higher income levels. The study revealed that clean energy and green technology significantly contributed to sustaining environmental quality in these countries. Additionally, natural resource depletion was found to directly impact environmental degradation, including CO_2 emissions, greenhouse gas emissions and ecological footprints. The authors emphasized the critical role of promoting clean energy, green technology and sustainable practices to achieve a balance between economic growth and environmental preservation. The study provided valuable policy recommendations for G-20 nations, stressing the importance of integrating sustainable development into their growth strategies.

2.1. Theoretical Framework

The theoretical framework for this study on the impact of clean energy on sustainable development in Africa is grounded in Endogenous Growth Theory, which emphasizes internal factors like human capital, innovation, and knowledge as primary drivers of long-term economic growth. Unlike traditional neoclassical models that attribute growth to external factors, this theory, developed by Paul Romer and Robert Lucas, highlights the role of research and development (R&D) and knowledge spillovers in sustaining economic progress. Recent studies, such as Okoye et al. (2021), Fernandes et al. (2021), and Shahbaz et al. (2022), have utilized this theory to explore the link between energy consumption and sustainable development.

The theory assumes constant returns to scale in capital and posits that technological advancement arises from economic activities. Policies promoting education, innovation, and R&D are essential for fostering sustained growth, particularly in African nations striving to balance economic development with environmental sustainability. Investments in clean energy technologies align with this framework by advancing innovation and infrastructure development, which are vital for achieving sustainable development goals.

The theory's basic equation, Y = AKαL1−α, expresses economic output (Y) as a function of capital (K), labor (L), and productivity (A), where α\alpha measures the contribution of capital to output. This model underscores how clean energy investments can catalyze innovation and productivity, driving sustainable growth. By applying this theory, the study points to the transformative potential of clean energy in Africa's pursuit of economic and environmental sustainability.

3. METHODOLOGY AND DATA

3.1. Model Specification

To achieve the research objectives of this study, the model utilized by Okoye et al. (2021) in their study analysing the energy consumption and economic growth nexus in Nigeria will be adapted. The model of Okoye et al. (2021) is given as;

$$GDPR_t = f(ELCON_t, OPR_t, FDPT_t, GFCF_t, INF_t) \quad (1)$$

Where, GDPR = GDP growth; ELCON = Electricity consumption; OPR = Oil price, FDPT = Financial development (proxied as private sector credit as percentage of GDP), GFCF = Gross fixed capital formation (proxy for infrastructure) and INF = Inflation.

To achieve the objective 1 and 2 of this study equation 1 will be modified as follows.

$$LEXP_{it} = f(EC_{it}, FDI_{it}, CF_{it}, AQI_{it}) \quad (2)$$

$$SCP_{it} = f(EC_{it}, FDI_{it}, CF_{it}, AQI_{it}) \quad (3)$$

The econometric equation is expressed as:

$$LEXP_{it} = \beta_0 + \beta_1 EC_{it} + \beta_2 FDI_{it} + \beta_3 CF_{it} + \beta_4 AQI_{it} + \mu_{it} \quad (4)$$

$$SCP_{it} = \beta_0 + \beta_1 EC_{it} + \beta_2 FDI_{it} + \beta_3 CF_{it} + \beta_4 AQI_{it} + \mu_{it} \quad (5)$$

Where;
LEXP = Life expectancy (SDG 3)
SCP = Sustainable consumption and production (SDG 12)
EC = Electricity consumption
AQI = Air quality indicator
FDI = Foreign direct investment
CF = Gross fixed capital formation
μ_{it} = Error term
β_0 = Intercept
β_1-β_4 = Co-efficient of the independent variables
i = cross-section
t = time period.

Table 1 below captures the definition and measurement of variables covered in this study.

