Journal of Applied Economics and Business Research
JAEBR, 9(1): 38-50 (2019)

Is Energy Consumption Responsible for Environmental Degradation in Ghana?

Solomon Aboagye[1]
University of Ghana, Ghana

Abstract

The quest to achieve greater expansion in the Ghanaian economy has culminated into consistent increase in economic activities which invariably entail ever-increasing energy consumption. Given the theoretical linkages between energy consumption and environmental degradation, then the continual increase in energy in the production, distribution and consumption of goods and services in Ghana could have stern implications on the quality of environment and in particular, on three major indicators of environmental degradation (namely, CO2 emissions, Biological Oxygen Density (BOD) and deforestation). Relying on recent annual dataset from the World Bank for the period 1980-2016 this study seeks to examine the environmental impact of energy consumption in Ghana within the standard Environmental Kuznets Curve (EKC) framework. Using the Autoregressive Distributed Lagged model estimation, the study reveals among other findings that energy consumption tends to increase air, water and land pollutions measured respectively by CO2 emissions, BOD and deforestation. This renders support to the assertion that the energy consumption could be blamed for a rise in environmental degradation in Ghana. Further, a robust EKC could not be established for any of the three environmental degradation indicators. This outcome is a major point of concern as the evidence does not support the view that Ghana can grow out of pollution problems with wealth within the context of energy consumption. Notwithstanding, FDI and the adoption of progressive technology are found to be necessary catalyst to enhance the quality of the environment by reducing CO2 emissions, water pollution as well as deforestation.

Keywords: Environmental degradation; energy consumption; Environmental Kuznets Curve; Autoregressive Lagged model; Ghana

JEL Classification: Q2, Q3, and Q4

1. Introduction

Human economic activities in most cases have adverse effects on the overall ecosystem, and hence lead to some severe environmental problems like floods, adverse climate change, depletion of natural resources, which if not well managed could lead to the loss of lives and substantial economic resources. Indeed, the quest to expand the Ghanaian economy has culminated in the rise in the level of economic activities, coupled with rising urbanization and industrialization. These trends have been accompanied by increased energy consumption, perhaps due to the fact that almost every economic activity in the modern Ghanaian economy rely on energy-based resources. For instance, Kwakwa et al (2014) demonstrated that, at the economy wide level, energy is needed

[1] Correspondence Author: Solomon Aboagye, Email: soaboagye@ug.edu.gh / sbaboagye@gmail.com

by the transport sector, manufacturing sector, agricultural sector, mining sector, construction sector, and public and commercial services for their operations. Energy also provides a means for households to achieve basic economic needs from cooking, lighting, warming, heating and washing to entertainment Kwakwa et al (2014). The role of energy especially in the industrial, manufacturing, service and even the agricultural activities underscores its crucial link economic growth. Indeed, Aboagye (2017) revealed that that energy-based resources and inputs constitute major components of industrial raw materials in both developed and developing countries and tend to be critical to sustainable economic development. However, higher level of energy consumption may result in environmental degradation more especially in countries with poor environmental awareness and concern. Thus, in the wake of rising population coupled with rapid urbanisation and industrial activities, energy consumption/demand could be expected to rise increase monotonically in the years ahead (Aboagye, 2017; Kwakwa and Aboagye, 2014). Whiles this trend is impressive and necessary for economic expansion, a rather major point of worry is the stern implications energy consumption could potentially have on the quality and sustainability of the environment.

For instance, Kwakwa (2012) and Kwakwa and Aboagye (2014) and Aboagye (2017) among others also argued that energy consumption in developing economies is closely linked to deforestation, environmental degradation/pollution, adverse climate changes and depletion of natural resources. Abdulai and Ramcke (2009) further demonstrated that about a third of all energy consumed in developing countries like Ghana comes from wood, crop residues, straw and dung, which is often burned in poorly designed stoves within ill-ventilated huts and thus could be linked to environmental pollution and degradation (also see Kleemann and Abdulai, 2013; Halicioglu; 2009; Costantini and Monni, 2008).

