The Anthropogenic Consequences of Energy Consumption and Population Expansion in Africa? Do governance factors make any difference?

Abstract

Sub-Saharan Africa is greatly affected by global warming and is the most affected region in the world. Although several studies in the literature have attempted to identify the causative agents and recommendations to the environmental damages, the gap remains unfilled as the situation is still not any better. This study contributes to the existing body of knowledge through the investigation of the role of governance, energy consumption and population on the environmental quality in Sub-Saharan Africa using data spanning over the period 1998 to 2014 for 46 countries in the region. For the empirical analysis, the System-Generalised Method of Moments (S-GMM) is employed to analyse the model. Findings from the study reveal that while the total population has a negative but insignificant impact on emissions, the urban population has a positive and statistically significant impact on emissions. The moderation effect of governance is found to overturn the adversities of the urban population on emissions, but this effect is statistically insignificant. The study recommends proper and strategic management of population pressure in urban centres to mitigate its impact on emissions

Keywords: **Energy Consumption; Population; Governance; Sub-Saharan Africa; CO2 Emissions**

1. Introduction

The role of population growth as a determinant of the rise in CO_2 emissions appears to be substantial (Birdsall, 1992). CO_2 emissions from human activities, especially energy consumption, have led to global climate change. This is because all human activities capable of generating GHGs such as; burning of fossil fuels are the causes of anthropogenic carbon emissions. Satterthwaite et al., (2009) believe that global warming is principally caused by people's consumption of goods and services whose production processes, distribution and consumption are capable of causing the emission of CO_2. As a rule, an increase in population is accompanied by increasing levels of the supply of the aforesaid goods and services including energy usage. Therefore, population expansion is closely associated with anthropogenic CO_2 emissions (Asumadu-sarkodie, 2016).

This impact of population on anthropogenic carbon emission varies at different stages of population size, generally being at its peak when the population is at its highest (Chen et al. 2018; Yi et al., 2017). This is perhaps why Birdsall (1992) advocated that any energy policy aimed at cutting carbon emission should include fiscal spending on spending to cut the rates of population growth particularly in developing economies. Looking at the negative effects attributable to anthropogenic carbon emissions such as; shortage of water, air pollution increased sunlight intensity due to the depletion of the ozone layer, several studies have sought to provide evidence for factors accounting for this (Adedoyin et al., (2020); Adedoyin et al., (2020); Adedoyin et al., (2020); Adedoyin and Zakari (2020); Etokakpan et al., (2020); Kirikkaleli et al. (2020); Udi et al., 2020)

This is because the environment is seen as a vital natural capital, hence, conserving it remains very primal. Consequent upon this, controlling anthropogenic CO_2 emission occupies a central core of scientific research and energy policy globally. Presently, the various governments of every country as well as economic and political blocs have devoted so much resource and are so committed to curbing the mitigating effects of anthropogenic CO_2 emission. Example of this commitment is the ratification of the Kyoto protocol in 1997 by 192 countries including Sub-Saharan Africa (SSA).

As the fight for control of anthropogenic carbon emissions is largely handled by the respective governments of different countries across the globe, empirics have shown that the quality of governance in the individual countries have a direct effect on the achievement of the targeted objective of reducing anthropogenic carbon emissions in the respective countries and the world at large **(**Halkos and Tzeremes, 2013**;** Bali et al., 2020**;** Omri and Bel, 2020)**.** It is thus, plausible to say that, countries with effective governance such as; Singapore, Switzerland and Finland as shown by governance effectiveness index of World Bank (2018) will do better in controlling the anthropogenic consequence of energy consumption than those countries on the bottom of the table of good governance such as the SSA.

Short-termism, policy summersault or inconsistency, lack of policy implementation, fiscal indiscipline, high-level of corruption are some of the governance bottlenecks bedevilling the SSA. These shortcomings will no doubt have effects on the ability, of the SSA to achieve its aim of cutting or reducing emissions. As the SSA harbours countries with explosive population growth (e.g. Nigeria) which practically, increases the anthropogenic consequence of energy consumption, it is, therefore, imperative to access the moderating effects of the respective SSA governments in tackling this menace. The over-reliance of the emerging economies such as the

SSA on fossil fuels alongside the uncontrolled population experienced in the region has put the countries therein on the verge of environmental damages (Bekun et al,2019). As such, Bekun & Agboola (2019) recommended for Nigeria as a member of the SSA to focus attention on the adoption of cleaner energy sources as a means to improve environmental sustainability and development.

