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Comparative Analysis of the Growth Impact of Pollution and Energy Use in Selected West African Nations

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Abstract

We adopt the FMOLS and Granger causality technique to analyse the effect of energy use and carbon emissions on output growth in selected West African economies, which includes Nigeria, Gambia and Ghana, from 1970 to 2019. Findings confirm that energy use enhances growth in the three selected West African economies. But in terms of significance, energy consumption is significant in Nigeria and Gambia at a 1% level of significance while it is insignificant for the Gambia. CO2 emission positively and significantly propels economic growth for the three selected West African economies. For Nigeria, causality evidence shows no direct influence among the variables. For Ghana, we find a bi-causal association between output growth and carbon emissions and a unidirectional causality from pollution to energy consumption. For Gambia, economic growth causes CO_2 emissions. We recommend that the West African government reinforce their stand on a sustainable growth path through energy conservation.

Keywords: Energy Use, Pollution, Output Growth, West Africa.

JEL Codes: O44, O55, Q40, Q53.

1. Introduction

Can West African nations achieve green growth while fossil fuel energy consumption is increasing? Considering the resultant amount of pollution generated from energy use, to what extent does carbon emissions affect economic growth among some of the major countries in West Africa? These are the critical questions that occupy the centre stage in this scientific enquiry, which focuses on comparatively analysing the link between energy consumption, carbon emissions (CO2) and output growth in Nigeria, Ghana, and The Gambia. Owing to their size in the sub-region and the similar features they exhibit in terms of official language, common trading and economic growth relations, they attract the focus of this study.

Promoting economic growth and not comprising environmental sustainability remains a twin problem facing both developed and developing economies. This is because the pursuit of economic prosperity without taking cognizance of the environment throws the environment into severe danger, due to man economic activities (See Jalil & Mahmud, 2009; Apergis & Payne, 2009; Mesagan & Adeniji-Ilori, 2018; Mesagan et al., 2018). On the other hand, strict environmental policies crowd out economic activities and consequently hamper growth (See Omay et al, 2014 & Mesagan, 2015). However, the speed of economic growth generally depends on the level of urbanization, industrialization, and transportation facilities (Waheed et al, 2019; Mesagan, 2021a, b; Mohsin et al, 2021; Mahalik et al, 2021). These growth drivers, rely heavily on energy consumption and demand for fossil fuel, coal, and natural gas to thrive (See Zhou et al, 2011; Mesagan, 2015; Tang & Tan, 2015; & Mohsin et al, 2021). For instance, fossil fuel, natural gas, and coal are utilized for industrial operations, electricity generation, and transport means usage. The intensity of energy consumption or demand drives economic growth and in turn, induces environmental degradation through the CO2 emission (See Zhang & Cheng, 2009; Shaari et al, 2013; Isola & Mesagan, 2014; Lee, 2018). Put directly, energy consumption enhances economic activities and retards environmental quality (Omay et al, 2014; Eregha & Mesagan, 2017; Lee, 2018). Conversely, conserving energy use aimed at reducing CO_2 emission limits the speed of economic activity, contracts growth, and intensifies low living standard (Shaari et al, 2013; Mesagan & Olunkwa, 2022). For better policy options to accelerate growth and enhance the environment, this study becomes apt for West African economies.

According to Worldometre (2021), the population of the West African region is about 416 million approximately and by 2030 it will hit about 1,688.32million. This huge population potential implies the need for expansion of productive economic activities through industrialization to meet the needs of the people and propel economic output. However, the production process requires energy consumption to heighten economic activities in the region. For instance, in the quest to expand economic growth in West African countries and cater for the teeming population, primary energy consumption has increased from 3.8 KWh in 1970 to about 7.0 KWh in 2019 with about a 3.8% annual consumption growth rate (See BP Statistical Review, 2021). Fossil fuel, crude oil, and coal constitute the major sources of energy use in the region (Maji et al, 2017; Ajide & Mesagan, 2022). For instance, fossil fuels (Oil & Gas) constitute almost 80 % of Nigeria's energy consumption while renewable energy plays a minimal role (See WorldData, 2021). While the intensity of energy use enhances economic growth, it constitutes a danger to the environment in West Africa. West Africa Economic Outlook (2020) shows that the region has consistently been the third fastest-growing region in Africa with a 3.6% growth rate in 2019, which is above the 2018 growth rate by 0.2%. Nigeria is the main driver of growth in the region (See West Africa Economic Outlook, 2020). Following the energy consumption-growth trajectory in West Africa, between 1990 and 2014 GHG emission in West Africa has grown by 17% contributing 2.03% of the global emission (See USAID West Africa GHG Emission Factsheet, 2019). Interestingly, Nigeria contributes about 1.01% to global emissions (USAID West Africa GHG Emission Factsheet, 2019). This means that Nigeria accounts for about 50% of the region's CO2 emissions. Following the energy consumption, environmental and growth dynamics in the West Africa region, implies that the limited resources of energy can limit economic activities and place an inhibiting restriction on the volume of emissions and thus hindering welfare improvement and growth in the process.