Table 1: Measurement of variables

Variables	Representation	Measurement	Data source
Sustainable development	SCP	CO_2 emissions (metric tons per capita)	WDI, 2024
	LEXP	Life expectancy at birth, total (years)	WDI, 2024
Clean energy	EC	Access to electricity (% of population)	WDI, 2024
	AQI	PM2.5 air pollution, population exposed to levels exceeding WHO guideline value (% of total)	
Foreign direct investment (FDI)	FDI	Foreign direct investment, net inflows (% of GDP)	WDI, 2024
Gross capital formation	CF	Gross capital formation (% of GDP)	WDI, 2024

WHO: World Health Organization

Table 2: Descriptive statistics

Variables	LEXP	EC	AQI	FDI	CF	SCP
Mean	58.23616	37.23000	99.99740	4.720209	22.59812	0.355225
Median	58.31750	34.40000	100.0000	2.693126	21.15947	0.262472
Maximum	72.98100	95.53354	100.0000	103.3374	52.66984	1.074460
Minimum	39.44100	1.300314	99.00000	−11.19897	1.096810	0.051341
Standard deviation	6.021010	22.03799	0.051031	9.502054	9.606640	0.249589
Skewness	0.065781	0.498899	-19.51929	7.077982	1.007195	1.058038
Kurtosis	3.339260	2.494189	382.0026	62.38814	3.952329	3.379066
Jarque-Bera	2.118496	20.02310	2322672.	59637.48	74.47043	73.94354
Probability	0.346716	0.000045	0.000000	0.000000	0.000000	0.000000
Sum	22362.69	14296.32	38399.00	1812.560	8135.324	136.4064
Sum square deviation	13884.73	186012.8	0.997396	34580.70	33131.23	23.85881
Observations	384	384	384	384	360	384

Source: Author's Computations, 2025

3.2. Method of Data Analysis

To achieve the objectives of this study, standard panel econometric techniques will be employed. The preliminary analysis will include descriptive statistics and the Augmented Dickey-Fuller unit root test to assess the stationarity of the data. Following this, the study plans to apply the panel dynamic ordinary least squares (DOLS) method to analyze the data for the first objective. However, the results of the unit root test will dictate the specific econometric analysis method utilized. There are 16 countries West Africa namely Benin, Burkina Faso, Cape Verde (Cabo Verde), Côte d'Ivoire (Ivory Coast), Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, Togo, and Mauritania. This study will employ 16 of the countries in West Africa in line with the objective of the study.

4. RESULTS

The descriptive statistics summarize six variables used in this study: Life Expectancy (LEXP), Electricity Consumption (EC), Air Quality Indicator (AQI), Foreign Direct Investment (FDI), Gross Fixed Capital Formation (CF), and Sustainable Consumption and Production (SCP). The data consists of 384 observations, except for CF, which has 360 due to missing data for Liberia (Table 2).

Life expectancy (LEXP), a measure of population health and well-being, shows a mean of 58.24 years and a median of 58.32 years, indicating a nearly symmetric distribution. The standard deviation of 6.02 reflects moderate variability, with values ranging from 39.44 to 72.98 years. The skewness of 0.07 and kurtosis of 3.34 suggest a near-normal distribution, supported by a Jarque-Bera test probability of 0.35, indicating no significant deviation from normality. Electricity consumption (EC) exhibits substantial variability, with a mean of 37.23 and a median of 34.40. The standard deviation of 22.04 and a range from 1.30 to 95.53 highlight disparities in electricity access. Slight right skewness (0.50) and kurtosis (2.49) suggest a flatter-than-normal distribution, with the Jarque-Bera test (P = 0.000045) confirming significant non-normality.

The air quality indicator (AQI) is highly concentrated, with a mean of 99.99 and minimal variation (SD = 0.05, range: 99.00-100.00). Extreme skewness (−19.52) and kurtosis (382.00) indicate clustering near maximum values, confirmed by the Jarque-Bera test (P = 0.000). Foreign direct investment (FDI) displays extreme variability, with a mean of 4.72 and a standard deviation of 9.50. Values range from −11.20 to 103.34, and high skewness (7.08) and kurtosis (62.39) reveal outliers, supported by a Jarque-Bera test probability of 0.000. Gross fixed capital formation (CF) shows moderate variability, with a mean of 22.60 and a standard deviation of 9.61. Slight right skewness (1.01) and kurtosis (3.95) suggest non-normality, confirmed by the Jarque-Bera test (P = 0.000). Finally, sustainable consumption and production (SCP) reflects low sustainability scores, with a mean of 0.36 and a range from 0.05 to 1.07. Moderate right skewness (1.06) and kurtosis (3.38) are evident, and the Jarque-Bera test (P = 0.000) confirms non-normality, likely due to lower SCP values in the dataset.