Given the evidence that, expansion in economic activities and energy use have also coincided in the rise in environmental degradation, in the form of increased air and marine pollution, desertification and deforestation, loss of biological diversity and climate change, especially in many developing countries, the hypothesized nexus between energy use and the environment requires a comprehensive empirical analysis to establish whether energy consumption could be blamed for increased environmental degradation. From a pure policy perspective, the pollution worry is further exacerbated by the fact that despite the large efforts made by different countries to increase the role of renewable energy, energy efficiency and energy conservation, fossil fuels still represent the dominant source of energy, representing 80% of the total energy used globally (World Development Indicators, 2013). This partly explains why the world has also witnessed a large environmental degradation problem, which is one of the major concerns that countries around the globe are currently facing. Al-mulali et al. (2015) argued that the substantial and rapid growth in the world's social and economic development and human welfare, has in turn increased the global demand for energy (fossil fuels in particular).

Against the backdrop of concerns about climate change and environmental degradation, it is imperative that an in-depth empirical examination is conducted to establish clearly, the linkages that exist between energy consumption or its intensity and the environment. The objective of this study is thus, to examine whether energy consumption actually drive CO_2 emissions, BOD and deforestation which are used loosely here to represent air pollution, water pollution and land pollution respectively. The study further examines whether the presence of technological progress could serve as a catalyst to enhance environmental quality.

 ISSN 1927-033X

2. Brief Literature Review

The bulk of extant literature on examining how the socio-economic variables affect environmental degradation has placed more emphasis on GDP and GDP growth. In Ghana, few studies have empirically discussed the impacts of energy consumption on environmental quality in different regions, income levels, and countries. Some other studies found the significantly positive/negative influence of urbanization on carbon emissions in different sample countries. For instance, Kwakwa et al (2014) disclosed that empirical examination into the existence of the Environmental Kuznets Curve (EKC) have focused principally on aggregate economic growth and environmental degradation with little knowledge on its potential existence in the individual sectors of the economy particularly the extreme cases of agricultural and industrial sectors. The authors' argument is that such evidence could usefully shape policy instruments aimed at ensuring environmental sustainability amidst the quest to promote growth in these sectors. Kwakwa et al (2014) therefore examines the effect of agricultural growth, industrial growth on environmental degradation in Ghana. Relying on data from the World Development Indicators for the period 1971-2008 and employing the Johansen cointegration technique, a long run EKC hypothesis is confirmed in the agricultural sector as well as the industrial sector. Energy usage is also found to positively affect environmental degradation meaning environmental degradation increases with high level of energy use.

Similarly, Aboagye (2017) noted that the past few decades have witnessed continued rise in the level of degradation and pollution in developing and emerging economies culminating into intensification of the debate on the costs, benefits and longer-term implications of growth policies on the environment has intensified among stakeholders. He was quick to highlight that although economic expansion remains paramount in policy, ensuring environmental sustainability amidst the quest to stimulate growth in Ghana has assumed a central theme in its contemporary growth agenda. Exploring annual time series data spanning 1975–2015 Aboagye (2017) examined, in Ghana, the environmental impact of economic expansion within the standard Environmental Kuznets Curve (EKC) framework. The Autoregressive Distributed Lagged bounds approach to cointegration did not confirm the existence of EKC for any of the environmental indicators in the short run, but was robustly established in the long run for CO2 emissions and energy consumption. The author admitted that this conclusion implies that, given the long-run parameters of Ghana, beyond a certain income level, degradation emanating from energy consumption and CO2emissions will eventually fall as the country's economy expands.

