

Promoting Environmental Sustainability Through Energy Transition, Natural Resource Rent and Economic Growth: Evidence from Sub-Saharan Africa

¹Benedict Ikemefuna UZOECHINA, ²Favour Chidinma ONUOHA, ³Kenneth JEGBEFUMWEN,
⁴Livinus Mmaduabuchi OKEKE, ⁵Kalu Ebi UMA, ⁶Eze A. EZE, ⁷Anthony Obinna CHIEDO, ⁸Uchenna
Nnanna ANYANWU

^{1,4,6,7&8}Department of Economics, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria
ib.uzoechina@unizik.edu.ng; un.anyanwu@unizik.edu.ng; ml.okeke@unizik.edu.ng;
ae.eze@unizik.edu.ng; obino82@yahoo.com

²Department of Economics, Evangel University, Akaeze, Akaeze, Ebonyi State, Nigeria
fc.onuoha@evangeluniversity.edu.ng

³Department of Economics, Novena University, Ogume, Delta State, Nigeria
Jekeken10@gmail.com

⁵Department of Economics & Development Studies, Alex Ekwueme, Federal University, Ndufu Alike
Ikwo. kaluskyebng@yahoo.com

*Corresponding Author: un.anyanwu@unizik.edu.ng

Abstract

Accelerating Africa's energy transition is key to achieving sustainable environment amidst recent global energy crisis. This study investigates the impact of energy transition on environmental sustainability in sub-Saharan Africa with special interest on the role economic growth plays for the period 2000 to 2020. Employing Instrumental Variable – Generalised Method of Moments (IV-GMM) approach and a two-stage least squares method for robustness check, results indicate that renewable energy consumption (rec) exerts a negative and significant impact on carbon emission and environmental sustainability both for the first and second models, while renewable electricity output (reo) exerts a negative but non-significant influence on CO₂ in SSA for the first model. Income level in SSA for the two models favours non-renewable energy consumption and deteriorates the environment. We recommend balanced transformative decarbonization until income threshold improves to impact positively on environment sustainability.

Keywords: *Energy transition, environmental sustainability, economic growth, renewable energy*

1. INTRODUCTION

Preserving the environment is not only important as a life-supporting platform and platform to support economic activities for the present generation but also for the future generation. In light of this, one of the three pillars of sustainable development is considered to be environmental sustainability. Eight of the 17 Sustainable Development Goals (SDGs) of the UN have some sort of direct or indirect connection to the environment, which further contributes to its significance. Globally, there have been notable extreme weather occurrences and a notable rise in greenhouse gas emissions in 2021 (IEA, 2021b). Because 2022 saw some of the most extreme weather events

in history, affecting a greater number of countries more frequently and having ever-more-significant effects on economies and populations, environmental quality became increasingly threatened (IEA, 2023d). Natural disasters and extreme weather occurrences are among the top 10 perceived hazards for the medium and long term, according to global business leaders (WEF, 2023). Figure 1 shows that approximately 73% of global greenhouse gas emissions in 2016 came from energy-related activities (IEA, 2023d). This covers emissions from the use of fossil fuels for production, transportation, heating, and cooling as well as for electricity generation.

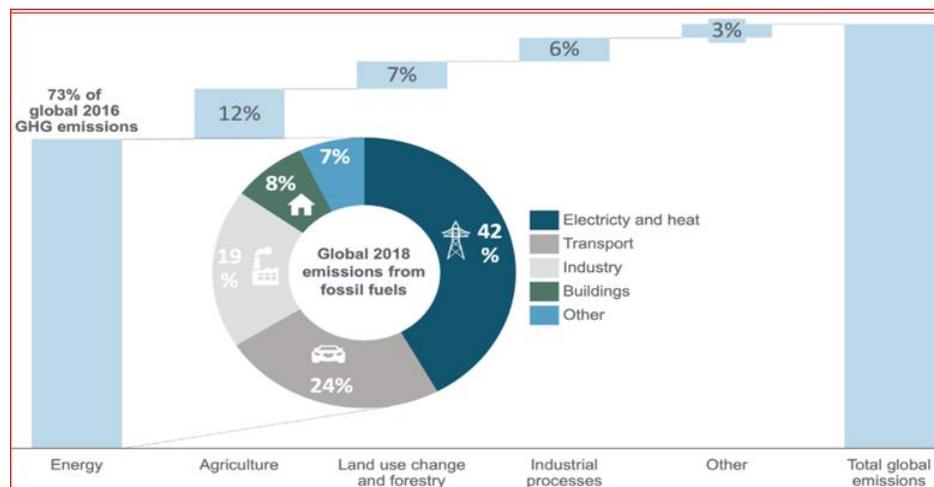


Figure 1: Global Green House Gas emission, 2016

Source: IEA, 2023d

Between 2008 and 2017, the average growth rate of greenhouse gas emissions in African nations was slower than that of other developing economies. Figure 2 shows that, at almost 42% of total energy-related CO₂ emissions in 2018, the electricity sector is the major contributor in Africa (IRENA, 2023c).

