Impact of economic growth on carbon emissions in selected West African countries, 1980–2019

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Abstract

Purpose – This study investigated the impact of economic growth on carbon emissions on selected West African countries between 1980 and 2019. Simon-Steinmann's economic growth model provides the relevant theoretical foundation. The main objective of this study was to ascertain whether economic growth will impact carbon emissions.

Design/methodology/approach – The study selected six-sample countries in West Africa and used secondary data obtained through the World Bank Group online database covering the period 1980–2019, employing panel econometric methods of statistical analysis.

Findings – The outcome indicates that the independent variable showed a positively significant impact on the dependent variable for the pooled samples in the short-run, with significant cointegration.

Research limitations/implications – The study concluded that economic growth significantly impacts the emissions of carbon, and a 1% rise in economic growth will result to 3.11121% unit rise in carbon emissions.

Practical implications – Policy implementation should encourage the use of energy efficient facilities by firms and government and the establishment of carbon trading hubs.

Social implications – Failure by governments to heed the recommendations of this research will result to serious climate change issues on economic activities with attendant consequences on human health within the region and globally.

Originality/value – This is one of the comprehensive works on subject covering the West African region within the continent.

Keywords Carbon-dioxide emissions, Population and economic growth, Greenhouse gas, West Africa, World Bank Group, Energy utilization and consumption

Paper type Research paper

1. Introduction

Some scholars had contended that economic growth refers to the problems of developed countries (Jhingan, 2008). The process of raising income level in developed climes had also been credited to economic growth (Maddison as cited in Jhingan, 2008). Schumpeter sees growth as a gradual and steady change in the long-run through increase in the rate of savings and population (Schumpeter, 1934 as cited in Jhingan, 2008). However, it has been counter-argued that growth has nothing to do with the type of economy but relates to the nature and causes of change.

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This refutes the assertion that economic growth only refers to the problems of advanced nations. There is also growth in developing economies such as West African countries. Jhingan (2008) asserts that growth is determined by economic and noneconomic factors. Economic factors comprise capital, enterprise, technology, natural and human resources while social institutions, political condition and moral values are summed as noneconomic factors. Schumpeter also postulates that savings and population affect economic growth. The power house of an economy is the inbuilt capacity of the human capital and available technology. The positive assumption is a rise in the population engineer's productive growth of in the economy. Brand (2009 as cited in Etugbo, 2020) supports the view that efficient human capital is key to growth. The resources available for economic growth are driven by the people. A rise in population leads to higher energy consumption for agricultural and industrial purposes. Productive energy supports labor and capital as input factors in the production process.

Energy in terms of electricity generated from coal and fuel are drivers of economic growth (Mulugeta *et al.*, 2012). Chindo and Abdul-Rahim (2018) consider growth as the rise in energy utilization since nations are making efforts to boost their productive capacities. It has been asserted that a rise in energy consumption leads to growth in carbon emissions (Hossain, 2014; Begum *et al.*, 2015). Fossil fuel utilization as a source of energy generates carbon-dioxide (Co_2) emissions into the atmosphere. Human activities have greatly escalated due to uncontrolled population, especially in West Africa. The predictions of Malthus on population growth are evident in Africa without measures to checkmate it. The activities of deforestation, bush burning, manufacturing and building are increasing greenhouse gases in the atmosphere (Chindo and Abdul-Rahim, 2018). Liddle (2015) also contends that rise in population can raise energy consumption resulting to rise in carbon emissions. The issue of carbon emissions due to increased human activities as well as geometric increase in population is a disturbing phenomenon, which cannot be overlooked. It has to be prevented to reduce its disastrous impact on global temperature, environment and human lives.

Based on this stand point, a protocol for the reduction of carbon emissions was developed in Kyoto, Japan in 1997 and effective in 2005. The United Nation framework on global climate change committed it members to abide by the emission reduction targets. The World's efforts in minimizing carbon emissions were corroborated by the Paris (COP 21) agreements in December 2015 and adopted by 195 countries to implement the first global climate deal (Chao and Hsiango, 2016). Economic growth has adversely impacted on the environment through intense pressure on natural resources. Economic growth and globalization are scenarios if not managed will cause systemic collapse of the planet's natural resources (Danella *et al.*, 2004; Allau, 1980). Environmentalists had advised countries to associate economic growth with quality of life, wasteful consumption, environment degradation and social inequality.

Sustainability of the planet should be uppermost consideration in policy formulation (Mckenzie, 2019 as cited in Ge *et al.*, 2020). In 2019, 11 scientists from 150 independent nations declared that over exploitation of the ecosystem and excessive extraction processes were caused by economic growth. They warned that efforts should be shifted from gross domestic product (GDP) growth to the sustenance of improved human lives. Other studies showed that a significant positive relationship exists between carbon gas emission and economic growth and disparities in carbon intensities (carbon emissions per GDP). They posited that global economic wealth was positively related to rate of global carbon emissions (Garret, 2009; Carrington, 2019).

To validate these postulations in West Africa, the study seeks to investigate whether economic growth has any influence carbon emissions. The study is significant because it will inform policymakers on the causes of carbon emission and global warming in the sub-region as well as provide measures that would lead to carbon emission reduction without necessarily reducing economic growth. The objective of the study is to determine whether economic growth exerts any impact on emissions of carbon in selected West Africa countries in the short run, as well as in the long run. The study formulated two hypotheses to test whether economic growth significantly impacts the emissions of carbon gas in the (1) shortrun and also in the (2) long-run, by employing econometric analyses based on data sourced from Nigeria, Ghana, Gambia, Liberia Senegal and Niger.

2. Review of related literature studies

Several literature studies were reviewed in respect of subject, covering the conceptual framework, theoretical framework and empirical review.