However, evidence in the literature on the true link between energy, emission from CO_2, and growth is conflicting. Costantini & Martini (2010), Ozturk & Acaravci (2010), and Omay et al (2014), identified variation in data series, methodology, and sample location as the possible reason for the disagreement in the literature. However, Ighodaro (2010), Chen (2010), Adhikari & Chen (2012), Omay et al. (2014), found that energy consumption positively expedites economic growth. While incorporating population, Shaari et al. (2013) concluded that population triggers energy consumption while energy consumption accelerates economic growth. Maji &

Sulaiman (2019), found that renewable energy consumption hinders economic performance. Mallick (2008) confirmed a bidirectional effect between energy consumption and growth, while Dantama and Inuwa (2012), Lau et al. (2015) found a uni-causal effect flowing from energy to growth, and Onuonga (2012), confirmed a uni-causal effect flowing from economic growth to energy consumption. Omojolaibi (2010), Boopen & Vinesh (2012), Tang and Tan (2014), and Mesagan (2015), confirmed that economic growth intensifies the emission of CO2. Lee (2018), posited that renewable energy and export reduce pollution but growth and industrialization worsen pollution. Including CO2 emission in the energy-growth model, Zhang and Cheng (2009), found a unidirectional effect from GDP growth to energy consumption and energy consumption to CO2 emission. Vidyarthi (2013) found a unidirectional effect flowing from energy consumption to CO2 emission and GDP. Mohalik et al (2021) posited that total energy use, GDP growth, and urbanization skyrocket CO2 emission. Some other studies like Yao et al.(2015), Mesagan & Nwachukwu (2018), Pata (2018), and Charfeddine & Kahia (2019) identified trade, urbanization, and financial sector development as the medium through which energy consumption instigate CO_2 emissions.

Since there is no consensus in the literature on the link between energy consumption, carbon emission and growth, this study becomes apt for West Africa owing to the necessity to drive growth and ensure environmental sustainability in the region. Hence, energy as a key infrastructure plays a crucial role in advancing the development of the economy by interacting with the other sectors. Carbon emission also is a key and important bi-product of energy demand in any economy. Studies like Zhou *et al* (2011) and Tang and Tan (2015) have shown that energy consumption intensifies carbon emission. Consequently, it means that both have implications for economic growth. It is also worthy to note that any shock in the energy sector affects the level of productivity, profitability, income, and growth. To this end, the research questions include: to what extent does energy consumption impacts economic growth in West Africa? How does output growth in the selected West African nations respond to changes in the level ofCO_2emissions?What causal nexus exist between energy consumption, carbon emissions and economic growth in West Africa? By analysing the impact of CO_2 emissions on economic growth, we account for the possibility of green growth among the selected countries in West Africa. The findings of this research will be useful in determining the energy conservation policies to pursue without jeopardizing the growth objectives of West African countries. Again, policymakers will benefit significantly from the study in their quest to determine the nature of the relationship between carbon emissions, energy consumption, and economic growth in West Africa.

To the best of our knowledge, empirical studies that closely relate to this scientific enquiry, especially for the West African sub-region, are scarce. Most of the similar studies either beamed searchlight on the link between output growth energy use (Mallick, 2010; Adhikari & Chen 2012; Omay et al, 2014; Mesagan et al., 2021) or analysed the nexus between economic growth and carbon emissions (See Omojolaibi, 2010; Boopen&Vinesh, 2012; Tang and Tan, 2014; Mesagan, 2015). While Yao *et al.* (2015) while some others like Mesagan & Nwachukwu (2018), Pata (2018), and Charfeddine & Kahia (2019) identified financial development, urbanization, and trade as the medium for energy consumption-led pollution. In fact, past studies have largely been either time series or even mostly panel analysis thereby ignoring the comparative analysis that this study has thrown up. A comparative analysis of this sort is crucial owing to the fact that the selected nations have their specific emissions reduction and energy policies and might not have similar features or result that a panel analysis would suggest. As affirmed in Mesagan *et al.* (2019), Dogru *et al.* (2019), and Mesagan *et al.* (2021b), since panel analyses always come with a "one size fits all" syndrome, drawing practical implications from them can be somewhat difficult. Hence, our study fills the gap by conducting a comparative analysis for Nigeria, Gambia, and Ghana using the time series framework. This helps to reveal the essentials in each country and makes it possible to recommend country-specific emissions reduction policies, which can then be built on by other nations in the sub-region. Also, the West African region is often omitted by the previous studies with similar focus and our study has now filled this noticeable gap because several countries in the region are hugely dependent on energy, which has implications for carbon emissions and growth. The organization of the study follows as thus 2. presents literature review; 3. presents research methodology; 4. presents the result and discussion; 5. presents the conclusion

2. Literature Review

Empirical literature showing the nexus among the three indicators has taking different forms in the past. For instance, Mallick (2008),analyzed the energy and growth nexus in India, for the period 1971 to 2005, using the Granger causality method, and found a bidirectional causal nexus between energy consumption and growth. Omojolaibi (2010) tested the Environmental Kuznets Curve (EKC) preposition for 3 West African countries Ghana, Sierra Leone, and Nigeria between 1970 and 2006 using panel methodology. The study showed that pool OLS confirmed the evidence of EKC for West Africa while the dynamic effect rejects the preposition for West Africa. Ighodaro (2010) decomposed energy consumption into electricity demand, crude oil consumption, electricity demand, and gas utilization to examine energy consumption and growth nexus in Nigeria between 1970 and 2005. The study revealed a unidirectional causal effect flowing from energy consumption to growth, electricity demand to growth, and gas utilization to growth. Similarly, for China, Chen (2010) found a long-run association between GDP and energy consumption between 1953 to 2007. Lau et. al. (2011) found a causal association flowing from GDP to energy consumption in the long run and energy consumption to GDP in the short run for 17 Asian countries. Boopen and Vinesh (2012) found a close relationship between CO2 emissions and GDP for Mauritiana between the period of 1975 and 2009. Adhikari & Chen (2012) focused on 80 developing economies between 1990 to 2009 using the panel cointegration method. The study disaggregated the panel into three thresholds as high, middle, and low-income countries. They revealed that for the whole panel energy consumption has a long-run association with GDP while similar evidence exists for high and middle-income countries but, for low-income countries economic growth fuels energy consumption. In the same vein, Dantama & Inuwa (2012) focused on the Nigerian economy and found a unidirectional causal effect from energy consumption to GDP between 1980 and 2010. While for Kenya, Onuonga (2012) found a causal association moving from economic growth to carbon emission.