However, going through various literature written on this area, to the best of our ability, none is seen to have considered this novelty at least not in the SSA. This kind of study is apt and timely and will be of immense benefit to both government and world leaders championing the cause of green world because it is believed that, even the legitimacy of global energy treaties such as the Kyoto protocol hinges on the strength of governance factors of the individual signatory nations (Hargrove et al., 2019). Therefore, the study will highlight areas of institutional strengths and weaknesses of the SSA in its fight to cut the consequences of the anthropogenic carbon emissions.

2. Review of Literature

2.1. Emissions, Energy Consumption and Population Nexus

The literature on anthropogenic carbon emission and population is vast and rich. Table 1 below shows a synopsis of some of the literature in this area. Generally, authors have applied different methodologies on diverse levels of data ranging from specific countries, regional as well as at the global level. The general outcome is that population derives increase in carbon emission by increasing the levels of energy consumption. This is plausible in the sense that an increase in population gears demand energy which naturally increases the release of CO_2 in the atmosphere.

However, there is an exception to this conclusion in the work of Cui et al. (2019) conducted in China. Explanations offered to this is that, as the authors are dealing with the urban population, it was therefore seen that as the urban population increases over time technological progress helps in increasing efficient energy usage. This reduces energy demand as well as carbon emission in China.

The work of Cui et al. (2019) has therefore highlighted the salient fact that technologically advanced countries may record low consequence of anthropogenic energy consumption even in the presence of explosive population like China. It is therefore apriori expected that the contrariwise of China's case will apply for technologically backward nations such as the subject of this study - the SSA. In other words, an increase in population will significantly increase carbon emission in the SSA. This supposition is affirmed by the work of Asumadu-Sarkodie and Owusu (2016) conducted in Ghana. It was empirically seen that 1% increase in population will derive the country's CO_2 level by 1.72%.

Table 1. Summary of literature on emissions, energy consumption and population

Author(s)	Country/Region	Variables	Methodology	Results
Birdsall (1992)	Global	CO_2 , Population, GNP	Descriptive statistics	Reductions in population will reduce CO_2 emissions
Knapp (1996)	Global	CO_2 and population	Causality	Bi-directional causality between CO_2 and population growth.
Zhu and Peng (2012)	China	CO_2 emission, population size, population structure and consumption level.	Ridge regression method	Population Granger causes CO_2 emissions,
Zhou and Liu (2016)	China	Population, income, energy consumption, CO_2 emissions	STIRPAT model	Population derives energy consumption and emissions
Asumadu-Sarkodie and Owusu (2016)	Ghana	CO_2 emissions GDP, EU—energy, population growth.	VECM and ARDL	1% increase in population spurs emission by 1.72%
Dong et al. (2018)	Global	CO_2 , population size, GDP, and renewable energy intensity	Panel cointegration test	Population increases CO_2 emissions
Cui et al.	China	CO_2	panel threshold	Population growth

(2019)		emission, Urban population size and behaviour control variables	regression	decreases CO_2 emission.
Hashmi and Alam (2019)	OECD countries	CO_2 emissions; population; GDP; environmental patent and tax	GMM	Population Increases carbon emissions.
Mafizur, Saidi and Ben (2020)	five South Asian countries	CO_2, population, trade, and GDP	panel co-integration approach	Causality runs from population to CO_2 emissions

2.2 Emissions and Governance Factors

Looking closely at table 2, it is clear that the literature on governance and emissions has global coverage. There is a consensus among all the works reviewed on the effect of governance on emission. The works so far reviewed have shown a negative relationship between governance and emission. In other words, effective and favourable governance outcomes come with attendant effect of decreasing the anthropogenic consequence of energy consumption in the countries and regions studied.