2.1 Conceptual framework

Key concepts were reviewed in the course of this study as highlighted in the supporting subsections:

2.1.1 Carbon (CO_2) emissions and economic growth. Growth is a progressive phenomenon that evolves through combination of factors (natural, human and technological) within specified periods. The dire need to grow the economy increases economic activities in countries of the world. Increase in the volume of economic activities had been argued as the causes of environmental hazards (Adu and Denkyirah, 2017). Economic growth is seen to be facilitated through industrialization and globalization. Industrialization serves as the economic engine for growth and development (Peet, 1987, as cited in Adu and Denkyirah, 2017). Industrialization and globalization are enhanced through technology and increased energy consumption. The increase in economic growth will induce global warming. Countries in West Africa are gradually shifting from the agricultural-based economy to attaining high level of growth. The establishment of industries by foreign entrepreneurs coupled with indigenous ones has made West African countries “pollution haven” due to weak environmental protection laws (Adu and Denkyirah, 2017).

In unraveling the debate whether economic growth causes disruption of the environment, Kuznets (1995) hypothesized that as per capita increases, income inequality reaches maximum and decreases in line with diminishing laws of returns. Increase in income is necessitated by economic growth and desire for pleasurable life. Studies from environmental Kuznets’ curve indicates that emerging economies such as West African countries will face degradations in the environment at the onset of economic development (Grossman and Krueger, 1995). Oil mining in Nigeria (Niger–Delta region) has drastically altered the ecosystem resulting to massive environmental pollution of the land, sea and air. The pollution caused by oil spillage, pipelines vandalism, gas flaring and local refineries is overwhelming and catastrophic to human and environmental resources. Meadows *et al.* (1972) suggest that activities in an economy constitute a source of environmental pollution. Despite the initiative canvassed by the Kyoto protocol in 1992, the West African Union under West Africa Economic and Monetary Union countries framework is still experiencing increasing CO_2 emissions (Youmanli, 2017).

It has been affirmed that industrialization, globalization, population growth and changes in lifestyles are major factors that increase energy consumption. As energy consumption increases, the level of carbon emissions invariably increases due to economic activities for enhanced GDP (Apergis and Ozturk, 2015). Youmanli (2017) argues that economic growth affects the natural chemistry of the environment positively or negatively depending on the composition effect. It was contended that manufacturing activities with less pollution intensive technologies mitigate the consequences of economic activities on the environment and vice versa (Brock and Taylor, 2005). Urbanization has also been seen as a necessary factor that affects the level of pollution (Hossain, 2011; Sharma, 2011). Al - Mulali *et al.* (2015) suggested urbanization increases pollution in Europe; however, population does not affect

CO_2 emissions in Malaysia (Begum *et al.*, 2015). The Malaysian study may require further probing to authenticate its veracity against contrasting results (Chindo *et al.*, 2015).

Aye and Edoja (2017) contended that economic growth had predictive ability of carbon emissions. Carbon emission is regarded as a greenhouse emission that causes global warming and indirectly, environmental degradation. The authors debunked the notion that environmental efficiency would improve as incomes increase, but rather advocate that more carbon dioxide would be released if measures are not taken to reduce carbon footprints. Environmental impacts are thus worsened by industrialization and development. Environmental impact otherwise referred to as degradation is the gradual wearing away of the environment and its constituent elements, including the ecosystem, water, soil, air, habitat and wildlife through uncontrolled human activities (Conservation Energy, CEF, 2016). Degradation of the environment had been reckoned officially as a major threat to nature and mankind (Aye and Edoja, 2017). A country's growth rate is determined by a number of factors such as population growth, economic capacities and natural resources. The objective of growth in an economy is to increase the wealth of nations, per capita income, enhanced living standard and economic stability. However, certain growth may produce negative consequences on the environment through pollution, over exploitation, degradation, loss of wildlife and climate change (Phimphanthavang, 2013).

Ayoade (2003) argues that industrial revolution increases the level of CO_2 in the Earth's atmosphere. The level of carbon gas at the beginning of industrial revolution was about 280ppm for about 700 years. However in 1860, the rate of emissions of CO_2 into the atmosphere is 0.5% per year (Mohamed *et al.*, 2012). CO_2 emissions arise from bush burning, oil and natural gas exploration activities, as well as coal as sources of energy for production. Carbon-dioxide emissions also escape into the air through wood burning, waste materials and industrial process such as cement production, refineries, alcohol factories, etc. The rise in peoples' economic activities doubles the degree of pollution of the environment. The economic activities of production and manufacturing revolve round these explicit causes of carbon dioxide emissions and environmental degradation.

2.2 Theoretical framework

This work is anchored on Simon-Steinmann's economic growth model and suggests that a larger population will induce a larger level of growth in technology, resulting to larger per capita income. There is causality and correlation among increased population, technology and per capita income. This is referred to as the population push model. The idea behind this model is that technology develops independent of population growth through learning-by-doing. By learning and doing, technology builds upon itself bringing to the unity of the pull and push effects of technological advancement. During the period of static population the proponents contend that there are some levels of technological progression however slower than in growing population.

Cobb–Douglas production function was used to explain the endogenous technological progression based on both learning-by-doing and population growth. The theory also buttressed the relationship between supply of labor and population while dismissing the impact of age-structure and dependency ratio on economic growth as negligible. The US and Japan economies were used to illustrate the difference between savings proportion and its output impact. Results from the model showed that average per capita economic growth was at equilibrium.

In 1986, Simon contended that the higher the population, the higher the rate of production through the adoption of technology. This asserts that negative population growth will limit growth, while large negative outflows in population will cause growth stagnancy. The author advised that the extent of composite technology available and in use should never decrease.

Consistent growth in population and technology will result to growth and development in the economy.

2.3 Empirical review

There have been inconsistencies in deciding the direction of the debate on carbon emissions, notwithstanding that limited studies have been undertaken in the Western coast of the African hemisphere on subject. For instance, some of the available studies are as follows:

Akinlo (2008) as well as Adom *et al.* (2012) both argued in favour of economic growth as a major factor affecting the increase of carbon gas emissions in selected African nations. Both studies used Granger causality approach and covered countries, such as Togo, Sudan, Nigeria, Congo, Gambia, Zimbabwe, Ghana, Kenya, Senegal and Ivory Coast from 1980 to 2003. The outcome of both Akinlo's (2008) study and his further studies with VECM econometric method recognized three brand of causality relationships existing among the variables of energy utilization and GDP with carbon emissions, namely, bidirectional causality for countries such as Senegal, Ghana and Gambia, the relationship was unidirectional for Zimbabwe and Congo DR, while the causality relationship was neutral for Nigeria, Togo, Cameroun, Kenya, Sudan and Ivory Coast. Eleazar (2015) also supported the neutrality influence existing between growth in the economy and energy utilization as revealed above by Adom *et al.* (2012) and Akinlo (2008). The results showed that using a Toda and Yamamoto Granger causality technique, economic performance and energy utilization had neutral effects in Cameroun, Senegal, South Africa and Togo in the long run. The researchers noted the possible implementation of energy efficiency policies in the study countries.