Furthermore, Ouedraogo (2013), found a unidirectional association flowing from energy consumption to GDP growth in the long run, while GDP growth to energy consumption in the short run for 15 ECOWAS countries between 1980 and 2008. Isola & Mesagan (2014) employed the VAR method and found that energy consumption deteriorated human welfare, between 1980 to 2012. Omay et al (2014),focused on the situation of G7 countries, concluded that the causal relationship between energy consumption and growth depends on the variation of business cycles. Tang & Tan (2014), confirmed the validity of the EKC hypothesis for Vietnam and also found a bidirectional causal association between CO2 emission and GDP, FDI, and CO2 emission while energy consumption granger causes CO2 emission between the period of 1976 and 2009. Yao et al (2015) identified economic growth and population growth as the main driver of environmental degradation in G20 countries. Accessing the situation of EU countries between 1961 and 2012, Lee (2018) concluded that renewable energy consumption and exports reduce emission while GDP growth and industrialization positively affect emission in the short run but in the long run, renewable energy consumption, exports, GDP growth, and industrialization impact reduces emission.

Moreover, Pata (2018), used the FMOLS and canonical cointegration regression method and revealed that financial development, urbanization, and GDP worsen environmental quality while renewable and hydropower energy consumption did not affect carbon emission in Turkey between 1974 and 2014. Using the ARDL approach, Mesagan & Nwachukwu (2018) concluded that financial development, income, and energy consumption significantly affected the environment in Nigeria while urbanization and investment did not have a significant effect on the environment between the period 1981 to 2016. Maji & Sulieman (2019) used the dynamic OLS to analyze the energy and growth linkage in 15 West African economies between 1995 and 2014 and found that renewable energy impedes growth. Munir et al (2019),focused on 5 ASEAN counties (Malaysia, Philippines, Singapore, Indonesia, and Thailand), and causality evidence revealed a unidirectional association from GDP to carbon emission in the Philippines, Malaysia, Singapore, and Thailand while unidirectional association from GDP to energy was found in Indonesia, Thailand, and Thailand. Also, energy unidirectionally caused GDP in Singapore while the Philippines had a feedback effect for GDP and energy consumption. Charfeddine & Kahia (2019), employed the PVAR method and found that financial development and renewable energy consumption weakly affect environmental quality and GDP for 24 Middle East and North African (MENA) countries between 1980 and 2015.Kadir et al (2019) included tourism in the carbon emission-growth model for 30 panels between 1996 and 2014. They found CO2 emissions to significantly affect growth while tourism and energy use exacerbate CO2 emissions significantly. Mahalik et al (2021) incorporated the role of education in reducing emission in the energy consumption and CO2 emission nexus for BRICS between 1990 and 2015. They decomposed education into primary and secondary levels and applied the Sys-GMM and found that primary education, general energy consumption, growth, and globalization positively drive

CO2 emissions while secondary education, renewable energy consumption, and urbanization improve environmental quality.

Following the review of the literature, previous studies that have investigated the nexus between energy consumption, CO2 emission and GDP have based their analyses on the causality among the variables (like Onuonga, 2012; Dantama & Inuwa, 2012; Ouedraogo, 2013; Tang & Tan, 2014; Omay et al, 2014). This study is different as it focuses on the direct impact of energy consumption and carbon emission on economic growth. Also, the inclusion of carbon emission in this study is very important because it has a huge implication for advancing green growth. As the volume of energy use increases vis-à-vis its impact on output growth, carbon emission is also produced and emitted in the process. Thus, as industrial and domestic pollution increases, it has implications for economic growth as described in the EKC model. Therefore, omitting it as most of the previous studies (Like Mallick, 2008; Ighodaro, 2010; Chien, 2010; Lau et al, 2011; Adhikari & Chen, 2012; Boopen & Vinesh,2012; Charfeddine & Kahia (2019) have done can make the information provided in the study incomplete. However, this study will not only analyse the effect ofCO_2emissions on growth but will also examine the causal relationship energy use, pollution, and growth to ascertain the direction of causality among them for West Africa. As explained in section 1, the study is unique since it is a comparative analysis on Nigeria, Ghana and Gambia to set the template for the promotion of green growth in the sub-region.

Trend analysis of the main indicators

Figures 1-3 presents a trend analysis for the three selected West African Countries (Nigeria, Gambia and Ghana) to understand the indicator's pattern of movement. Fig 1 shows that Nigeria has the highest energy use per capita for the study period compared to Ghana and Gambia. The possible reason for the surge in energy consumption may be the population growth rate of the nation. However, comparing Ghana to the Gambia, Ghana has a higher energy consumption per capita than the Gambia over the period.