For example, the study of Awais and Wang (2019) in BRICS reported a negative relationship between governance and emission. Because the economic system in the BRICS is mature, the governance system has an incentive system that regulates any market failure that might lead to environmental degradation (Awais and Wang, 2019). Governance factors were found to help institutionalize as well as in the implementation of environmental laws that help in curbing CO_2 levels in the economic bloc. The result of Halkos and Tzeremes (2013) conducted in the G – 20 countries conforms with these facts as reported in Awais and Wang (2019)

Similar results are recorded in 47 SSA, 23 emerging economies as well as across the globe, by Asumadu, Adams, and Leirvik (2020), Omri and Bel (2020) and Bali, Kambhampati, and Karimu (2020) respectively. Notwithstanding, the negative and favourable significance of governance on emission levels, it is seen that the six governance factors; (voice and accountability, government effectiveness, political stability, control of corruption, rule of law and regulatory control) have different dimensions of affecting the level emission. Their effects on the emission level are at varying degrees. For instance, in Halkos and Tzeremes (2013), although control of corruption and rule of law are seen to have led to a decrease in CO_2, control of corruption has a higher impact. While political stability appears to be a positive driver of emission, the voice of accountability is neutral in its effect.

In the same vein, the work of Bali, Kambhampati and Karimu (2020) conducted across the globe confirmed that amongst the six governance variables, only control of corruption has a negative significant effect on anthropogenic CO_2. This means that the more controlled corruption is in an economy, the cleaner the economy from CO_2 and vice versa.

Table 2. literature on emissions and governance factors

Author(s)/Year	Country/Region	Variables	Methodology	Results
Halkos and Tzeremes (2013)	G -20	CO_2 and governance factors	non-parametric technique	Good governance lowers emission levels
Awais and Wang (2019)	BRICS	CO_2, GDP, Government Effectiveness, Political stability, corruption, rule of law, regulatory control	Westerlund panel Co-integration	Governance decreases CO_2
Hargrove, Qandeel and Sommer (2019)	Global (162 nations	CO_2 , Multilateral Treaty Ratifications and governance factors	2-way fixed effects regression	Climate treaties are associated with larger decreases in emissions in nations with

				higher levels of state governance.
Asumadu, Adams and Leirvik (2020)	47 SSA countries	CO_2 emissions, GDP, FDI, renewable energy and governance.	Panel co-integration technique	Governance negatively affects emissions
Bali, Kambhampati and Karimu (2020)	Global, 58 countries	Environmental variables, governance factors and the informal economy	GMM	Governance (CoP) improves environmental quality in the non-OECD
Omri and Bel (2020)	23 emerging economies	CO_2 emissions, FDI, governance quality and Technological innovation.	System-GMM	Governance decrease the level of CO_2 emissions.

3. Data and Methods

3.1 Data and Variables

For this study data was collected over the period 1998 to 2014[1]. The data are summarised in table 3 below.

Table 3. Description of Variables

Code	**Variable**	**Source**

[1] Unavailability of data on governance factors and emissions sets this limitation.

RGDP	GDP per capita, constant 2010 dollars	The World Bank
ROL	Rule of law index (-2.5 weak; 2.5 strong)	The World Bank
GEI	Government effectiveness index (-2.5 weak; 2.5 strong)	The World Bank
COC	Control of corruption (-2.5 weak; 2.5 strong)	The World Bank
RQI	Regulatory quality index (-2.5 weak; 2.5 strong)	The World Bank
VAI	Voice and accountability index (-2.5 weak; 2.5 strong)	The World Bank
PSI	Political stability index (-2.5 weak; 2.5 strong)	The World Bank
CO2	Carbon dioxide emissions per capita	The World Bank
ENC	Energy Consumption, thousands barrel per day	The U.S. Energy Information Administration
TPOP	Population size, in millions	United Nations Population Division
UPOP	Percent urban population	United Nations Population Division
RPOP	Rural population, per cent of the total population	The World Bank

3.2 Model and Methods

An econometric analysis with the use of a panel data model is vital for insightful policy-making (Adedoyin et al., 2020). Hence, this study covers several countries, it is mandatory to utilize panel data analysis. Given that the number of countries under study is relatively larger than the period of the study (N > T), it justifies the use of the system-GMM (Generalized Method of Moments). The system-GMM is more suitable for a larger set of panel studies compared to other econometric approaches.

The GMM model is recognised to be a better estimator when compared with other methodologies such as; the LS technique, 2SLS, IV regression technique among others because it yields more consistent and efficient estimate particularly in models characterised with serial correlation and heteroscedasticity (F. F. Adedoyin et al., 2017).

Besides, several pre and post diagnostics tests were carried out. The pre-diagnostics include; a summary statistic- gives the full picture of the panel, the pair-wise correlation matrix- that shows the level of association among the variables, bin scatter plots- to show us the tolerability of our standard error. The post-estimation diagnostics conducted are; the Hansen and Sargan test to ascertain the instruments' validity as well as to test for auto and serial correlation of the error term to ensure the reliability of the moment conditions.