Chiu (2012) in a study of 52 nations from 1972 to 2003 using established variables (trade openness, rural population, per capita GDP, population density and free political association) employed panel smooth transaction regression (PSTR). The outcome debunked the existence of Kuznets curve theory of the environment (commonly known as EKC) for the selected countries. Farhani and Rejeb (2012), focused on the study of 15 Middle East and North Africa countries between 1973 and 2008 using GDP, energy consumption and carbon emissions as variables. The study which used panel cointegration and panel causality test methods revealed no significant relationship as existing between energy utilization and GDP and between CO_2 emission and energy utilization in the short run. In the long run, however, a unidirectional causality was observed between GDP and CO_2 emission and energy consumption. Duarte *et al.* (2013) in a study of 65 countries between 1962 and 2008 using variables such as income per capita, water per capita, political freedom and precipitation observed using a PSTR econometric method, a U-shaped relationship with marked downward slope dominated nexus.

Chen and Hang (2014) in their study using 36 countries from 1985 to 2012, adopting oil consumption, natural gas consumption, coal utilization, GDP per capita and CO_2 per capita with a PSTR method, argued in support of a regime switching relationships among per capita measure of GDP and carbon gas with a significant outcome on coal consumption, natural gas and oil consumption. (These energy sources are carbon emitting in their very nature). Heidari *et al.* (2015) using five Association of South-East Asian Nations countries from 1980 to 2008 defined variables comprising energy consumption, carbon emissions and economic performance. Again, the PSTR method was used and the result revealed a contradiction with Chiu (2012). Saidi and Hammami (2015) investigated 58 countries between 1990 and 2012, employing variables such as GDP per capita, capital stock, population, CO_2 emissions per capita, energy utilization per capita and financial development. The investigation which used dynamic panel variables with GMM revealed a positive correlation between GDP per capita and energy consumption with carbon emissions per capita.

More recent studies in the African terrain revealed a significant relationship between carbon gas emissions and short-run economic growth, while in the long run no significant relationship was detected between CO_2 emission and economic growth. The no significant correlation implies no EKC existence in African sub-region and the selected study areas (Adu and Denkyirah, 2017; Youmanli, 2017; Aye and Edoja, 2017). Esso and Keho (2016) from their studies discovered that economic growth Granger-causes CO_2 emissions in the short run in sample areas of DR Congo, Ghana, Benin, Senegal and Nigeria.

Finally, contemporary studies such as Bismark and Li (2018) using panel econometric methods insist on a unidirectional causal effect of GDP on carbon gas emissions in Africa. Also, while Olusanya and Musa (2018) contended in favour of a negative effect of GDP on carbon gas emissions in the short run for countries such as Zimbabwe, Senegal, Liberia and Malawi, Chun and Xiaoxin (2019) maintains that financial development significantly affects carbon emissions in emerging economies and least developed countries. Hence, this study will attempt to reconcile most of these disparities and disagreements that above studies have generated with appropriate policy directions for the West African governments toward reducing the incidents of global warming.

3. Materials and methods

This section considers the various diagnostics and standard tests to be carried out as well as formulation of variables and models.

3.1 Research design

The research employed secondary panel data obtained online through World Bank Group website and the Central Bank of the selected study countries covering the period1980–2019. The selected panel sample countries included in this study are Nigeria, Ghana, Senegal, Liberia, Niger and Gambia.

3.2 Model and variable specification

Several researchers have conducted investigations on subject, and this work is modeled after the study of Saidi and Hammami (2015), who used GDP per capita, capital stock, population, CO_2 emissions per capita, energy consumption and financial development with moderate modifications as follows:

$$RGDP = \alpha_0 + \alpha_1 ENCSP + \alpha_2 PGDP + \alpha_3 CO_2E + \alpha_4 INFR + t_n \quad (1)$$

Where, $RGDP$ = real gross domestic product;

$PGDP$ = population per gross domestic product;

CO_2E = carbon dioxide or simply carbon emissions;

$ENCP$ = energy consumption;

$INFR$ = inflation rate;

$\alpha_0 - \alpha_4$ = parameters and

t_n = error term at period n.

A prior expectation is a positively significant correlation: $RGDP > 0 > CO_2E$

Equation (1) above could be transformed into a panel model, as follows;

$$RGDP_{it} = \alpha_0 + \alpha_1 ENCSP_{it} + \alpha_2 PGDP_{it} + \alpha_3 CO_2EM_{it} + \alpha_4 INFR + \omega_{it},\ \omega_{it} = t_i + V_{it} \quad (2)$$

(Random effect)

4. Data and analysis

The statistical analysis undertaken will cover both diagnostic tests and the hypothesis testing including panel descriptive statistics, unit root tests, panel regression and Granger-causality tests and cointegration econometric tests with relevant diagnostic testing (Heteroskedasticity tests).

4.1 Basic econometric tests

4.1.1 Panel descriptive statistic. Figure 1 shows a normally distributed normal panel series with significant Jarque-Bera probability of 0.0000 comprising the six-study sample areas of Niger, Ghana, Senegal, Nigeria, Gambia and Liberia.

The descriptive statistics in Table 1 show a total generated observation of 232 for the panel series with positively distributed mean, median and standard deviations. The skewness ranges from negative peakedness of −2.185093 to highest peakedness of positive 10.63081 before closing at a low positive of 0.752006 depicting a normal distribution curve (Figure 1). The kurtosis is averagely platykurtic with a significant Jarque–Bera probability of 0.0000. The Jarque–Bera test is a statistic test used to measure the difference of the skewness and kurtosis of the series with those from the normal distribution. It is observed that while some of the countries in the study area may not fall within a normal distribution, the panel series of the combined series will tilt toward a normal distribution as depicted in Figure 1.