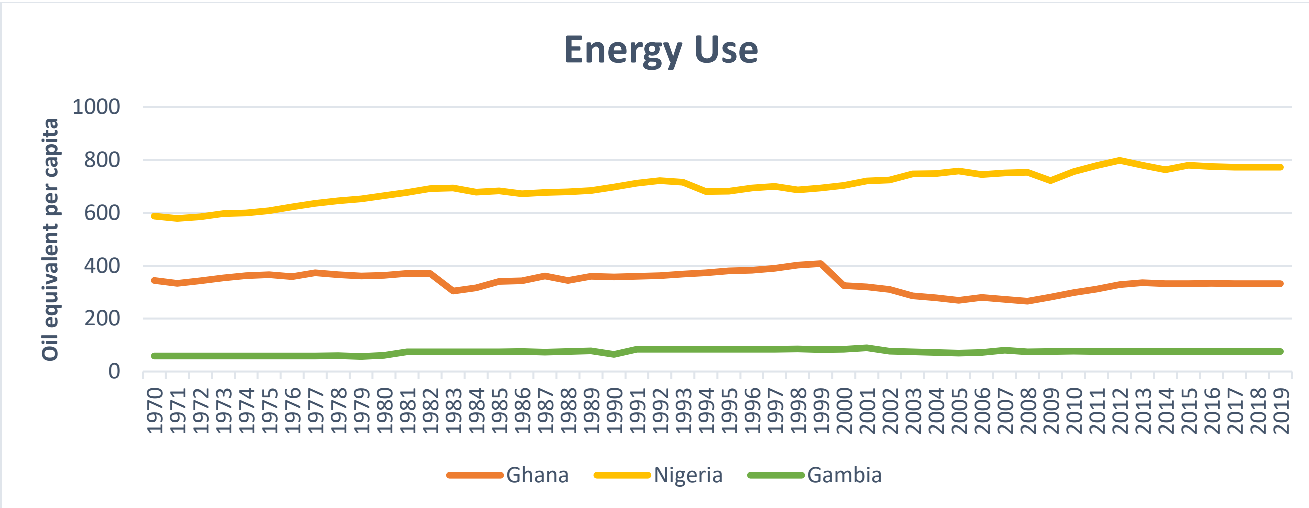

Fig 1: Energy Use Trend
Source: Authors' Computation

Fig 2 presents the CO2 emission trend for Nigeria, Gambia and Ghana. The trend evidence shows that Nigeria witnessed a drastic rise in CO2 emission between 1970 to 1977 but by1978 to 2002 the trend changed to a downward. This means that from 1978 to 2002, CO2 emission was on the decline for Nigeria. Regardless, Nigeria's emission is still above that of Ghana and Gambia. Moreso, Nigeria'sCO2 emission till 2019 remained above that of both Ghana and Gambia while Gambia is the least CO_2 emitter compared to Nigeria and Ghana.

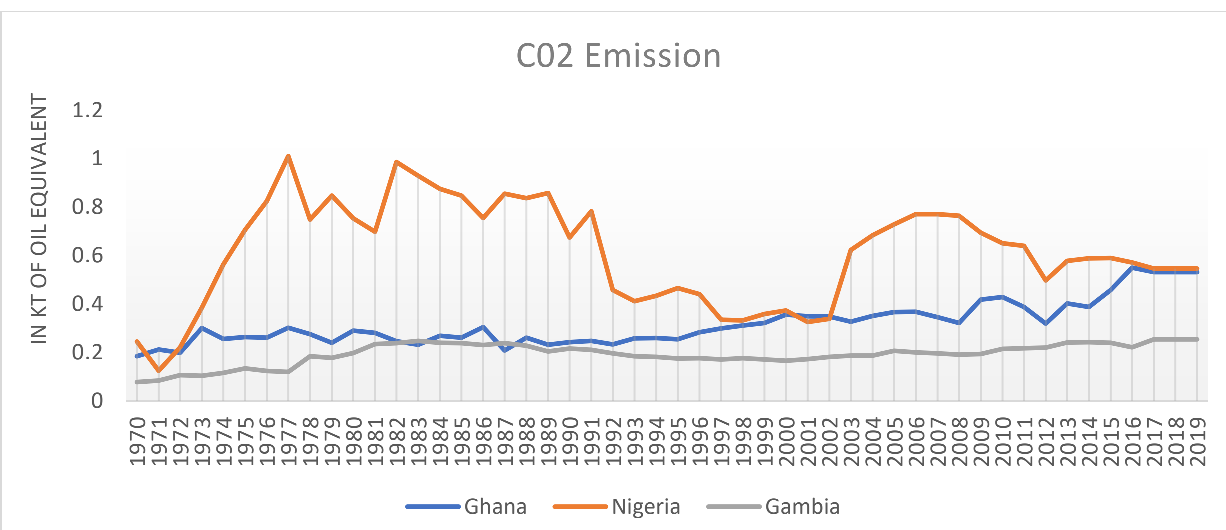

Fig 2: CO2 Emission Trend
Source: Authors' Computation

We present trend evidence to ascertain the economic growth pattern of the selected West African countries. Fig 3 depict that from 1970 to 2017 Nigeria's GDP per capita was the highest compared to Gambia and Ghana but in 2018 Ghana GDP per capita was slightly above Nigeria's own, but in 2019 the trend shows that Nigeria GDP slightly converges above that of Ghana. However, the Gambia GDP per capita remains far below Nigeria and Ghana. This means that Nigeria experienced higher economic growth compares to Ghana and Gambia over the study period.