3.3 Model Specification

To estimate the impact of governance, energy consumption and population on emissions, the following equation is specified;

$$\mathbf{LCO2} = \mathbf{f}\ (\mathbf{LRGDP}, \mathbf{LPOP}, \mathbf{LENC}, \mathbf{GOV}) \quad (1)$$

$$LC02 = \alpha_0 + \beta_1 LRGDP_{it} + \beta_2 LPOP_{it} + \beta_3 LENC_{it} + \beta_4 GOV_{it} + \varepsilon_{it} \quad (2)$$

In our attempt to ensure a constant variance as much as possible, most of the variables undergo a logarithmic transformation. Where LC02, LRGDP, LENC, GOV are the variables and ε_{it} , α and β's represents the stochastic, intercept, and partial slope coefficients respectively.

4. Results, Discussions and Implications of Research Findings

Table 2 presents the summary statistics for the variables. As can be seen, LRGDP has the highest average value and single maximum observation, while LC02 is the most dispersed variable. Political stability records the least single value among the observations. Table 3 presents the results for the Pearson correlation matrix. The matrix reveals that there is a linear association between the dependent variable LC02 and LRGDP, LENC, ROL, GEI, COC, RQI, VAI, PSI and GOV. On the other hand, there is a negative association between LTPOP and the dependent variable LC02.

Table 4. Summary Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
LCO2	779	-1.257	1.424	-3.912	2.301
LRGDP	757	7.009	1.041	5.234	9.930

LENC	782	2.640	1.400	-0.511	6.791
LTPOP	779	1.908	1.572	-2.526	5.173
ROL	690	-0.721	0.683	-2.610	1.080
GEI	690	-0.760	0.631	-2.450	1.040
COC	690	-0.638	0.627	-1.870	1.220
RQI	690	-0.706	0.653	-2.650	1.130
VAI	690	-0.591	0.749	-2.230	1.010
PSI	690	-0.542	0.966	-3.310	1.280
GOV	690	-0.660	0.648	-2.450	0.882

Table 5. Correlation Matrix

	LCO2	LRGDP	LENC	LTPOP	ROL	GEI	COC	RQI	VAI	PSI	GOV
LCO2	1										
LRGDP	0.9115*	1									
	0										
LENC	0.3212*	0.2408*	1								
	0	0									
LTPOP	-0.4062*	-0.4340*	0.6766*	1							
	0	0	0								
ROL	0.4500*	0.3943*	0.1277*	-0.2853*	1						
	0	0	0.0008	0							
GEI	0.5014*	0.4219*	0.2949*	-0.1654*	0.9111*	1					
	0	0	0	0	0						
COC	0.4278*	0.3468*	0.0443	-0.3612*	0.8854*	0.8584*	1				
	0	0	0.245	0	0	0					
RQI	0.3814*	0.3335*	0.3115*	-0.0604	0.8738*	0.8799*	0.7423*	1			
	0	0	0	0.114	0	0	0				
VAI	0.3774*	0.2865*	0.1384*	-0.2343*	0.8425*	0.7772*	0.7469*	0.7900*	1		
	0	0	0.0003	0	0	0	0	0			
PSI	0.5260*	0.4829*	-0.0939*	-0.5107*	0.7917*	0.6854*	0.6939*	0.6504*	0.6977*	1	
	0	0	0.0136	0	0	0	0	0	0		
GOV	0.4964*	0.4285*	0.1331*	-0.3175*	0.9715*	0.9280*	0.8965*	0.8972*	0.8927*	0.8538*	1