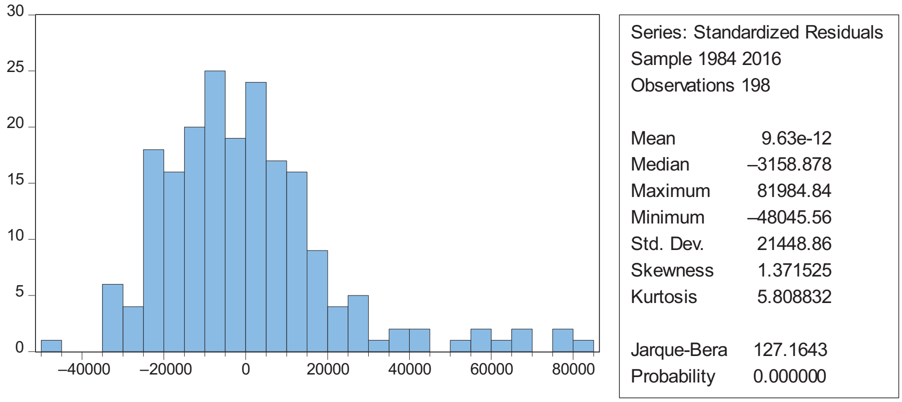

Figure 1.
Normality distribution

Source(s): Author's E-views 10 computation

4.1.2 Stationarity test. The Stationarity test at 0.05 significance level and indicates that the panel variables have significant probabilities of 0.0000 with first level difference integration. Hence, the panel series do not have unit roots and are all stationary at the first level of integration (see Table 2).

4.2 Hypothesis testing

4.2.1 Restatement of Hypothesis 1.

H0. Economic growth does not show significant outcome on emissions of carbon in the selected study areas in the short run.

H1. Economic growth does show significant outcome on emissions of carbon in the selected study areas in the short run.

	RGDP	*CO_2E*	*INFR*	*PGDP*	*ENCSP*
Mean	3.048967	14400.59	11.25323	1.1108	107.9080
Median	3.517628	1917.841	7.432672	535.9886	0.000000
Maximum	15.32916	131685.6	122.8745	1.2910	408.2541
Minimum	−30.14513	0.000000	−7.796642	0.000000	0.000000
Std. dev.	4.621803	29879.96	16.48071	1.1909	133.1158
Skewness	−2.185093	2.453438	3.381949	10.63081	0.752006
Kurtosis	15.36698	7.970216	19.25065	114.0159	2.031844
Jarque–Bera	1663.059	471.5446	2995.062	123507.0	30.92735
Probability	0.000000	0.000000	0.000000	0.000000	0.000000
Sum	707.3603	3340936.	2610.749	2.5810	25034.65
Sum sq. dev.	4934.406	2.0611	62742.77	3.2920	40932.76
Observations	232	232	232	232	232

Source(s): Author’s E-views 10 computation

Table 1. Panel descriptive statistics

Variable	ADF statistic	I, P and S statistic	Probability	Integration level
CO_2E	−6.4111	−6.7317	0.0000	I(1)
PGDP	*−2.5130*	*−5.7711*	*0.0060*	I(1)
RGDP	*−12.0803*	*−15.6428*	*0.0000*	I(1)
INFR	*−9.5943*	*−10.4853*	*0.0000*	I(1)
ENCSP	*−3.32964*	*−10.605*	*0.0004*	I(1)

Source(s): Author’s E-views 10 computation

Table 2. Levin, Lin and Chu Panel unit root test

The panel model is translated into a random panel model and tested using panel ordinary least square with the result in Table 3. This hypothesis will be tested using both the panel regression and panel Granger-causality methods; in addition, the individual country contributions to the overall panel results will be highlighted.

The panel regression result in Table 3 reveals that RGDP has positively significant outcome on carbon gas emissions at the 5% confidence level with a probability of 0.0021. Hence, a 1% rise in the RGDP will result to 3.11121% rise in the gas emissions for the selected sample countries. Similarly, at a lead of two levels, there is a positive and significant impact of the energy utilization/consumption on subject gas emissions in the shorter period. The R^2 and adjusted R^2 at 12.06 and 9.98%, respectively, shows a good goodness fit and the model is capable of taking up more variables. The Dubin–Watson value 1.79769 shows a strong regulation of autocorrelations or its reduction to a very acceptable minimum.

4.2.1.1 Granger-causality results. The result in Table 4 indicates only a unidirectional Granger-causality impact of PGDP on CO_2E being significant with a p-value of 0.0164 at the chosen level of 5% significance for Niger. For Senegal, the result indicates there is no Granger-causality impact of PGDP and RGDP on CO_2E with insignificant p-value above 5% at the chosen level of significance. Hence, Senegal did not contribute to the observed short-run economic growth impact on carbon emissions. Similarly, the results for Ghana show that PGDP and RGDP do not Granger-cause CO_2E. Thus, economic activity levels for subject country has no significant impact on carbon gas emissions with p-values above 5% confidence level. However, the causality outcome for Nigeria indicates that PGDP Granger-causes CO_2E in a unidirectional fashion with a significant p-value of 0.0230. Thus, economic activity levels in Nigeria produces a significant outcome on CO_2E. Again, the Granger-causality output for Gambia in same Table 4 indicates a significant unidirectional causal

Dependent variable: RGDP				
Method: Panel least squares Date: 04/26/21 Time: 16:23 Sample (adjusted): 1985 2013 Periods included: 29 Cross-sections included: 6 Total panel (balanced) observations: 174				
Variable	Coefficient	Std. error	*t*-statistic	Prob.
C	2.233808	0.445421	5.015043	0.0000
$CO_2E(2)$	3.111205	9.960106	3.121163	0.0021
INFR(-5)	0.002875	0.017595	0.163426	0.8704
ENCSP(2)	0.007279	0.002418	3.010254	0.0030
PGDP(6)	4.050110	2.201010	1.841205	0.0673
R-squared	0.120587	Mean dependent var.		3.666237
Adjusted *R*-squared	0.099772	SD dependent var.		4.189622
SE of regression	3.975127	Akaike info criterion		5.626305
Sum-squared resid	2670.476	Schwarz criterion		5.717082
Log likelihood	−484.4885	Hannan–Quinn criter.		5.663130
F-statistic	5.793405	Durbin–Watson stat.		1.797694
Prob(*F*-statistic)	0.000215			

Source(s): Author's E-views 10 computation

Table 3.
Panel regression

impact of RGDP on CO_2E with a *p*-value of 0.0062 at the 5% level. While, the results for Liberia show that there is no significant causal impact of PGDP and RGDP on CO_2E at 0.05 confidence level. Hence, economic activity levels in Liberia do not influence carbon emissions.