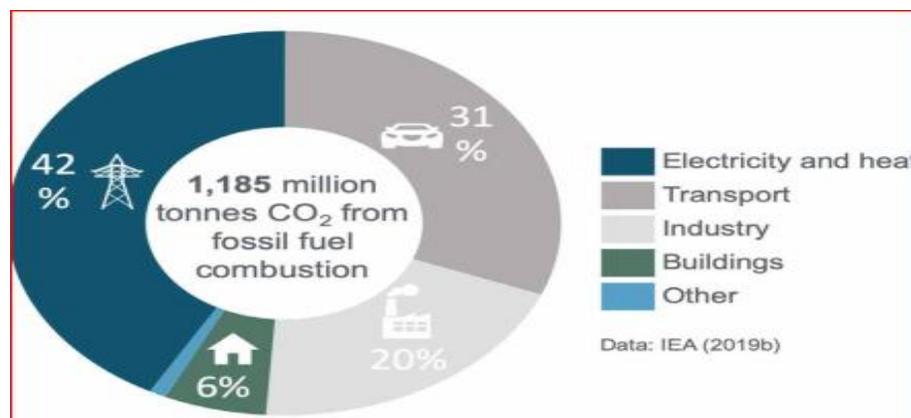


Figure 2: Share of energy-related CO₂ emissions in Africa by sector, 2018

Source: IEA, 2023d

The fact that Africa is home to some of the world's poorest nations and has one of the fastest rates of population increase in the world complicates this scenario (World Bank, 2022). Africa must switch to modern energy sources from traditional ones. Cavard (1989) defined the energy transition as the process by which the amount and percentage of commercial energy rises to the point where it substitutes conventional fuels as the primary energy source. In order to overcome Africa's numerous energy and environmental issues, higher-quality fuels must be made available and used, leading to a more balanced energy mix, as the IMF (2022d) aptly stresses. The primary issue of how to increase sustainable energy against conventional energy without damaging the already declining ecosystem of the continent is based on the fact that commercial energy production and use largely contribute to the generation of greenhouse gases.

Drawing on an empirical analysis of growth and energy consumption in SSA, Kahsai et al. (2012) concluded that there is evidence for the existence of the fact that growth is driven by energy consumption and growth is stimulated by the use of energy in the long run. It has been estimated by a recent report that a rise in the use of renewable energy by 1% will enhance long-term growth by a steady 1.9% and short-term growth by 0.07% in Africa (Qudrat-Ullah and Nevo, 2021). The UN High-Level Dialogue on Energy in 2021's topic report, "Enabling SDGs through All-inclusive Just Energy Transition states that, "energy is inevitably associated with virtually all the SDGs and transforming the global energy landscape will create new employment opportunities, promote gender equality, and empower people, communities, and societies" (UN, 2021a).

This study is significant because the infrastructure development gap is tied to growth in income, which further affects the level of energy consumption, whether renewable or non-renewable, thus, affecting the speed of energy transition and environmental sustainability. According to Cavard (1989), the energy transition process varies from one country to another, reflecting changes in economic growth, urbanisation, the nation's role as an energy exporter, the amount of forest and woodland resources, and the prevalence of poverty. Therefore, the economic index for Africa is also a reflection of the energy sector's share in an economy with implications on environmental sustainability (IRENA, 2021a).

Figure 3 reflects the annual GDP growth of SSA countries, which although varies exhibits a downward general trend.



Fig. 3: Real GDP Growth Rate (Annual %) of sub-Saharan African

Source: World Bank, 2022

This general downward trend of GDP in Africa holds some implications on the nexus between energy transition and environmental sustainability in Africa as posited by Cavard, (1989) and (IRENA, 2021a). Therefore, this paper, in particular, hypothesizes that inter-country variations in the level of economic growth have implications on how energy transition affects the achievement of a sustainable environment. This study is, therefore, significant because it empirically investigated if this theoretical postulation by Cavard, (1989) holds for Africa. Furthermore, from the literature reviewed, extensive studies have been carried out on the relationship between energy transition and environmental quality in SSA with varying outcomes of insignificant relationships, positive and negative significant relationships respectively. These divergent conclusions by scholars could be attributed to the proxies adopted for environmental quality and energy transition. This present study introduces two measures of environmental quality (CO₂ and ecological footprint) and energy transition (renewable energy consumption and renewable electricity output) with income playing a moderating or enhancing role for robust analysis and effective and efficient policy prescriptions.

2. LITERATURE REVIEW**2.1. Theoretical Literature Review**

The relationship between environmental sustainability and the transition of energy is conceptually addressed through the new neoclassical theory of environmental sustainability that became popularly adopted due to individual research works of Boulding (1966) and Dragulanescu and Dragulanescu (2013). The extensive economy which sustains life on earth and the actual economy which is the part of the ecosystem which acknowledges the interdependence of the environment and the economy constitute the complex web that is the economy, as the theory suggests. Value creation, economic activity, and the effective distribution and allocation of finite resources comprise the real economy. They also stated that the environment, which is the real economy's ecological base, is necessary for it to operate as an open and circular subsystem. In order to preserve both economic and natural resources sustainability, it is essential to maintain equilibrium between the two economies.