Codjoe and Dzanku (2009) have also shown a negative impact of economic expansion (through the structural adjustment programme, SAP) on deforestation in Ghana through both direct and indirect channels. Sharma (2011) using a panel dataset of 69 countries examined the determinants of CO2 emissions for the period of 1985–2005; the sample is divided into sub-panels of high income, middle income, and low income, Sharma (2011) showed that trade openness, GDP per capita, and energy consumption have a positive influence on CO2 emissions, whereas urbanization negatively affects CO2 emissions for all the sub-samples. However, the overall sample results reveal that urbanization, trade openness, and per capita electric power consumption negatively influence CO2 emissions, while GDP per capita and per capita total primary energy consumption have a positive impact on CO2emissions.

Mabey and McNalley (1999) have further argued that FDI (especially from advanced economies to developing economies) is usually accompanied by improved technology which enhances production efficiency compared to domestic investment which often uses crude production technology. Xing and Kolstad (2002) also found weak evidence for the pollution haven hypothesis which asserts that developing countries tend to utilize lax environmental regulations as a strategy to attract dirty industries from developed countries. He (2006) examined the FDI-environment nexus between 1994 and 2001 using panel data on 29 Chinese provinces' industrial SO2 emissions. Employing a system Generalized Method of Moment to study the dynamism of the environment the author reported that an increase in FDI inflows results in a moderate deterioration of environmental quality. Also, Sharma (2011) in a study on the determinants of carbon dioxide emissions among 69 countries found among other things that urbanization has a negative impact on CO2emissions in high income, middle income and low income panels. Wang et al. (2013) found that factors such as population, urbanization level, GDP per capita, industrialization level and service level, can cause an increase in CO2 emissions.

In a related study, Abdulai and Ramcke (2009), Cole and Elliott (2001) and Dasguptaet al. (2002) found that there are signs that trade liberalization might be harmful to poor countries considering the adverse effect of trade openness on the environment of poor countries. Antweileret al. (2001), however, found the contrary to exist. Coderoni & Esposti (2011) further established a two-way and bidirectional impact of agriculture on the environment which may help advance the "Agricultural Environmental Kuznets Curve". They point out that on the one hand, agricultural activities lead to pollution of water bodies, deforestation, loss of biodiversity, alteration of habitat and emission of Green House Gases whiles on the other hand, agriculture also provide a sink for Green House Gases, prevents and controls floods and helps in conserving biodiversity. Dogan and Turkekul (2016) used the autoregressive distributed lags (ARDL) approach in the USA during 1960–2010 and investigate the impact of energy consumption (alongside urbanization and trade openness) on carbon emissions. The outcome shows that urbanization and energy consumption negatively influence the quality of the environment, while trade openness enhances environmental quality. This study also failed to ratify the validity of the environmental Kuznets curve (EKC) hypothesis in the USA. Agras and Chapman (1997, 1999) estimate energy prices as a significant factor affecting both CO2 emissions and energy consumption despite the fact that no EKC-pattern arises. The authors place emphasis on the oil shocks in the 1970's that led to shifts in the energy mix.