Overall, the panel Granger-causality test result in Table 4 indicates that population per gross domestic product (PGDP) exerts a significant impact on CO_2E in a unidirectional fashion with a probability of 0.0192 at a confidence level of 5% for the panel series. Also, PGDP exerts unidirectional significant impact with a *p*-value of 0.0082 on carbon emissions at a confidence level of 5%. However, RGDP indicates an insignificant causality impact on carbon emissions.

Decision: The panel regression tests show a significant *p*-value of 0.0021 of RGDP on CO_2E with a significant unidirectional causality. We thus accept the alternative hypothesis that RGDP and PGDP (measuring growth in the economy) exerts a significant impact on CO_2E in selected West African countries in the short run.

4.2.2 Restatement of hypothesis 2.

H2. Economic growth does not show significant outcome on emissions of carbon gas in the selected study areas in the long run.

H3. Economic growth does show significant outcome on emissions of carbon gas in the selected study areas in the long run.

4.2.2.1 Cointegration results. *Comments*: Results in Table 5 indicate a long-run impact for Ghana with two cointegrating vectors at 0.05% level of confidence and two cointegration vectors between RGDP/PGDP and carbon gas emissions in Niger at same 0.05 confidence level. Similarly, results for Senegal using autoregressive distributed lag (ARDL) econometric tests show three cointegrating vector between RGDP/PGDP and CO_2E at the 5% chosen level of confidence.

Also, the cointegration test result in Table 5 reveal the existence of eight cointegrating equations at the 0.05 significant level for Nigeria. The cointegration test result for Gambia,

Null hypothesis	Obs	*F*-statistic	Prob.
Panel granger (PG) causality tests			
ENCSP does not influence CO_2E	218	0.40198	0.6695
CO_2E does not influence ENCSP		0.27663	0.7586
PGDP does not influence CO_2E	218	4.02651	0.0192
CO_2E does not influence PGDP		0.44368	0.6423
RGDP does not influence CO_2E	218	0.98564	0.3749
CO_2E does not influence RGDP		0.55046	0.5775
PGDP does not influence ENCSP	228	4.91056	0.0082
ENCSP does not influence PGDP		0.30181	0.7398
Sample country's causality results			
Granger causality tests (Niger)			
ENCSP does not influence CO_2E	35	1.53680	0.2315
CO_2E does not influence ENCSP	2.04730	0.1467	
PGDP does not influence CO_2E	35	4.72752	0.0164
CO_2E does not influence PGDP	1.50796	0.2377	
RGDP does not influence CO_2E	35	0.83956	0.4418
CO_2E does not influence RGDP	0.90875	0.4138	
Granger causality tests (Senegal)			
ENCSP does not influence CO_2E	35	0.68331	0.5126
CO_2E does not influence ENCSP	4.10983	0.0265	
PGDP does not influence CO_2E	35	3.01328	0.0642
CO_2E does not influence PGDP	0.95113	0.3976	
RGDP does not influence CO_2E	38	0.46254	0.6337
CO_2E does not influence RGDP	0.06203	0.9400	
Granger causality tests (Ghana)			
ENCSP does not influence CO_2E	38	5.81823	0.0068
CO_2E does not influence ENCSP	2.62728	0.0873	
PGDP does not influence CO_2E	38	0.07723	0.9258
CO_2E does not influence PGDP	0.42055	0.6602	
RGDP does not influence CO_2E	38	1.98967	0.1528
CO_2E does not influence RGDP	0.47025	0.6290	
Granger causality tests (Nigeria)			
ENCSP does not influence CO_2E	37	12.0787	0.0001
CO_2E does not influence ENCSP	0.44914	0.6421	
PGDP does not influence CO_2E	37	1.00428	0.3776
CO_2E does not influence PGDP	4.25393	0.0230	
RGDP does not influence CO_2E	37	1.08830	0.3489
CO_2E does not influence RGDP	0.07350	0.9293	
Granger causality tests (The Gambia)			
PGDP does not influence CO_2E	34	1.32200	0.2822
CO_2E does not influence PGDP	0.32027	0.7285	
RGDP does not influence CO_2E	34	6.09510	0.0062
CO_2E does not influence RGDP	1.60304	0.2186	
PGDP does not influence ENCSP	37	0.77965	0.4671
ENCSP does not influence PGDP	6.29635	0.0049	
RGDP does not influence ENCSP	37	0.25164	0.7791
ENCSP does not influence RGDP	0.78887	0.4630	
Granger causality tests (Liberia)			
ENCSP does not influence CO_2E	35	0.68331	0.5126
CO_2E does not influence ENCSP	4.10983	0.0265	
PGDP does not influence CO_2E	35	3.01328	0.0642
CO_2E does not influence PGDP	0.95113	0.3976	
RGDP does not influence CO_2E	35	1.03854	0.3663
CO_2E does not influence RGDP	2.87093	0.0723	