2.2. Empirical Literature Review

The effect of the energy transition on environmental sustainability in Africa and other regions of the world has been the subject of some empirical research. For example, Samson (2023) used the cross-sectional autoregressive distributed lag approach (CS-ARDL) to examine how the ecological sustainability of 44 African nations was affected by their use of renewable energy. The study's conclusions show that there is no significant relationship between the REC and CO₂. Similarly, Muddassar, Sobia, and Muhammad (2022) investigated the relationship among the G-7 countries. The study's findings, which were obtained using quantile regression and Fully-Modified Ordinary

Least Squares (FMOLS), show that rising trends in information technology (ICT), renewable energy, GDP, and GCF degrade environmental quality while causing increases in CO₂ emissions. On the other hand, Mulugeta et al. (2023) used the Augmented Mean Group Model to analyse panel data for the years 2000–2020 in 30 SSA countries. They discovered a bidirectional causality between the two and a significant positive relationship (CO₂). Ibrahim et al. (2022) studied the impact in 45 SSA nations between 2008 and 2020, using the system GMM. The findings show a substantial and adverse correlation between CO₂ and renewable energy. This suggests that adding institutional quality to renewable energy will raise CO₂ emissions. Chunjiao and Hongxi (2023) used second-generation panel techniques for developed economies and discovered that electricity derived from renewable resources, environmental taxes, and the development of environmental technologies significantly lower consumption-based emissions while promoting environmental sustainability. Mahmood, Zahoor, Sana, and Rafael (2023) used panel data from emerging countries and the results indicate that while the usage of green energy reduces CO₂ emissions, natural resource rentals increase them. Similarly, Wei, Jiandong, and Saleem (2023) used the CS-ARDL method to study the effects between 1990 and 2018 in the leading future sustainable economies globally. The study's findings demonstrate that green trade improved green economic growth and dramatically decreased CO₂ emissions.

In addition, Ansari et al. (2021) concluded that the use of renewable energy decreases EFP in the highest-consuming countries of renewable energy outside Africa using the FMOLS, dynamic OLS (DOLS), and PMG methodologies. Similarly, Yang et al. (2021) employed the AMG and common correlated effects mean group (CCEMG) approaches and confirmed that the APEC economies experienced declining EFPs as a result of utilizing renewable energy. Mohsin et al. (2021) applied the Hausman-Taylor regression (HTR) and robust random effect (RE) approaches in a study that covered 25 developing countries in Asia. The findings of the study indicate that the adoption of renewable energy has a negative impact on the mitigation of CO₂. Using vector error correction (VECM) and ARDL models, Qayyum et al. (2021) demonstrated that the adoption of renewable energy reduces CO₂ in India. In a study on the BRICS nations, Chien et al. (2021) used MMQR technique and came to the conclusion that renewable energy worsened CO₂ emissions. Additionally, using MMQR, Anwar et al. (2021) shown that renewable energy reduces CO₂ emissions in ASEAN nations. Similar techniques were used by Miao et al. (2022) in a study on recently industrialised nations (NICs) utilising MMQR, FMOLS, DOLS, and fixed effects (FE) OLS. The results of the study demonstrated that EFP is hampered by renewable energy. Employing bootstrap ARDL, Suki et al. (2022) discovered that renewable energy has a positive impact on Malaysia's EFP. By applying the MMQR approach, Chien (2022) further showed that the use of renewable energy decreased CO₂ emissions in N-11 countries. Using the ARDL, DOLS, FMOLS, and canonical cointegrating regression (CCR), Raihan and Tuspekova (2022) demonstrated how renewable energy reduces CO₂ emissions in Peru.

From the literature reviewed, extensive studies have been carried out on the relationship between energy transition and environmental quality in SSA with varying outcomes of insignificant

relationships, and positive and negative significant relationships respectively. This present study introduces a new dimension to the debate on the relationship between energy transition and a sustainable environment by arguing that renewable energy is cost-competitive and that income growth could impact how smooth or difficult economies can transition from non-renewable to renewable energy. Cavard, (1989) argued that that inter-country variations in income growth could mirror how smooth or difficult energy transition promotes economic growth. Consequently, the hypothesis of this research is that disparities in the rate of economic growth could explain inter-country variances in the degree of energy transition, which could enable the achievement of a sustainable environment. This study is, therefore, significant because it empirically investigates if this theoretical postulation by Cavard, (1989) holds for Africa.