3. Methodology and Data

3.1. Theoretical framework and model specification

Energy consumption may have been linked to various forms of environmental degradation. This paper explores whether energy consumption in Ghana should indeed be blamed for environmental degradation, particularly air, water and land forms of pollutions. The study employs Biochemical oxygen demand (BOD) as a measure of water pollution and carbon dioxide (CO_2) emissions as measure of air pollution whiles deforestation measures land pollution. In general, the use of deforestation, BOD and carbon dioxide (CO_2) emissions to proxy environmental degradation is not unusual in the literature (see Kleemann and Abdulai, 2013; Costantini and Martini, 2010; Costantini and Monni, 2008). Following Aboagye (2017), Aboagye and Alagidede (2016), Kwakwa et al (2015) and Aboagye and Nketiah-Amponsah (2016) among others, it is also important to highlight here that empirical of environmental degradation is usually traced to the seminal work of Grossman and Krueger (1993) and Panayotou (1993) which were essentially inspired by Kuznets (1995). EKCs are widely based on the argument that when an economy is at the initial stages of economic growth there is usually an increase pollution along with an increase in material consumption but once per capita income exceeds a threshold, not only does the structural changes in the economy leads to a fall in environmental degradation, but also people can manage to pay for a cleaner environment (Beckerman, 1992; Shafik, 1994; Shafik and Bandyopahay, 1992). Thus, at early stages of development, pollution is generated as a result of increasing production and extraction of natural resources. This is called the scale effect of production on environment which results in the upward trend of an EKC. When production shifts from primary production to industrial production economic expansion gives rise in the establishment of information-based industry and services (composition effect) as well as improving production techniques or adopting cleaner technology (technique effect). Both composition and techniques effects can overcome the scale effect and generate the downward trend of an EKC curve (Aboagye and Alagidede, 2016; Panayotou, 2003; Grossman and Krueger, 1995; Dinda, 2004). The improvement in environmental quality can be achieved by advancing the technological mode of production (de Bruyn, 1997; Xiaoli and Chatterjee, 1997) or by exporting the "dirty industry" to low income countries (Rock, 1996; Suri and Chapman, 1998). Guided by the initial works of Grossman and Krueger (1993) and Panayotou (1993), various empirical studies, including Aboagye (2017), Aboagye and Kwakwa (2017), Kwakwa et al (2014), Cole, Rayner, & Bates, 1997; Cropper & Griffiths, 1994; Grossman and Krueger, 1993, 1995; Roberts and Grimes, 1997; Selden and Song, 1994; Shafik, 1994; Shafik and Bandyopahay, 1992) have examined environmental degradation within the EKC framework and have support to the EKCs along with theoretical models. The basic approach in many empirical studies has nonetheless changed little from the initial study of Grossman and Krueger (1993).

Situating the underlying model within the standard EKC requires that the real GDP per capita (hereafter referred to as income) and its squared term are added to the set of explanatory variables, in which case, the EKC is said to exist if income is positively signed and income squared has a negative coefficient. The foregoing argument results in the estimation of three (3) fundamental models.

$$CO_{2_t} = \alpha_t + \beta_1 Y_t + \beta_2 Y_t^2 + \beta_3 E_t + \beta_4 T_t + \beta_5 F_t + \beta_6 U_t + \beta_7 P_t + \beta_8 K_t + \beta_9 I_t + \beta_{10} A_t + \varepsilon_t \text{ -- (1)}$$

$$BOD_t = \alpha_t + \beta_1 Y_t + \beta_2 Y_t^2 + \beta_3 E_t + \beta_4 T_t + \beta_5 F_t + \beta_6 U_t + \beta_7 P_t + \beta_8 K_t + \beta_9 I_t + \beta_{10} A_t + \varepsilon_t \text{ -- (2)}$$

$$DEF_t = \alpha_t + \beta_1 Y_t + \beta_2 Y_t^2 + \beta_3 E_t + \beta_4 T_t + \beta_5 F_t + \beta_6 U_t + \beta_7 P_t + \beta_8 K_t + \beta_9 I_t + \beta_{10} A_t + \varepsilon_t \text{ -- (3)}$$

In equations (1)-(3), three environmental quality variables namely CO_2 emissions (CO_2), Biological Oxygen Density (BOD) and Deforestation (DEF) to *loosely* capture air pollution, water pollution and environmental sustainability respectively. Also, in equations (1) to (3):

Y= Income	F = Foreign Direct Investment	A = Agriculture sector
Y^2 = Income squared/intensity	T = Trade openness	I = Industry sector
E = Energy consumption	U = Urbanization	ε = white noise
P = Population growth	K = Capital growth	

3.2. Estimation of empirical models

The estimation of the underlying models (i.e. equations 1 – 3 above) proceeds as follows. At the first stage the study examines the stationarity properties of the variables using relevant time series unit root test approaches, specifically, the Augmented Dickey–Fuller and Phillips–Perron tests. The second step is to examine the existence of long-run relationships among variables using the ARDL bounds cointegration technique. This is followed by an ARDL estimation of dynamic long-