Source(s): Author's E-views 10 computation

Table 4. Granger-causality result table

PANEL COINTEGRATION RESULT					
Series: CO_2E ENCSP INFR PGDP RGDP					
Sample: 1980 2019					
Included observations: 240					
Unrestricted rank tests (Trace and maximum eigenvalue)					
Hypothesized No. of CE(s)	Fisher stat.* (from trace test)	Prob.	Fisher stat.* (from max-eigen test)		Prob.
None	100.4	0.0000	63.42		0.0000
At most 1	55.41	0.0000	35.62		0.0001
At most 2	27.63	0.0021	15.17		0.1259
At most 3	21.13	0.0202	17.37		0.0665
At most 4	19.34	0.0361	19.34		0.0361
SAMPLE COUNTRY COINTEGRATION OUTCOME					
Niger					
Unrestricted rank tests (Trace)					
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical value		Prob.**
None *	0.597938	84.56672	69.81889		0.0021
At most 1*	0.543721	52.67648	47.85613		0.0165
Trace test shows two cointegration vectors at 0.05 level					
Senegal					
Dependent variable: CO_2E					
Method: ARDL					
Sample (adjusted): 1984 2016					
Dynamic regressors (four lags, automatic): ENCSP INFR PGDP RGDP					
Number of models evaluated: 2500					
Selected model: ARDL(1, 2,)					
Variable	Coefficient	Std. error	*t*-statistic		Prob.*
ENCSP	−2.693006	2.085471	−1.291318		0.2161
ENCSP(-1)	7.404463	2.483545	2.981409		0.0093
PGDP	0.274436	1.160702	0.236440		0.8163
PGDP(-1)	−4.339312	1.610085	−2.695082		0.0166
PGDP(-2)	5.901431	1.232884	4.786689		0.0002
RGDP	160.3699	56.06274	2.860544		0.0119
Ghana					
Unrestricted rank tests (Maximum eigenvalue)					
Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical value		Prob.**
None *	0.833908	68.21802	33.87687		0.0000
At most 1 *	0.712897	47.42080	27.58434		0.0000
Max-eigenvalue test shows two cointegration vectors at 0.05 level					
Nigeria					
Unrestricted rank tests (Maximum eigenvalue)					
Hypothesized No. of CE(s)	Eigenvalue	Max-eigen Statistic	0.05 Critical value	Prob.**	
None *	0.636511	37.44425	33.87687	0.0179	
At most 1 *	0.545253	29.15652	27.58434	0.0312	
At most 4 *	0.110587	4.336176	3.841466	0.0373	
Max-eigenvalue test shows three cointegrating vectors at 0.05 level					
Gambia					
Unrestricted rank tests (Maximum eigenvalue)					

Table 5.
Cointegration results

(*continued*)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical value	Prob.**
None *	0.757660	48.19205	33.87687	0.0005
Max-eigenvalue test shows 1 cointegrating vector at 0.05 level				
Liberia				
Unrestricted rank tests (Maximum eigenvalue)				
Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical value	Prob.**
None *	0.630785	34.87319	33.87687	0.0379
Max-eigenvalue test shows one cointegrating vector at 0.05 level				

Source(s): Author's E-views 10 computation

Table 5.

revealed the existence of two cointegrating relationships in the panel series at the 0.05 significant level. Again, the cointegration test result for Liberia, displayed the existence of two cointegrating relationships in the panel series at 0.05 level.

Overall, the results in the panel cointegration for the selected samples in Table 5 revealed eight cointegrating vectors in the panel series with highly significant *p*-values at the chosen 5% confidence level.

Decision: We thus accept the alternative hypothesis to reject the null hypothesis that there is high level of cointegration impact of economic growth measured by RGDP on carbon emissions in the selected sample of the West Africa sub-region of the African continent.

4.2.3 Diagnostic testing – heteroskedasticity test. The residual's null of the panel series assumes that the probability values of the panel series is significant if less than 5% level, and it is not heteroskedastic. Hence, from Table 6, the *p*-value of 0.0000 for the panel series residual indicates the absence of heteroskedasticity.

4.3 Discussion of findings

The results of this investigation that studied the economic growth impact as measured by PGDP and real gross RGDP on CO_2E in selected West African countries including Niger, Senegal, Ghana, Nigeria, Gambia and Liberia from 1980 to 2019 using various econometric methods such as panel least square, Granger-causality and cointegration. The result for the hypothesis one, revealed that for the pooled studies, economic growth had positively significant outcome on carbon gas emissions and PGDP and RGDP, both Granger-caused carbon emissions; these outcomes were only contributed by countries three countries including Niger, Nigeria and Gambia while the other countries of selection showed an

Panel cross-section heteroskedasticity LR test
Null hypothesis: Residuals are homoscedastic
Equation: UNTITLED
Specification: CO_2E C ENCSP(-4) PGDP(-2) RGDP INFR(3)

	Value	df	Probability
Likelihood ratio	934.5595	6	0.0000
LR test summary			
	Value	df	
Restricted LogL	−2255.187	193	
Unrestricted LogL	−1787.907	193	

Source(s): Author's E-views 10 computation

Table 6. Heteroskedasticity output

insignificant Granger-causality impact. The outcome of this test agrees with the literature and theoretical studies of Simon-Steinmann's population push model. The result of this findings is further corroborated by the outcome of Saidi and Hammami (2015) as well as Bismark and Li (2018).

The second hypothesis was to ascertain whether the studied impact was significant in the long-run, using pooled and individual country cointegration tests. The pooled result showed the existence of long-run impact of growth in the economy on carbon gas emissions in the selected study area. The trace and maximum-eigen value tests show eight cointegrating vectors in the pooled result, and this outcome was contributed by all the sampled country. Again, these results is supported by the literature studies, theory by Simon-Steinmann and the outcome of Saidi and Hammami (2015) and also with Kais and Ben Mubarak (2017).

4.4 Policy implications

This study brings to the fore the global warming challenges associated with industrialization and development in emerging West African economies with the following implications;

(1) As population continues to increase in the sub-region, there will be serious incidence of uncontrollable growth in greenhouse emissions.

(2) Consequently, since a significant impact exists between the subject variables measured by GDP on carbon emissions, industrialization resulting from this growth will trigger increased carbon emissions destructive to human and animal health. Hence, this study has shown that a 1% rise in the RGDP will result to 3.11121% unit rise in carbon emissions.

(3) The above will ultimately negate the various United Nations agreements and conventions as well as efforts to reduce the incidence of greenhouse carbon emissions.