3. METHODOLOGY

3.1. Data

This study used annual data for environmental sustainability indicators (carbon dioxide emission and ecological footprint), and energy transition indicators (renewable energy consumption, renewable electricity output). Other variables used are GDP per capita (following the EKC Hypothesis), natural resource rent, urbanization, and globalization. Carbon emission and ecological footprint were adopted as dependent variables following existing environmental sustainability literature (Gao and Chen, 2023); Ahmad et al, 2023; and Abbasi et al, (2021). Based on Chien, et al. (2023) and Udemba and Tosun (2022), we used renewable energy consumption and renewable electricity output to measure energy transition. In line with Wang and Razzaq (2022), total natural resource rent is included in the study to account for the effect of natural resources on environmental quality. Finally, globalization and urbanization are equally included in the model to recognize the critical effect of globalization and urbanization on environmental sustainability (Sarfraz, Naseem, and Mohsim (2022).

3.2. Model Specification

Following the works of Samson, (2023); Muddassar, Sobia, Muhammad (2022); and Ibrahim, et al, (2022), we present carbon emission (C0_2) and ecological footprint (EFP) as functions of renewable energy consumption (REC), renewable electricity output (REO), and a set of control variables (X) which exhibit a more predictive power towards environmental sustainability variables – natural resource rents, GDP Per Capita (GDPC), globalization (GLO) and Urbanization (URB) and this accounts for our objective. Hence the model is specified as:

$$Y_{it} = \alpha_i + \delta X_{it} + \theta Z_{it} + \gamma_{it} + \varepsilon_{it} \quad (1)$$

Where, i and t denote nations and years, respectively. Y is the energy transition indicators, X stands for the vector of our key variables (REC and REO), and Z denotes a control variables' vector; γ and ε are country fixed effect and white noise assumptions respectively. In this study, we predict that $\delta < 0$, that is to say, the key explanatory variables are expected to have a reducing effect on environmental indicators. We selected control variables (Z) taking into account natural resource rent (NRRT), GDPC, GLO, and URB. The parameter estimates and their respective economic

expectations are $\theta > 0$. This means that the variables are expected to trigger environmental degradation. Details of all our variables are captured in Table 1.

Table 1: Variables Description

Variables	Measurement	Sources
CO ₂	Metric tons per capita	World Bank (WDI) Data
EFP	Gha per person	Global Footprint Network Database
REC	% of total final energy consumption)	WDI
REO	Renewable electricity output (% of total electricity output)	WDI
GDPPC	Constant 2010 US\$	WDI
NRRT	Total natural resources rents (% of GDP)	WDI
URB	Urban population (% of total population)	WDI
GLO	KOFI Globalization Index	KOFI

Source: Authors Computation

4. ANALYSIS AND DISCUSSION

4.1. Descriptive statistics

The descriptive statistics of our variable are presented in Table 2. The findings show that the average values of CO₂, EFP, REC, REO, NRRT, GDPC, GLO and URB are 0.878, 0.913, 66.262, 52.305, 10.271, 2158.015, 47.816, and 40.044 respectively. Also, the standard deviations are CO₂ (1.446), EFP (0.455), REC (23.465), REO (35.249), NRRT (10.132), GDPC (2433.977), GLO (8.177) and URB (17.108). This reveals that GDPC has the highest mean value followed by REC and then REO and GLO in SSA countries. The coefficients of the skewness for CO₂, EFP, NRRT, GDPC, GLO and URB are positive which means their distributions are skewed to the right while those of REC and REO are negative implying that their distributions are skewed to the left. EFP and GLO have kurtosis values equal to 3 meaning that they are mesokurtic and thus they are normally distributed. Also, Kurtosis values for CO₂, NRRT, and GDPC are greater than 3 implying that they are Leptokurtic. This further entails that their series is peaked relative to a normal distribution (or long-tailed), whereas REC, REO, and URB series is platykurtic as their values are less than 3, and as such the distributions have flat curves. Consequently, the hypothesis of this research is that disparities in the rate of economic growth could explain inter-country variances in the degree of energy transition.

Table 2: Descriptive Analysis

Variables	CO ₂	EFP	REC	REO	NRRT	GDPC	GLO	URB
Mean	0.8781	0.9126	66.262	52.30	10.271	2158.0	47.816	40.044
Median	0.3722	0.7711	76.330	53.41	7.2085	1112.6	47.794	38.904
	22	22	80	51	70	15	46	32
	67	05	40	07	23	20	68	00

Maximum	8.4466 50	2.3378 64	95.554 50	134.1 08	59.683 87	10892. 54	71.932 10	90.092 00
Minimum	0.0251 12	0.1850 00	8.7521 00	- 13.436	0.0023 60	194.87 31	27.580 91	14.610 00
Std. Dev.	1.4458 67	0.4553 38	23.465 03	35.24 94	10.132 11	2433.9 77	8.1770 86	17.108 10
Skewness	3.4029 66	1.2900 07	- 0.91321	- 0.0493	2.1984 66	1.7667 71	0.4350 00	0.5394 92
Kurtosis	15.549 48	3.7355 04	2.6920 39	1.647 12	8.2436 01	5.1217 26	3.7807 85	2.8361 19
Jarque-Bera	5885.0 17	207.82 60	99.058 99	53.13 03	1352.1 69	490.51 82	39.458 43	34.392 00
Probability	0.0000 00	0.0000 00	0.0000 00	0.000 00	0.0000 00	0.0000 00	0.0000 00	0.0000 00
Sum	608.53 84	632.44 68	45920. 12	36247 .4	7118.2 87	149550 5.	33136. 80	27750. 71
Sum Sq. Dev.	1446.6 49	143.47 45	381020 .4	85985 .4	71040. 48	4.10E+ 09	46270. 40	202539 .4
Observations	693	693	693	693	693	693	693	693