	0	0	0.0005	0	0	0	0	0	0	0	

Figure 1. Bin Scatter Plots

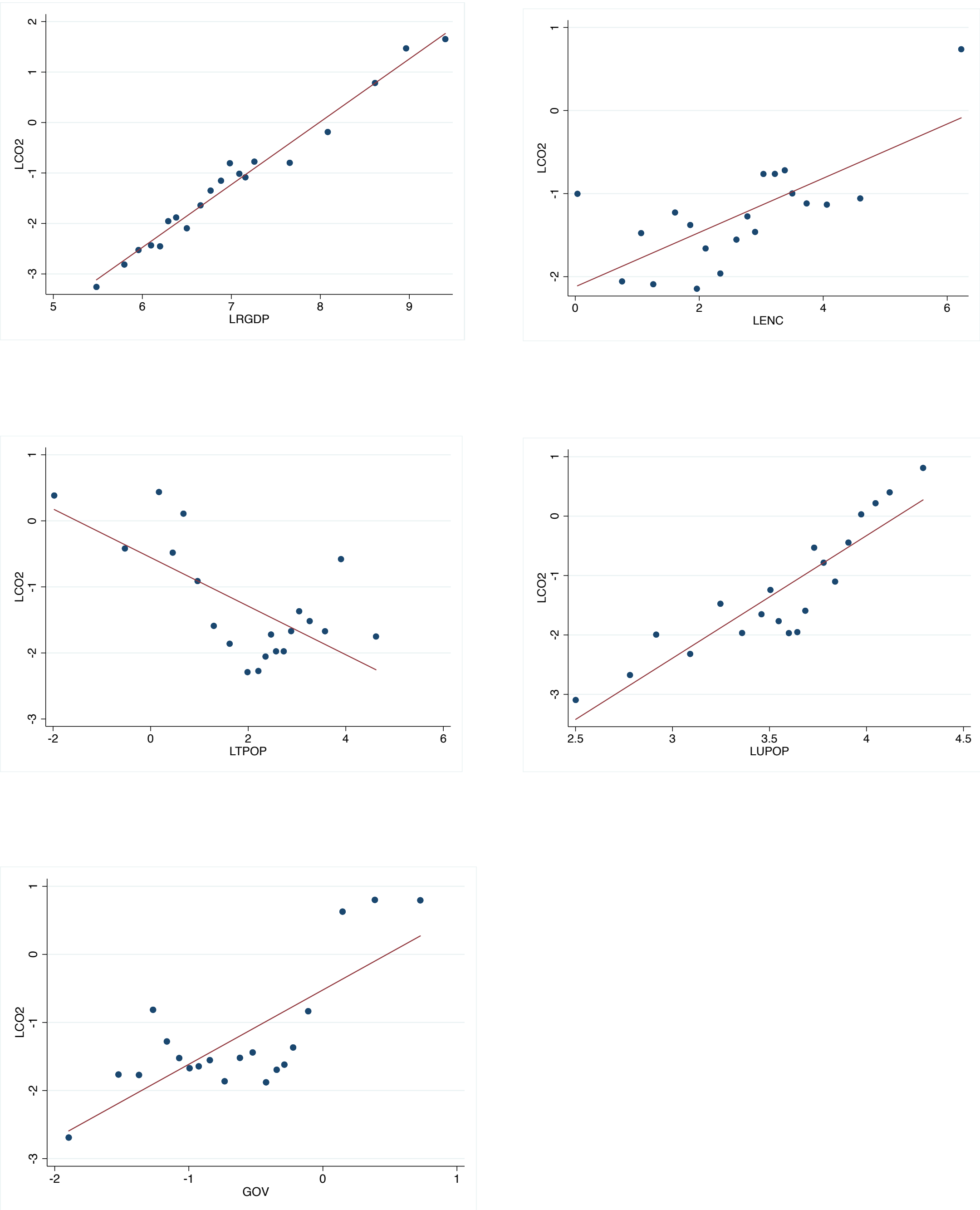

Table 6 presents the estimation results for the model. The model is consistent with previous studies and is significant. The results reveal that economic growth has a positive impact on emissions at a 1 % level of significance. This finding is similar to that of Acheampong (2018) for 116 countries and Bakhsh et. al. (2017) for Pakistan. Specifically, a 1 % rise in economic growth is associated with a 0.923% increase in emission. This implies that continuous economic expansion in sub-Saharan Africa will give rise to the level of emissions in the environment thus depleting the quality of the environment. Subsequently, this points to the fact that economic activities as having been practised over the years involve carbon-emitting processes that harm the environment. On the other hand, energy consumption has a positive impact on emissions at a 5% level of significance. This finding corroborates those of Eggoh et al. (2011) for 21 African countries and Shabaz et al. (2013) for Indonesia. A 1% rise in energy consumption will be accompanied by a 0.03 % rise in emissions which implies that energy consumption in Africa is detrimental to the quality of the environment as it triggers a rise in emissions in the region. This could be because energy consumption in the region is comprised highly of carbon-emitting energy resources like fossil fuels and coal.