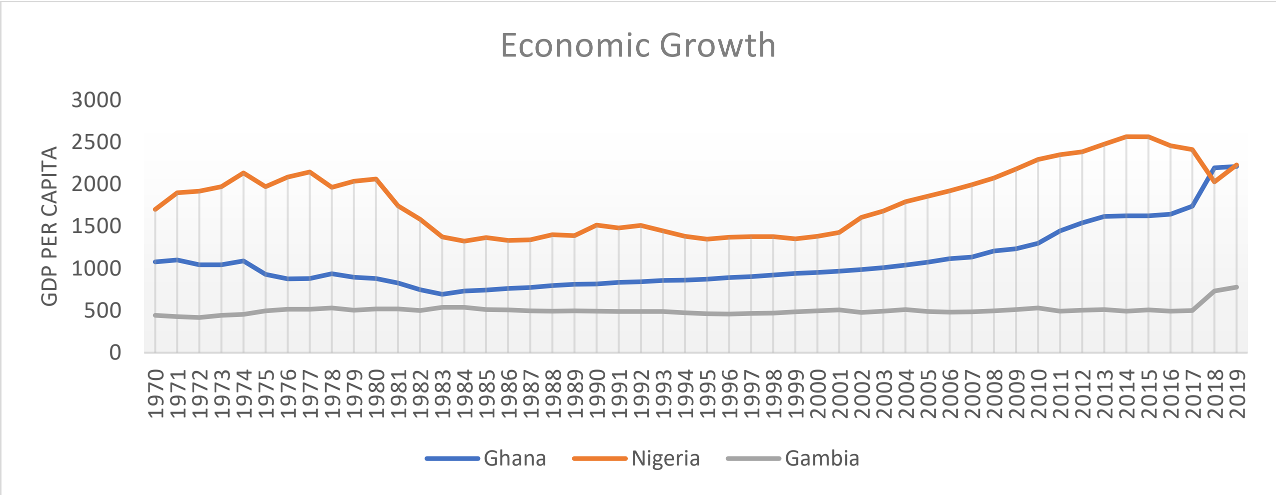

Fig 3: Economic Growth Trend
Source: Authors' Computation

3. Methodology

This study is based on the theoretical foundation of the neoclassical growth model of Solow and Swan (1956). The proposition of the model holds that output (economic growth) depends on the level of capital accumulation (K), labour (L) and technological progress (A). Meaning that variation in K, L, and A will affect output expansion. This study also drew methodological insight from Keller (2006), Heshmati (2001), Barro (1996),and Mesagan et al. (2022). Mathematically, the Solow neoclassical growth model is specified thus;

$$Y(f) = A(t)K(t)^{1-\beta}L(t)^{\beta}$$

(1)

Where K and L are capital and labour inputs respectively, $\alpha = 1 - \beta$ and β are their shares of output (Y) and A is an index of production efficiency.

With the need to determine the effect of energy consumption and carbon emission on economic growth in West Africa, we modify equation (1) to incorporate the role of energy consumption and carbon emission in economic growth. This represents an extension to the Solow model to incorporate these other variables from energy resources. In this respect we present the energy consumption and growth nexus as thus;

$$Y_{it} = \phi_0 + \phi_1 K_{it} + \phi_2 L_{it} + \phi_3 EN_{it} + \phi_4 TO_{it} + \mu_{it}$$

(2)

In equation (2), ϕ_0 is the constant term; ϕ_{1-4} are parameter coefficients; μ is the error term; i and t represent the cross-section and time factor. Further, *Y* is real GDP per capita and *K* is capital investment, *L* is labour force, EN is energy consumption and TO is trade openness. Trade openness is a control variable in the model. However, it is expected that trade openness can drive energy consumption and consequently fuel growth.

More so, we also present a model to estimate the linkage between carbon emission and growth for West Africa by modifying equation (1) as thus;

$$Y_{it} = \phi_0 + \phi_1 K_{it} + \phi_2 L_{it} + \phi_3 CO2_{it} + \phi_4 TO_{it} + \mu_{it}$$

(3)

In equation (3), CO2 is the volume of carbon emission while other components in the equation remain as defined.

We adopt the fully modified ordinary least squares (FMOLS) analytical technique based on the framework of co-integration regression suggested by Pedroni (2001) to estimate equations (2) and (3). The technique is advantageous because it accounts for possible endogeneity and serial correlation. All the data for estimation covering the period 1970 to 2019 are sourced from the World Development Indicators (WDI, 2020). We select 3 West African (WA) countries which are Nigeria, Gambia, and Ghana for analysis. This is owing to their huge role in the discussion to promote economic integration and common currency in the West African Monetary Zone (WAMZ). They are also selected because they exhibit similar features as predominantly English-Speaking countries.