Source: Author’s computation

4.2: Correlation analysis

Table 3 contains the correlation analyses of our variables and the result indicates that for Panel A (when carbon emission represents an environmental sustainability variable), REC and REO have a negative relationship with C0_2 whereas NRRT, GDPC, GLO, and URB have a positive linkage with C0_2. However, in panel B (when the ecological footprint is adopted as an environmental sustainability indicator), REC, REO, and NRRT are negatively correlated with EFP while GDPC, GLO, and URB are positively correlated with EFP.

The absence of multicollinearity in the chosen models is confirmed by a robust check from post-estimation, which is shown in Appendix 2, which demonstrates that the mean and VIF values are all much lower than the theoretical redline.

Table 3: Correlation

<i>Variables</i>	<i>C0_2</i>	<i>rec</i>	<i>reo</i>	<i>nrrt</i>	<i>gdpc</i>	<i>Glo</i>	<i>Urb</i>
Panel A							
<i>C0_2</i>	1.000						
<i>rec</i>	-0.467	1.000					
<i>reo</i>	-0.199	0.444	1.000				
<i>Nrrt</i>	0.086	0.541	0.151	1.000			

<i>Gdpc</i>	0.689	-0.669	-0.238	-0.292	1.000		
<i>Glo</i>	0.448	-0.567	-0.142	-0.408	0.588	1.000	
<i>Urb</i>	0.618	-0.437	-0.190	0.052	0.632	0.322	1.000
	EFP	rec	reo	nrrt	Gdpc	Glo	Urb
Panel B							
<i>EFP</i>	1.000						
<i>rec</i>	-0.574	1.000					
<i>reo</i>	-0.265	0.444	1.000				
<i>Nrrt</i>	-0.333	0.541	0.151	1.000			
<i>Gdpc</i>	0.576	-0.669	-0.238	-0.292	1.000		
<i>Glo</i>	0.410	-0.567	-0.142	-0.408	0.588	1.000	
<i>Urb</i>	0.239	-0.437	-0.190	0.052	0.632	0.322	1.000

Source: Author's computation

This study employed IV-GMM which is presented in Table 4 below. Using carbon dioxide emission as an indicator for environmental sustainability (model 1), we found that energy transition such as REC exerts a negative and significant impact on carbon emission while REO exerts a negative but insignificant influence on CO₂ in SSA. Specifically, a percent rise in the use of REC reduces CO₂ by 0.33%. The negative and significant linkage between REC and CO₂ aligns with the findings of Ibrahim, et al, (2022), but against the findings of Samson, (2023) and Muddassar, Sobia, Muhammad (2022). Natural resource rent (NRRT), GDPC, and URB have positive and significant influences on CO₂. The outcome of the relationship between NRRT and CO₂ corroborates with the findings of Mahmood, Zahoor, Sana, and Rafael (2023). This implies that a percent rise in NRRT, GDP, and URB endangers environmental quality. The outcome of NRRT and CO₂ attunes to the findings of Mahmood, Zahoor, Sana, and Rafael (2023). Also, the GLO has a positive but insignificant impact on CO₂ in SSA.

Table 4: Result of IVGMM TWO-STEP SYSTEM (Dependent variables = C0_2 and EFP)

	<i>MODEL 1(C0_2)</i>	<i>MODEL 2 (EFP)</i>
<i>Variables</i>	coef	coef
<i>rec</i>	-0.333** [0.158]	-0.218*** [0.072]
<i>reo</i>	-0.020 [0.025]	-0.020** [0.010]
<i>Nrrt</i>	0.381*** [0.050]	0.014 [0.018]
<i>gdpc</i>	0.528***	0.199***

	[0.130]	[0.061]
<i>glo</i>	2.586	0.545
	[1.669]	[0.742]
<i>Urb</i>	0.465***	-0.202***
	[0.093]	[0.051]
<i>Constant</i>	-15.665**	-2.066
	[6.226]	[2.796]
<i>Diagnostics tests:</i>		
<i>Kleibergen-Paaprk LM statistic</i>	5.514	5.175
<i>p-value</i>	0.227	0.127
<i>Crag-Donald Wald F-Statistic</i>	4.618	4.618
<i>Kleibergen-Paaprk Wald F statistic</i>	2.380	2.380
<i>Hansen J statistic</i>	0.276	3.110
<i>p-value</i>	0.871	0.211
<i>Observations</i>	647	647
<i>R²</i>	0.755	0.500

Source: Author's computation, 2023

From Model 2, which used EFP as an indicator for environmental sustainability, findings indicate that REC, REO, and URB exhibited negative and significant linkages with environmental sustainability in SSA within the period under study. This means that a percent increase in REC, REO, and URB enhances environmental sustainability by reducing EFP by 0.22%, 0.02%, and 0.20% respectively. This result is in tandem with the findings of Ansari et al. (2021); Raihan and Tuspekova (2022); Yang et al. (2021); and Qayyum et al. (2021) but contrary to the findings of Mohsin et al. (2021). GDP exerts a positive and significant impact on EFP and by implication rise in income degrades the environment in SSA.