On the other hand, the total population has a negative but insignificant impact on emissions in the region. This entails that the influence of population on emissions is not significant. Among all government indicators, Rule of law, Control of Corruption and Regulatory Quality have a negative but insignificant impact on emissions. While government effectiveness and Voice and Accountability have a positive but insignificant impact on emissions. Only Political Stability appears to have a significant impact on emission which is a positive impact. This implies that emissions are sensitive to political stability in sub-Saharan Africa and that an improvement in political transition triggers an increase in the level of emissions. This could be because peaceful political transitions send positive signals to the economy which leads to an expansion in economic activities.

In the second model, we include the interaction term between governance and population. We find that again, economic growth leads to an increase in emissions at a 1 % level of significance. This confirms that economic activities are an important trigger of emissions in the region. Similarly, energy consumption also has a positive impact on emissions at a 10 % level of significance. This result agrees with that of model 1, thus, confirming that energy consumption contributes to rising emissions in sub-Saharan Africa.

The impact of the total population on emissions is negative but insignificant. A similar result was obtained in model 1. This implies that the population is not important in explaining changes in the level of emissions in the sub-Saharan Africa region. The interaction term between population and governance has a positive but statistically insignificant impact on emissions. This entails that even with the combination of governance and population has no significant impact on emissions.

Table 6. Results of Dynamic System GMM for Total Population

	(1)	(2)
VARIABLES	LCO2	LCO2
L.LCO2	0.923***	0.930***
	(0.0738)	(0.0710)
L2.LCO2	0.00653	0.00164
	(0.0696)	(0.0676)
LRGDP	0.0497***	0.0507***
	(0.0136)	(0.0143)
LENC	0.0323*	0.0328*
	(0.0181)	(0.0184)
LTPOP	-0.0224	-0.0214
	(0.0148)	(0.0142)
ROL	-0.0225	
	(0.0286)	
GEI	0.0308	
	(0.0271)	
COC	-0.0165	
	(0.0151)	
RQI	-0.00650	
	(0.0183)	
VAI	0.00478	
	(0.0100)	
PSI	0.0224*	
	(0.0129)	
LTPOPGOV		0.00578
		(0.00495)
GOV		0.00302
		(0.0153)
Constant	-0.448***	-0.451***
	(0.140)	(0.145)
Observations	626	626
Number of countryid	45	45
Post-estimation Diagnostics		

AR (1) z Test Statistic	-4.48	-4.50
AR (1) P value	1.33	0.000
AR (2) z Test Statistic	0.000	1.35
AR (2) P value	0.184	0.179
Sargan test Chi2	300.35	303.20
Sargan P value	0.123	0.101
Hansen test Chi2	34.83	36.63
Hansen P value	1.000	1.000
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1		

In table 7 we use the urban population as a proxy for pollution in the two models and while the results are for most of the variables are similar to those obtained in table 6, those for the population are different. Beginning with economic growth, results reveal a positive relationship between economic growth and emissions in Sub-Saharan Africa as already obtained in table 6. Similarly, energy consumption has a positive impact on emissions as already recorded in table 6. On the other hand, the urban population has a positive impact on emissions. This result is unique compared to the findings of several studies that the population has no impact on emissions. Specifically, a 1 % rise in urban population will bring about a 0.038% increase in emissions in the region. This implies that as urban population rise, they bring about a rise in emissions. This result is in line with the findings of Alam, et al (2016) for India and Brazil and Asumadu-Sarkodie and Owusu (2016) for Ghana. According to Abdallah and Abugamos (2017), as the urban population grows, there is an increase in manufacturing and construction activities in the urban areas hence these activities constitute an increase in the level of emissions. The governance indicators (ROL, COC, VAI, RQI, PSI, GEI,) in the model have no significant impact on emissions.

In the second model, where the interaction term between urban population and governance is included in the model, results reveal that economic growth continues to lead to a rise in emissions by an average of 0.927 %. Similarly, energy consumption has a positive impact on emissions. A 1 % rise in energy consumption will be accompanied by a 0.0091% increase in the level of emissions in the region. Unlike results in model 1, the urban population has a positive but insignificant impact on emissions. This could be as a result of the inclusion of the interaction term in the model. To support this position, the interaction term between urban population and governance hurts emissions but this impact is statistically insignificant. However, this points to the fact that an improvement in governance is capable of overturning the adverse impact of the urban population on emissions in Sub-Saharan Africa, even though such influence is not statistically notable. On the other hand, governance has a positive but insignificant impact on emissions.