5. Conclusion

Based on the findings of this study, we conclude that economic growth demonstrates a positively significant impact on carbon gas emissions in both short-run and long-run periods in the selected West African countries.

Based on the above conclusion, we recommend the following actions:

(1) West African governments are advised to implement policies that will encourage the utilization of energy efficient facilities that emit low carbons and put in-place appropriate infrastructures and frameworks to support such policies. This includes establishment of energy efficient hydroelectric power generating plants, energy efficient waste and water treatment plants, etc.

(2) Governments of sub-continental region are admonished to set-up carbon trading hubs and institutions across industry and company lines as well as countries to ensure efficient management and trading in carbon emissions within specified thresholds while imposing appropriate sanctions for every excess.

References

Adom, P.K., Bekoe, W., Amuuakwu-Mensa, F., Mensah, J.T. and Botchway, E. (2012), "Carbon dioxide emissions, economic growth, industrial structure and technical economic growth, industrial structure and technical efficiency: empirical evidence from Ghana, Senegal and Morocco on causal dynamics", *Energy*, Elsevier, Vol. 47 No. 1, pp. 314-325.

Adu, D.T. and Denkyirah, E.K. (2017), "Economic growth and environmental pollution in West Africa: testing the environmental Kuznets curve hypothesis", *Kasetsart Journal of Social Sciences*, Vol. 40 No. 2, pp. 281-288, doi: 10.1016/j.kjss.2017.12.008.

Akinlo, A.E. (2008), "Energy consumption and economic growth: evidence from 11 sub-Sahara African countries", *Energy Economcs*, Vol. 30 No. 5, pp. 2391-2400.

Allau, S. (1980), *The Environment: From Surplus to Scarcity*, Oxford University Press, New York, Vol. 8 No. 4, pp. 412-414, available at: http://www.jstor.org/stable/4602575.

Al - Mulali, U., Saboori, B. and Ozturk, I. (2015), "Investigating the environmental Kuznet curve hypothesis in Vietnam", *Energy Policy*, Vol. 26 No. c, pp. 123-131, doi: 10.1016/j.exp.1.2014.11.019.

Apergis, N. and Ozturk, I. (2015), "Testing environmental Kuznets curve hypothesis in Asian countries", *Ecological Indicators*, Vol. 52, pp. 16-22, doi: 10.1016/jecolind.

Aye, G.C. and Edoja, E. (2017), "Effect of economic growth on CO_2 emission in developing countries: evidence from a dynamic panel threshold model", *Research Gate*.

Ayoade, J.O. (2003), *Climate Change: Synopsis of its Nature, Causes, Effects and Management*, Vantage Publishers, Ibadan.

Begum, R.A., Sohag, K., Abdullah, S.M.S. and Jaafor, M. (2015), "CO_2 emissions, energy consumption, economic and pollution growth in Malaysia", *Renewable and Sustainable Energy Reviews*, Vol. 41, pp. 594-607, doi: 10.1016/j.rser.2014.07-205.

Bismark, A. and Li, Y. (2018), "Analysing the impact of GDP on CO_2 emissions and forecasting Africa's total CO_2 emissions with non-assumption driven bidirectional long short-term memory", *Sustainability Journal*, Vol. 10 No. 9, p. 3110, doi: 10.3390/su10093110.

Brock, W. and Taylor, M.S. (2005), "Economic growth and the environment: a review of theory and empirics", in Durlauf, S. and Agluion, P. (Eds), *The Handbook of Economic Growth*, Elsevier, Amsterdam, pp. 1749-1821.

Carrington, D. (2019), *Climate Crisis: 11,000 Scientists Warn of Untold Suffering*, The Guardian.

Conservation Energy Future (CEF) (2016), "What is environmental degradation?", *News*, November 5, 2019, available at: https://www.conserve-energyfuture.com/causes-and-effects-ofenvironmental-degradation.php.

Chao, Y. and Hsiang, L. (2016), *Impact of Population and Economic Growth on Carbon Emissions in Taiwan Using an Analytic Tool STIRPAT*.

Chen, J.H. and Huang, Y.-F. (2014), "Nonlinear environment and economic growth nexus: a panel smooth transition regression approach", *Journal of International and Global Economic Studies*, Vol. 7 No. 2, pp. 1-16.

Chindo, S. and Abdul-Rahim, A.S. (2018), "Population growth and CO_2 emission in Nigeria a recursive ARDL approval", *Safe Journals*, Vol. 8 No. 2.

Chindo, S., Abdulrahim, A., Waziri, S.I., Huong, W.M. and Ahmad, A.A. (2015), "Energy consumption, CO_2 emissions and GDP in Nigeria", *Geo Journal*, Vol. 80, pp. 315-322.

Chiu, Y.B. (2012), "Deforestation and the environmental Kuznets curve in developing countries: a panel smooth transition regression approach", *Canadian Journal of Agricultural Economics/ Revue comedienne d'agroeconomie*, Vol. 60, pp. 177-194, doi: 10.1111/cjag.2012.60.issue-2.

Chun, J. and Xiaoxin, M. (2019), "The impact of financial development on Carbon emissions: a global perspective", *Sustainability Journal MDPI*, Vol. 11 No. 19, p. 5241, doi: 10.3390/su11195241.

Danella, H., Jorgen, H.R. and Dennis, L.M. (2004), *Limits T Growth: The 30-Year Update*, Chelsea Green, White River Junction, VT.

Duarte, C.M., Inigo, J.L. and Nuria, M. (2013), "The roles of coastal plant communities for climate change mitigation and adaptation", *Nature Climate Change*, Vol. 3, pp. 961-968.

Eleazar, Z.L. (2015), *CO_2 Emissions, Growth, Energy Consumption and Foreign Trade in Sub-Sahara African Countries*.

Esso, L.J. and Keho, Y. (2016), "Energy consumption, economic growth and carbon emissions: cointegration and causality: evidence from selected African countries", *Energy Journal*, Vol. 114, pp. 49-497.

Etugbo, C. (2020), *Causality and Correlation Among Population Growth, Carbon – Dioxide (Co_2) Emission and Economic Growth*, A study of selected West African countries (1980 – 2017). An (M.sc) proposal presented to the Department of Economics, faculty and of social sciences; Delta State University Abraka, Nigeria.