Following the predictions of the EKC Hypothesis, findings indicate that GDPPC has a positive nexus with environmental sustainability variables. This implies that GDPPC within the period under review has a debilitating effect on the environment. This is not surprising given the overall trend in GDP growth rate evidenced in Figure 3. This situation is critical to energy transition given the fact that many countries in SSA still grapple with rising poverty levels and infrastructure gaps necessitating the pursuit of economic growth, of which the use of non-renewable energy could be inevitable.

From the stand point of the EKC Hypothesis, a positive linkage between economic growth and environmental degradation implies that Africa is yet to approach the income threshold that is capable of pushing energy consumers from non-renewable energy to renewable energy consumption. Although energy transition variables have significant mitigating impacts on environmental degradation when the EFP is used to represent environmental sustainability, the

impacts are very small given that the energy transition index for developed countries is high as seen in Figure 4 while SSA is almost the least.

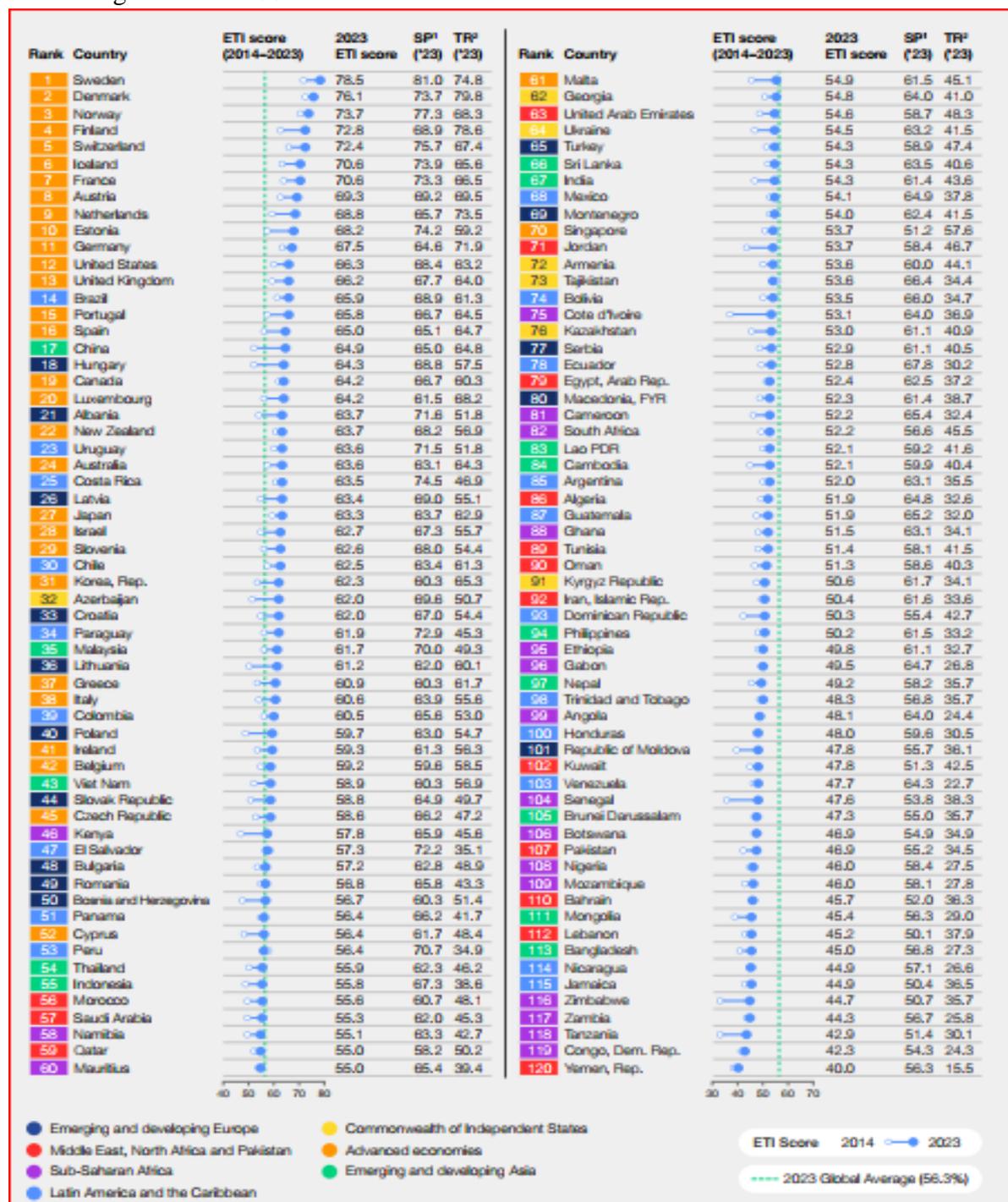


Figure 4: Energy transition index ranking, 2023

Source: World Economic Forum, 2023

Furthermore, when C0_2 is used to represent environmental sustainability, only one energy transition variable (REC) is significant, thus, buttressing the point already made.