Table 7. Results of Dynamic System GMM for Urban Population

	(1)	(2)
VARIABLES	LCO2	LCO2
L.LCO2	0.919***	0.927***
	(0.0735)	(0.0733)
L2.LCO2	0.0174	0.0136
	(0.0706)	(0.0706)
LRGDP	0.0488***	0.0486***
	(0.0141)	(0.0125)
LENC	0.00982*	0.00909**
	(0.00564)	(0.00353)
LUPOP	0.0384**	0.0323
	(0.0182)	(0.0266)
ROL	-0.00643	
	(0.0296)	
GEI	0.0432	
	(0.0263)	
COC	-0.0244	
	(0.0168)	
RQI	-0.0135	
	(0.0191)	
VAI	0.00604	
	(0.0115)	
PSI	0.0197	
	(0.0132)	
LUPOPGOV		-0.00810
		(0.0211)
GOV		0.0567

		(0.0812)
Constant	-0.541***	-0.510***
	(0.159)	(0.177)
Observations	626	626
Number of countryid	45	45
Post-estimation Diagnostics		
AR (1) z Test Statistic	-4.50	-4.49
AR (1) P value	0.000	0.000
AR (2) z Test Statistic	1.24	1.24
AR (2) P value	0.216	0.216
Sargan test Chi2	287.34	286.33
Sargan P value	0.176	0.187
Hansen test Chi2	32.93	38.47
Hansen P value	1.000	1.000
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1		

5. Conclusion and Policy Directions

Sub-Saharan Africa remains the worst affected region by global warming. While several studies have been carried out to identify causes and solutions to the environmental crisis. Our study seeks to investigate the role of governance, energy consumption and population on the environmental quality in sub-Saharan Africa is investigated using data spanning over the period 1998 to 2014 for 46 countries in the region. The System-Generalised Method of Moments is used to analyse the model. According to the findings from the study, while the total population has a negative but insignificant impact on emissions, the urban population has a positive and statistically significant impact on emissions. The moderation effect of governance overturns the adverse impact of the urban population on emissions, but this effect is statistically insignificant. Energy consumption has a positive impact on emissions in the region.

The study makes a few policy recommendations for stakeholders to emulate. Firstly, having established that urban population pressures could aggravate emissions in the region, by stimulating demand for economic goods and services such as transportation, housing, food and other services. In response to these demands, there is a rise in manufacturing and construction activities which gives rise to emissions. This study, therefore, recommends that the governments in the region adopt strategic and sustainable policies to mitigate this adverse impact of the rising urban population. For instance, governments can make provisions for social and economic infrastructural facilities for non-urban centres to reduce the excessive influx of urban centres. Similarly, the adoption of a sustainable transport system in urban centres such as electric trains will go a long way to reduce emissions associated with transiting a high population of people in cities. The results from the study also indicated that an improvement in the quality of governance can mitigate the adverse impact of the urban population on emissions in the environment. To this effect, it is suggested that quality governing initiatives be adopted to manage the urban population and its impact on the environment. The government can introduce more stringent regulatory measures such as carbon tax to discourage carbon-emitting firms from the excessive use of fossil fuels in the course of their economic activities as well as encourage the adoption of cleaner energy sources as alternatives in the region. The use of renewable energy will aid will lead to a reduction in the level of emissions thus improving the quality of the natural environment in the region.

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Appendix

Table A.1 List of Countries in the sample

Angola	Kenya
Benin	Lesotho
Botswana	Liberia
Burkina Faso	Madagascar
Burundi	Malawi
Cameroon	Mali
Cape Verde	Mauritania
Central African Republic	Mauritius

Chad	Mozambique
Comoros	Namibia
Democratic Republic of the Congo	Niger
Equatorial Guinea	Nigeria
Eritrea	Republic of the Congo
Ethiopia	Rwanda
Gabon	Sao Tome and Principe
Gambia	Senegal
Ghana	Seychelles
Guinea	Sierra Leone
Guinea-Bissau	Somalia
Ivory Coast	South Africa
	Sudan
	Tanzania
	Togo
	Uganda
	Zambia
	Zimbabwe