Table 1: Data Sources

Variables	*Name*	*Measurement*	*Source*
Y	Economic growth	Measured with real GDP income per capita	WDI, 2020
K	Capital	Measured with the gross capital formation in % of GDP	WDI, 2020
L	Labour	Measured with total labour force	WDI, 2020
EN	Energy consumption	energy consumption measured in kilogram of oil equivalent per capita	WDI, 2020
CO2	Carbon Emission	carbon emission measured in kilotonnes of oil equivalent	WDI, 2020
TO	Trade openness	trade in % of GDP	WDI, 2020

Source: Author's Compilation

4. Results and Discussion

Table 2 presents the unit root result for the chosen nations in WA. To this end, we use the Augmented Dickey-Fuller (ADF) unit root test to check the stationarity status of the series. The ADF result indicates that the series for the three countries Nigeria, Gambia, Ghana are stationary at I(1) at a 1% significance level. This means that for the three selected West African countries, we reject the null hypothesis of no stationarity at I(1) and it denotes that the series are mean reverting and converge towards a long-run path. With the evidence of unit root, we present Johansen's cointegration evidence for the selected West African countries in Table 3.

Table 2: ADF Unit Root Result

Variables	ADF Statistic			Order of Integration
	Nigeria	Gambia	Ghana	
Y	-5.4187***	-4.3035**	-3.7272**	I(1)
	(-3.5107)	(-3.5130)	(-3.5266)	
K	-3.6289***	-8.6359***	-6.0455***	I(1)
	(-3.5180)	(-3.5063)	(-3.5085)	
L	-5.3396***	-4.5143**	-3.7309**	I(1)
	(-3.515)	(-3.5085)	(-3.5297)	
EN	-6.5486***	-9.1289***	6.4407***	I(1)
	(-3.5063)	(-3.5063)	(-3.5063)	
CO2	-7.5199***	-7.3178***	-9.3861***	I(1)
	(-3.5063)	(-3.5063)	(-3.5063)	
TO	-7.7897***	-8.0130***	-4.3206***	I(1)
	(-3.5063)	(-3.5063)	(-3.5236)	

Note: *critical values are shown in parenthesis. *** and ** signify 1% and 5% significance level.*

In Tables 3 and 4, we present Johansen's cointegration result for the selected West African nations. Specifically, Table 3 shows Johansen's Trace evidence while Table 4 shows the Maximum-Eigen evidence for both energy consumption and growth model and CO2 emission and growth model. In Table 3, Trace statistic shows that there are 2 cointegrating equations for Nigeria and 1 cointegrating equation for Gambia and Ghana for energy consumption and growth model while carbon emission and growth model Trace statistic shows that there are 2 cointegrating equations for Nigeria and 1 cointegrating equation for Gambia and Ghana respectively. This implies that at a 5% significance level we reject the null hypothesis of no cointegration. Meaning that there is a long-run association among capital (K), labour (L), energy consumption (EN), CO2 emission (CO2) and economic growth (Y) for the three selected West African countries.

Table 3: Johansen Cointegration Trace Test

Number of cointegrating equations	Nigeria		Gambia		Ghana	
	Trace Statistic	Prob. @5%	Trace Statistic	Prob. @5%	Trace Statistic	Prob. @5%
Energy consumption-growth Model						
None *	88.2107*	0.0009	97.3356*	0.0001	79.6523*	0.0067
At most 1 *	54.9416*	0.0094	43.9649	0.1107	39.9602	0.2239
At most 2	25.9394	0.1305	19.6483	0.4470	17.8487	0.5773
At most 3	12.6221	0.1294	8.4143	0.4222	7.4815	0.5224
At most 4	2.9413	0.0863	1.0796	0.2988	0.0569	0.8114
CO2 emission-growth Model						
None *	75.1095*	0.0178	82.8420*	0.0032	83.9205*	0.0025
At most 1 *	46.1062*	0.0723	42.7107	0.1398	44.2418	0.1050
At most 2	25.9979	0.1288	20.6711	0.3785	23.0514	0.2435
At most 3	12.6528	0.1282	7.8428	0.4823	9.8138	0.2953
At most 4	3.3171	0.0686	1.5411	0.2144	0.9169	0.3383

Key:* implies that we reject the null hypothesis at 5% level

Again, for the Maximum-Eigen statistic presented in Table 4 for both models, it shows that there is 1 cointegrating equation respectively for the three selected West African countries for energy consumption and growth model, and also carbon emission and growth model. This implies that at 5% significance level, the Maximum-Eigen statistics rejects the null hypothesis of no cointegration, and conclude that there is a long-run association among capital (K), labour (L), energy consumption (EN), CO2 emission (CO2) and economic growth (Y) for the three selected West African countries. The unit root and cointegration evidence indicate that our series is satisfactory for further scientific enquiry.

Table 4: Johansen Cointegration Maximum-Eigen Test

Number of cointegrating equations	Nigeria		Gambia		Ghana	
	Max-Eigen Stat	Prob. @5%	Max-Eigen Stat	Prob. @5%	Max-Eigen Stat	Prob. @5%
Energy consumption-growth Model						
None*	33.2691	0.0589	53.3702*	0.0001	39.6921*	0.0091
At most 1 *	29.0021*	0.0327	24.3166	0.1241	22.1115	0.2147
At most 2	13.3173	0.4235	11.2344	0.6240	10.3672	0.7096
At most 3	9.6807	0.2337	7.33473	0.4503	7.4245	0.4402
At most 4	2.9413	0.0863	1.0796	0.2988	0.0569	0.8114
CO2 emission-growth Model						
None*	29.0033*	0.0410	40.1313*	0.0079	39.6787*	0.0091
At most 1	20.1083	0.3337	22.0396	0.2183	21.1903	0.2649
At most 2	13.3451	0.4210	12.8282	0.4682	13.2376	0.4306
At most 3	9.33569	0.2593	6.3016	0.5748	8.8969	0.2948
At most 4	3.3171	0.0686	1.5411	0.2144	0.9169	0.3383