Additionally, we used four diagnostic tests—the Kleibergen-Paaprk Wald F-Statistic, the Hansen J statistic, the Kleibergen-Paaprk LM statistic, and the Crag-Donald Wald F-Statistic—to assess the feasibility of the IV-GMM approach. The findings showed that there are no invalid instrument problems with our estimates. The Stock-Write LM test shows that the over-identifying restrictions are true across specified models and that the coefficient on the change in the explanatory variable is equal to zero under the assumption of an under-identified model. As a result, the J-Hansen statistic confirms that the estimation tools are accurate. The two models' respective coefficients of multiple determinations (R²), which quantify the variations in the dependent variable that can be attributed to the explanatory variables, are 0.755 and 0.505. This means that in the two models, the independent variables account for around 76% and 50% of the changes in the dependent variables, respectively.

4.4. Robustness analysis with Two-Stage-Least Square estimation

We tested and confirmed the reliability and robustness of our estimates by implementing the 2SLS estimation, which takes care of endogeneity issues just like IV-GMM. The outcome also confirms a similar result with the IV-GMM regression model (see Table 5). For instance, in the CO₂ model, rec exerts a significant negative influence on C0_2 while reo has a negative and negligible impact on C0_2. The 2SLS estimation suggests that a 1% increase in REC reduces C0_2 by 0.33% in SSA. For NRRT, GDPC, and URB, the 2SLS estimation indicates that a 1% rise in NRRT, GDPC, and URB deteriorates the environment by 0.39%, 0.52%, and 0.46% respectively. On the contrary, GLO shows a beneficial and insignificant linkage with CO₂.

For model 2, REC, REO, and URB were found to exert a negative but significant impact on the ecological footprint in SSA. GDPC exhibits a positive and significant impact on EFP while GLO again does not influence EFP. Above all, the estimated results of the 2SLS confirm that IV-GMM is reliable.

Table 5: Two-Stage Least Square Estimation (Dependent Variable = CO₂ and EFP)

	<i>MODEL 1</i>	<i>MODEL 2</i>
<i>Variables</i>	<i>Coef</i>	<i>Coef</i>
<i>rec</i>	-0.328** [0.169]	-0.207*** [0.076]
<i>reo</i>	-0.022 [0.028]	-0.022** [0.013]
<i>Nrrt</i>	0.384*** [0.046]	0.019 [0.021]
<i>Gdpc</i>	0.524*** [0.127]	0.184*** [0.057]
<i>Glo</i>	2.659 [1.653]	-0.218 [0.043]

<i>Urb</i>	0.464***	-0.202***
	[0.096]	[0.051]
<i>Constant</i>	-15.938**	-2.690
	[6.226]	[2.788]
<i>Diagnostics tests:</i>		
<i>Anderson canon. corr. LM statistic</i>	13.752	13.752
<i>p-value</i>	0.0033	0.003
<i>Crag-Donald Wald F-Statistic</i>	4.618	4.618
<i>F*</i>	164.93	73.65
<i>Prob> F</i>	0.000	0.000
<i>Sargan statistic</i>	0.334	3.135
<i>p-value</i>	0.846	0.209
<i>Observations</i>	647	647
<i>R²</i>	0.7537	0.4832

Author's computation

5. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

This study investigated the nexus between energy transition and environmental sustainability and the role economic growth plays in this nexus. The study is relevant because it can serve as a mirror of reflection through which Africa can see itself and thus, help in repositioning Africa in the fight to achieve a sustainable environment. Africa is undoubtedly well-positioned to supply clean, reasonably priced electricity to its expanding population and economies due to its abundance of renewable energy supplies, which will have a positive effect on environmental sustainability. Each nation, however, will follow a different path in the energy transition and environmental sustainability because of its unique socioeconomic beginnings. This analysis comes to the conclusion that each nation's existing economic level, reliance on non-renewable energy sources, urbanisation, and natural resource rent will all have an impact on the real pace and ultimate results of the energy transition's impact on environmental sustainability. Economic growth is critical in the nexus between energy transition and environmental sustainability in SSA because SSA still pursues economic development as a macroeconomic objective to solve issues of poverty. This is where the balanced energy mix by IMF, (2022d), comes into play as an interim measure for SSA to overcome the various energy and environmental problems facing Africa. To achieve a secure, equitable, and sustainable environment, SSA needs to take steps to innovate, support education and build human capital, strengthen energy regulations and political commitment, and provide finance for investment in renewable energy sources. The nexus between sustainable environment and readiness for energy transition is well captured in Figure 5.