Farhani, S. and Rejeb, J. (2012), "Link between economic growth and energy consumption in over 90 countries", *Interdisciplinary Journal of Contemporary Research in Business*, Vol. 3, pp. 199-210.

Garret, T.-J. (2009), "Are where basic physical constraints on future anthropogenic emission of carbon – dioxide?", *Climate Change*, Vol. 104 Nos 3-4, p. 437, doi: 10.1007/5/0584-009-9717-9.

Ge, S., kelvin, B., Silvio, F. and Julia, J.I. (2020), "Managing forest and water for people under a changing environment", in *A Handbook*, Special Issue ed., MDPI Publishing, ISBN 978-3-03928-823-6.

Grossman, G. and Krueger, A. (1995), "Economic growth and the environment", *Quarterly Journal of Economics*, Vol. 110, pp. 353-377, doi: 10.2307/2118443.

Heidari, H., Turan Katircioglu, S. and Saeidpour, L. (2015), "Economic growth, CO_2 emissions, and energy consumption in the five ASEAN countries", *International Journal of Electrical Power and Energy Systems*, Vol. 64, pp. 785-791, doi: 10.1016/j.ijepes.2014.07.081.

Hossain, M.D.S. (2011), "Panel estimation for CO_2 emissions energy consumption, economic growth, trade openness and urbanization of newly industrialized countries", *International Journal of Sustainable Energy*, Vol. 36, pp. 840-854, doi: 10.1080/14786451.2015.1102910.

Hossain, S. (2014), "Multivariate granger causality between economic growth, electricity consumption, exports and remittance for the panel of three SAARC countries", *European Scientific Journal*, Vol. 8, pp. 349-376.

Jhingan, M.L. (2008), *Advanced Economic Theory. Micro and Macro-Economics*, 12th ed., Vol. 36, Vrinda Publications (p), Delhi, pp. 840-854, 1SSN: 81-87125-75-6.

Kais, S. and Ben Mubarak, M. (2017), *Dynamic Relationship Between CO_2 Emissions, Energy Consumption and Economic Growth in Three North African Countries*.

Kuznets, S. (1995), "Economic growth and income equality", *American Economic Review*, Vol. 45 No. 1, pp. 1-28.

Liddle, B. (2015), "What are the carbon emissions elasticities for income and population? Bridging STIRPAT and EKC via robust heterogeneous panel estimates", *Global Environment Change*, Vol. 31, pp. 62-73.

Meadows, D.H., Meadows, D.L., Randers, J. and Behrens, W.W. III (1972), *The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind*, Universe Books, New York, ISBN 0876631650 (accessed 26 November 2017).

Mohammed, T., Shaaban, M., Azza, T. and Mowafy, E.I. (2012), "Production of some biopolymers by some selective Egyptian soil bacteria isolates", *Journal of Applied Sciences Research*, Vol. 8, pp. 94-105.

Mulugeta, D., Sheleme, B. and Mulugeta, L. (2012), "Impact of slope position on soil carbonand total nitrogen stock along a catena in Kindo koye water shed, Southern Ethiopia", *Ethiopian Journal of Natural Resources*, Vol. 2 No. 2, pp. 185-195.

Olusanya, O. and Musa, D. (2018), "Carbon emission: energy consumption and economic growth in Africa", *MPRA Journal*, pp. 1-15, MPRA Paper No. 96159, posted 27 September 2019 00:20 UTC, available at: https://mpra.ub.uni-muenchen.de/96159.

Peet, R. (1987), "Industrial restructuring and the crisis of international capitalism", in Peet, R. (Ed.), *International Capitalism and Industrial Restructuring*, Allen and Unwin, Boston, MA, pp. 9-32.

Phimphanthavang, H. (2013), "The impacts of economic growth on environmental conditions in Laos", *International Journal of Business Management and Economic Research*, Vol. 4, pp. 766-774.

Saidi, K. and Hammami, S. (2015), "The impact of CO_2 emissions and economic growth on energy consumption in 58 countries", *Energy Reports*, Vol. 1, pp. 62-70, doi: 10.1016/j.egyr.2015.01.003.

Sharma, S.S. (2011), "Determinants of Carbon dioxides emissions: empirical evidence from 69 countries", *Applied Energy*, Vol. 88 No. 1, pp. 326-382, doi: 10.1016/j.apenergy.2010.07.022, Review Economics of Climate Change Part III Stabilization P. 183.

Youmani, O. (2017), "CO_2 emissions and economics growth in the West African Economics and Monetary Union (WAEMU) countries", *Environmental Management and Sustainable Development*, Vol. 6 No. 2, ISSN 2164-7682, World Bank data, available at: www.microtrend.net/countries/NGA/Nigeria/carbon-CO_2-emission (World Bank Group, African Economic Outlook, 2020).

Further reading

Ali-mulali, U. and Sab, C.N.B.C. (2012), "The impact of energy consumption and CO_2 emissions on the economic and financial development in 19 selected countries", *Renewable and Sustainable Energy Reviews*, Vol. 16, pp. 4365-4369.

Anderson, K and Blackhurst, R. (1992), *The Greening of World Trade Issues*, University of Michigan Press and Harvester Wheatsheaf, London and Ann Arbor.

Duarte, R., Pinilla, V. and Serrano, A. (2013), "Is there an environmental Kuznets Curve for water use? A panel smooth transition regression approach", *Economic Modelling*, Vol. 31, pp. 518-527, doi: 10.1016/j.econmod.2012.12.010.

Kahsai, M., Nondo, C., Schaeffer, P.V. and Gebremedhin, T. (2010), *Does Level of Income Matter in the Energy Consumption and GDP Nexus: Evidence from Sub-Saharan African Countries*.

Murat, C. and Eyyup, E. (2015), "Urbanisation, energy consumption and CO_2 emissions in Sub-Saharan countries. A panel cointegration and causality analysis", *Journal of Economics and Development Studies*, Vol. 3 No. 2, pp. 66-76.

Appendix

The Appendix file is available online for this article

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