Key:* implies that we reject the null hypothesis at 5% level

In Table 5-6, we present the regression output of the FMOLS estimates for specific countries (Nigeria, Gambia and Ghana) for the energy-led growth model and CO2 emission-led growth model. In Table 5, the slope of energy consumption is 2.9554, 0.0082 and 0.3940 for Nigeria, Gambia and Ghana respectively. This implies that for the three selected West African economies, energy consumption positively engenders economic performance such that variation in energy consumption is responsible for a rise in economic performance in Nigeria by 2.95554, the Gambia by 0.0082 and Ghana by 0.3940. The evidence shows that energy use is most growth-enhancing in Nigeria, followed by the Gambia, and then Ghana. In terms of significance, energy consumption significantly drives economic activities in Nigeria and Ghana at a 1% level of significance, while it is insignificant for driving economic performance for the Gambia. The insignificant status of energy in driving the Gambian economy explains why energy use in Gambia is far below that of Nigeria and Ghana as presented in Fig 1. Concerning the fitness of our model, the R-squared showed that our model is a good fit for Nigeria, Gambia and Ghana. This is because the regressors jointly explain the variation in the economic performance of the selected West African economies by about 80%, 74% and 97%, respectively. Even after adjusting for the degree of freedom, the regressors explain the changes in GDP in the selected countries by about 78%, 72% and 97% respectively. This indicates that our model is good.

Table 5: Energy and Growth nexus in West Africa

Variables	**Regressand: Economic Growth (Y)**		
	Nigeria	**Gambia**	**Ghana**
K	-0.0015 (0.0013)	0.0013 (0.0014)	-0.0005 (0.0007)
L	3.0754*** (0.3871)	0.7445 (0.4211)	4.1495*** (0.1632)
EN	2.9554*** (0.7939)	0.0082 (0.1971)	0.3940*** (0.0804)
TO	0.0005 (0.0007)	-0.00006 (0.0004)	-0.0002 (0.0001)
C	17.0623*** (2.4575)	-1.2738 (2.2563)	29.0125*** (1.0473)
R-square	0.8070	0.7462	0.9746
Adj. R-square	0.7846	0.7202	0.9716

Note:* denotes 1% significance level and Std error values are in ( )

In Table 6, CO_2 emission positively and significantly propels economic growth for the three selected West African countries. An increase in CO2 emission expedites economic performance by 0.1555 for Nigeria, 0.6285 for Gambia and 0.2144 for Ghana. This means that as Nigerians, Gambians and Ghanaians emit more carbon in the process of economic activities, it results in more economic output. Moreso, the R-squared estimate shows that our model is good with all the regressors jointly accounting for changes in output performance in the three selected West African countries by 83%, for Nigeria, 78% for the Gambia and 96% for Ghana. Moreover, after adjustment, the coefficient becomes 81% for Nigeria, 77% for the Gambia and 95% for Ghana. Afterwards, we present causal evidence in Table 7 to show the flow of influence among the variables.

Table 6: Carbon emissions and Growth nexus in West Africa

Variables	Regressand: Economic Growth (Y)		
	Nigeria	**Gambia**	**Ghana**
K	-0.0018* (0.0011)	0.0022* (0.0012)	0.0008 (0.0009)
L	2.8791*** (0.2926)	0.1695 (0.4958)	3.8071*** (0.2617)
CO2	0.1555*** (0.0379)	0.6285** (0.3227)	0.2144** (0.1027)
TO	0.0007 (0.0006)	-0.0006 (0.0005)	-0.0004** (0.0002)
C	23.8253*** (2.1513)	1.7076 (2.5683)	27.7342*** (1.7256)
R-square	0.8317	0.7823	0.9634
Adj. R-square	0.8121	0.7705	0.9591

Note:*** denotes 1% significance level and Std error values are in ( )

Table 7 shows a neutral causal association amongCO2 emission, energy consumption and economic output for Nigeria. The implication is the absence of a direct linkage between growth and energy consumption and CO2 emission in Nigeria. However, for Ghana bi-causal association exists between CO2 emission and economic performance while CO2 emission causes energy consumption. In the same vein, for the Gambia, economic activities cause a rise in CO2 emission, meaning that the intensification of economic activities by Gambians causes the emission of carbon dioxide to rise also.

Table 7: Causality Result

F-statistic	*CO2*	*EN*	*Y*
		Nigeria	
CO2	-	0.10166	0.5917
EN	1.5970	-	0.3117
Y	0.3619	1.1664	-
		Ghana	
CO2	-	1.9019**	5.6102***
EN	0.07406	-	1.4462
Y	5.3597***	0.4972	-
		Gambia	
CO2	-	1.6533	1.9280
EN	2.0710	-	0.2730
Y	4.7616***	0.4808	-