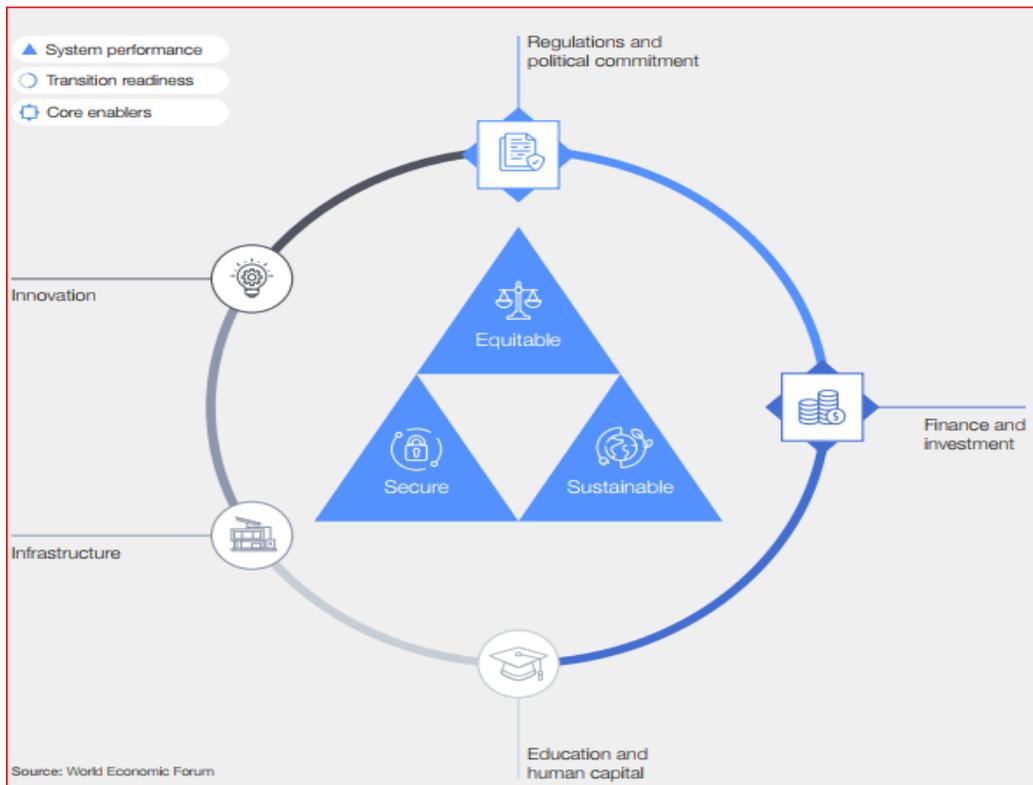


Figure 5: Energy transition readiness/enablers and environmental sustainability
 Source: World Economic Forum

5.2. Recommendations

We recommend that African nations should develop the human capacity and skills they need to carry out energy transitions on their own terms, while simultaneously fostering economic expansion and job creation throughout the continent.

The energy transition could propel socioeconomic growth on a large scale. Until environmental conditions improve beyond the income level, we suggest energy policies that promote balanced revolutionary decarbonisation.

The demand for electricity rises as developing economies grow. To put it succinctly as economies expand in emerging nations, households choose to spend a portion of their increased income on appliances and electricity. We recommend that SSA should provide funding and invest in innovations to exploit the rich renewable energy potentials since Africa possibly has the largest potential for renewable energy of any continent.

SSA should build functional, competent institutions and human capital to drive the energy transition process.

6. LIMITATIONS AND FURTHER STUDIES

Data for some variables in SSA were unavailable prompting the reduction in countries within SSA. Non-inclusion of some countries could have some level of impact on the outcome of the result. We suggest that a comparison between advanced countries and Africa be done.

AUTHOR DECLARATIONS

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Appendix 1: The Study Sample (29 SSA Nations)

Angola, Benin, Botswana, Burkina Faso, Cabo Verde, Cameroon, Central Africa Republic, Congo Republic, Cote d'Ivoire, Eswatini, Ethiopia, Gabon, Ghana, Guinea, Kenya, Lesotho, Malawi, Mali, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome & Principe, Senegal, Sierra Leon, South Africa, Tanzania, Togo, Uganda, Zambia and Zimbabwe

Appendix 2

Variance Inflation Factor (VIF).

<i>variables</i>	<i>C0_2</i>		<i>EFP</i>	
	<i>VIF</i>	<i>1/VIF</i>	<i>VIF</i>	<i>1/VIF</i>
<i>REC</i>	3.07	0.326	3.07	0.326116
<i>REO</i>	1.29	0.775	1.29	0.775
<i>NRRT</i>	1.74	0.574	1.74	0.574
<i>GDPC</i>	2.77	0.361	2.77	0.361
<i>GLO</i>	1.75	0.571	1.75	0.571
<i>URB</i>	1.94	0.514	1.94	0.514
<i>Mean VIF</i>	2.09		2.09	

Source: Authors Computation

N/B: Theoretically, if VIF is greater than 10 and the Average