Table 3 below captures the test for stationarity of the variables and their order of integration.

Life expectancy (LEXP), air quality indicator (AQI), and foreign direct investment (FDI) are stationary at level, with significant ADF test results indicating integration of order I(0). This stability allows their use in econometric models without transformation. Conversely, sustainable consumption and production (SCP), electricity consumption (EC), and gross fixed capital formation (CF) are non-stationary at level but achieve stationarity after first differencing, becoming I(1). This mix of stationarity levels necessitates advanced econometric approaches, such as cointegration analysis, to accommodate variables with different integration orders, ensuring robust modeling and accurate relationships among the variables.

Table 4 below captures the regression output used to evaluate the research objective.

The panel dynamic ordinary least squares (DOLS) regression results analyze the impact of electricity consumption (EC), Air quality indicator (AQI), foreign direct investment (FDI), and gross fixed capital formation (CF) on sustainable development goals: Life expectancy (LEXP) for SDG 3 and Sustainable Consumption and Production (SCP) for SDG 12.

For Life Expectancy (LEXP), EC has a positive and significant effect (coefficient: 0.3987, P = 0.0012), while AQI, despite a positive coefficient (0.4253), is insignificant (P = 0.5895). FDI shows a weakly significant negative relationship (coefficient: −0.5340, P = 0.0733), and CF has an insignificant negative effect (coefficient: −0.0571, P = 0.2386). The model explains 99.68% of the variability in LEXP (R-squared: 0.9968) with a robust Adjusted R-squared of 0.9840 and a low standard error (0.2317).

Table 3: ADF panel unit root test

Variables	Number of deferencing	T-statistics (Probability)	Order of integration
LEXP	Level	68.4720 (0.0002)	I (0)
	First Diff.	NA	---
SCP	Level	33.7161 (0.3844)	---
	First Diff.	137.764 (0.0000)	I (1)
EC	Level	13.3453 (0.9985)	---
	First Diff.	189.744 (0.0000)	I (1)
AQI	Level	7.26397 (0.0265)	I (0)
	First Diff.	NA	---
FDI	Level	62.8320 (0.0009)	I (0)
	First Diff.	NA	---
CF	Level	39.7356 (0.1101)	---
	First Diff.	172.766 (0.0000)	I (1)

Source: Author's Computations 2025

Table 4: Panel dynamic ordinary least squares regression

Variables	Dependent variables	
	LEXP (SDG 3)	SCP (SDG 12)
EC	0.398686* (0.0012)	0.022566** (0.0028)
AQI	0.425281 (0.5895)	−0.125773 (0.0700)
FDI	−0.534030 (0.0733)	−0.066316** (0.0132)
CF	−0.057078 (0.2386)	0.002484 (0.4414)
R-Squared	0.996795	0.993049
Adj. R-squared	0.983977	0.965247
S.E. of regression	0.231723	0.020250
Long-run variance	0.005725	2.85E−05
Mean dependent var	59.53238	0.490697
S.D. dependent var	1.830629	0.108625
Sum squared resid	0.214781	0.001640

Source: Author's Compilation 2025

For Sustainable Consumption and Production (SCP), EC positively and significantly influences SCP (coefficient: 0.0226, P = 0.0028). AQI has a weakly significant negative relationship (coefficient: −0.1258, P = 0.0700), while FDI has a significant negative effect (coefficient: −0.0663, P = 0.0132). CF's positive impact is insignificant (coefficient: 0.0025, P = 0.4414). The SCP model accounts for 99.3% of variability (R-squared: 0.9930) with an Adjusted R-squared of 0.9652 and a minimal standard error (0.0203).