Note:*** and ** denotes 1% and 5% significance level

Discussion of Findings

For the first model, the FMOLS shows that in the three selected West African economies, energy consumption positively relates to high economic output. This means that for Nigeria, Gambia and Ghana energy consumption propels growth. The economic intuition of this evidence is that energy constitutes a useful infrastructure that is connected to key sectors such as transportation, manufacturing, mining and housing that are drivers of growth. The significant impact that energy use has on growth for Nigeria and Ghana may be traceable to the conscious efforts of the governments to improve the efficiency in power generation and access to electricity. For instance, the Nigerian government partly privatized the power sector in 2013 to boost electricity access to 90% by 2030 from 56.5% in 2018, and also the Renewable Energy Master Plan (RAMP), which aims to improve electricity supply from 13% in ratio to total energy supply in 2015 to 23% and 36% by 2025 and 2030 respectively (See Energy for Growth Hub, 2018 & Centurion Analysis, 2021). Therefore, as energy becomes accessible, industrial and residential energy uses increase, output expands and consequently results in economic growth. Similarly, the commitment to the National Energy Efficiency Action Plan (NEEAP) by the Ghanaian government between 2015 to 2020 to improve energy accessibility and consumption may inform the significant contribution of energy use in Ghana's economic performance. While the insignificant status of energy consumption on growth in the Gambia may be attributable to the limited ambition of the country to increase energy generation and supply, compared to Nigeria and Ghana, perhaps due to population size when compared with Nigeria and Ghana.

Interestingly, the finding is similar to that of Chen (2010) for China, Ighodaro (2010) for Nigeria, Adhikari & Chen (2012) for 80 developing economies, Omay et al (2014) for G7 countries.

Similarly, for the second model, CO_2 emissions positively and significantly enhances growth in the three selected West African nations. This means that the emission of carbon dioxide contributes significantly to the expansion of economic activities in Nigeria, Gambia and Ghana respectively. The reason for this evidence is not far from the fact that these economies rely on export earnings from extractive industries. For instance, crude oil export constitutes 95% of foreign exchange (FX) earnings and 80% source of budgetary revenue for Nigeria (see Global Edge Report, 2021). For Ghana, gold mining accounts for 95% of export earnings and Ghana gold mining output has reached 4.8million ounces compared to South Africa with 4.2million ounces in 2019,thus making Ghana the largest producer of gold in Africa (See ITA, US Department of Commerce Report, 2021). While for the Gambia, sawn wood, rough wood and refined petroleum constitute sources of top export earnings for the economy with sawn wood contributing about $15.4million, rough wood contributing about $46.8million and refined petroleum contribute on an average of $11.6million to the economy (See OEC Report, 2021). Therefore, in the process of extracting crude oil to earn more income, gas flaring occurs and consequently intensifiesCO_2 emission. This implies that as extraction of output increases, resulting in general economic expansion, gas flaring also increases. In the same manner, the mining of gold and sawing of wood to enhance national income require the consumption of energy resources, such as fossil fuels, oil, coal and natural gas, which are mostly CO_2 emission drivers. Again, another possible justification for this evidence is that CO_2 emission from vehicular use can trigger a rise in economic growth in the West African region. Motor vehicles are the major means of transportation to facilitate economic activities in West Africa. As vehicular ownership and movement increase, fossil fuel demand and use increase and, as a result,CO_2 emission rises, which consequently brings about an increase in economic performance. For instance, the Be Forward analysis (2019) reveals that for every 12 Nigerians there is one vehicle, while for every 22 Ghanaian, there is one vehicle. This means that as vehicle per capita increases in the West African region, CO_2 emissions rises and as a result brings about high economic output. This resonates with the findings of Kadir et al (2019), for 30 countries but is at variance with the findings of Omojolaibi (2010) for 3 West African nations, Boopen &

Vinesh (2012) for Mauritania, Tang and Tan (2014) for Vietnam and Mesagan (2015) for Nigeria.

5. Conclusion

We employ the FMOLS method of data analysis to analyse the CO_2 emission, energy consumption and economic growth in three selected West African countries, which include Nigeria, Gambia and Ghana between 1970 and 2019. The study identifies a noticeable gap in the literature by using a stepwise regression to assess the energy consumption and economic growth impact and also pollution and economic growth impact. FMOLS estimate reveals that energy consumption propels growth in Nigeria, Gambia and Ghana. It denotes that as firms, industries and households consume more energy, output increases and consequently results in economic growth in West African countries. However, in terms of significance, energy consumption is significant in accelerating growth in Nigeria and Ghana but insignificant for the Gambia. Moreso, CO2 emission positively and significantly triggers economic growth in the three selected West African nations, implying that the emission of carbon dioxide in Nigeria, Gambia and Ghana have a strong positive implication for economic prosperity.

Furthermore, assessing the causal association between and amongCO_2 emission, energy consumption and economic output expansion, for Nigeria, there is a presence of neutral association among the variables. It means the absence of direct linkage among CO_2 emission, energy and economic expansion in Nigeria. For Ghana, CO_2 emission and economic performance influence each other. This means that carbon emissions engender economic activities and economic activities also engender pollution. In the same vein, CO_2 emission causes energy consumption. For the Gambia, economic activities influence CO_2 emission. Owing to the scientific evidence, the West African countries governments should reinforce their stand on the pursuit of sustainable economic growth through proper energy conservation plans to attain prosperity without compromising their ecological footprint.

Declarations

Ethics approval and consent to participate:

Not Applicable

Consent for publication:

Not Applicable

Availability of data and materials:

The data used in this study are available from the corresponding author on reasonable request

Competing interests:

The authors declare that they have no competing interests

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Authors' contributions:

EPM conceptualised and presented the literature review.

EOanalysed the results and conducted the editorial review of the paper.

HA presented the methodology section.

All authors read and approved the final manuscript.

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