4.1. Discussion of Results

The positive coefficient and statistical significance of electricity consumption indicates that a 1-unit increase in electricity consumption is associated with a 0.3987-year increase in life expectancy. Supported by studies such as Fahlevi et al. (2023), Somoye et al. (2024), the result underscores the essential role of electricity access in improving living standards, facilitating access to healthcare services, and supporting modern infrastructure, all of which contribute to increased life expectancy. Air quality findings suggest that changes in air quality do not have a statistically significant effect on life expectancy in the context of the analyzed dataset. However, the result shows a direct relationship which is in line with the studies of Yin et al. (2020), Kanat et al. (2024). This result may indicate that other mediating factors, such as healthcare services or technological advances, mitigate the direct impact of air pollution on public health.

The negative coefficient and statistical insignificance of foreign direct investment, supported by Forte and Abreu 2023, suggests that although FDI typically supports economic growth, its environmental and social consequences, such as pollution-intensive industrial activities or economic inequalities, may offset potential health benefits, leading to a net negative effect on life expectancy. Aalipour et al. (2023) and Chiappini et al. (2023) do not agree with this finding. Similarly, the result of gross capital formation implies that long-term investments in physical infrastructure may not immediately translate into better life expectancy outcomes, possibly due to delays in infrastructure development or misallocation of investment funds.

In terms of sustainable consumption and production as the dependent variable, the result of electricity consumption, one of the proxies of clean energy consumption, suggests that increased electricity consumption can promote sustainable production processes, especially when electricity is used efficiently and sourced from cleaner energy alternatives. The positive impact, also supported by Ali et al. 2022, highlights electricity's critical role in supporting energy-intensive but sustainable industrial activities. As for the result of air quality indicator, a proxy for clean energy consumption, it indicates that worsening air quality, likely caused by pollution from industrial production, may hinder progress toward achieving sustainability goals. The negative association highlights the environmental trade-offs often associated with economic development.

The finding of FDI which is indicates that inflows may be linked to environmentally harmful industrial activities, especially in developing economies where environmental regulations may be weaker. The result, which is in line with the study of Chien et al. 2023, suggests that while FDI can boost economic development, it can also undermine sustainability efforts if not properly managed. The result of gross capital formation which has a positive coefficient but statistically insignificant indicates that long-term investments in infrastructure and productive assets may have limited direct effects on sustainable consumption and production, possibly due to inefficient allocation of resources or delays in realizing infrastructure benefits.

5. CONCLUSION AND RECOMMENDATIONS

This study analyzed the impact of clean energy consumption on sustainable development in West Africa (2000-2023) using data from 16 countries. Employing econometric methods, the study examined life expectancy (SDG 3) and Carbon Emissions (SDG 12) as dependent variables, with electricity consumption and air quality indicator as clean energy proxies, alongside Foreign direct investment (FDI) and Gross Fixed Capital Formation (CF) as controls.

The findings highlight Electricity Consumption's critical role in enhancing life expectancy and promoting sustainable practices, emphasizing the need to expand clean energy infrastructure. However, FDI exhibited negative effects on both variables, likely due to investments in pollution-intensive industries. Air quality, a significant challenge, negatively affected sustainability while showing no significant link to life expectancy, reflecting inadequate environmental regulations. CF showed limited impact, underscoring the necessity for targeted infrastructure investments in clean energy and sustainability-focused projects to achieve meaningful development outcomes.

This study recommends, based on its findings, expanding clean energy infrastructure, particularly through renewable energy projects and rural electrification, to improve health outcomes and sustainability. Additionally, given the negative impact of Foreign Direct Investment (FDI) on sustainable consumption and production due to pollution-intensive industries, stricter environmental regulations and incentives for green investments are essential. These measures would align FDI with sustainability goals, ensuring that economic growth supports both environmental and social development in the region.

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