 ISSN 1927-033X

run and short-run relationships. The final step entails the estimation of causality relationships between energy consumption and economic growth on the one hand and causality relationships between energy consumption and the three selected environmental degradation variables using dynamic vector error correction model (VECM) within the standard Engle and Granger causality framework. In particular, Engle and Granger (1987) argue that if two or more series are integrated of order one (1) and are cointegrated, then there could be at least one causal relationship in one direction. The direction of causality is then examined by appropriate technique(s). The causality test is performed employing the traditional Engel–Granger causality (1987) test technique over the Toda–Yamamoto test. But unlike the Toda–Yamamoto, the Engel–Granger detects causality through the Vector Error Correction (VECM) model by saving the residuals corresponding to the deviation from equilibrium point of long run cointegrating vectors. Thus, in the first step in the causality test is to find out the long-run equilibrium and followed by estimating the parameters related to the short-run adjustment.

3.3. Data

The study uses annual time series dataset from the World Bank from 1985-2010. Data on all variables are obtained from the World Development indicators (WDI) of the World Bank (see http://data.worldbank.org/data-catalog/world-development-indicators). Since environmental quality has many dimensions, each of which may respond to economic variables differently, the study uses three different measures of environmental quality, namely CO_2 emissions and BOD and deforestation. It is important to emphasize that in the WDI, sufficient data on the relevant environmental variables (i.e. CO_2 emissions, BOD and deforestation) under study hardly exist. Despite the insufficiency of data, it the study extracted considerably consistent data for variables for the empirical analysis. Sample period thus limited essentially by data availability. Natural logs of all data have been taken to reduce the data to a common range so as to avoid heteroscedasticity and also to obtain elasticity coefficients of the regressors.

4. Results and discussions

4.1. Unit root test

The results of the unit root test as shown in Table1 indicate that most the variables are non-stationary in levels even at 10% critical levels. In particular, apart from trade expansion, agriculture, and capital growth which attained stationarity at level, all the variables are integrated of order one [I (1)]. It is also worth-noting that all the three (3) environmental variables are also I (1) and this justifies the use of the ARDL bounds approach to investigate the existence of cointegration relationships between environmental degradation and the energy consumption in Ghana. More so, since the variables are a mixture of I(0) and I(1) with regard to their integration order, the ARDL remains the most appropriate technique to use for the analysis (Pesaran et al.2001). Thus, given the results of unit root tests, the study now employs bounds test for cointegration to examine the long-run relationship among the variables within ARDL framework specified in equations (1), (2) and (3). The Sharwz Information Criterion (SIC) is used to select optimal lag for cointegration as it tends to produce more parsimonious specifications and generally preferred over other criterion (Pesaranet al., 2001). An optimal lag length of one (1) is selected by the SIC. The ARDL bounds cointegration results are reported by Tables 2A – 2C.

 ISSN 1927-033X

Table 1: Unit root/Stationarity results

Variables	Augmented Dickey-Fuller				Phillips-Peron				Order of Integration
	Level		*1st differences*		*Level*		*1st differences*		
	t-stats	*Prob.*	*t-stats*	*Prob.*	*t-stats*	*Prob.*	*t-stats*	*Prob.*	
CO_2 emissions	-2.21	0.28	-8.74	0.00	-2.25	0.29	-8.19	0.00	**I(1)**
BOD	-0.86	0.84	-3.40	0.03	-0.85	0.90	-9.51	0.00	**I(1)**
Deforestation	-1.41	0.65	-8.77	0.00	-1.41	0.69	-8.22	0.00	**I(1)**
Energy consumption	-0.08	0.98	-6.97	0.00	-0.11	-1.04	-6.45	0.00	**I(1)**
GDP per capita	-1.41	0.65	-8.77	0.00	-1.41	0.69	-8.22	0.00	**I(1)**
FDI	-1.58	0.57	-7.34	0.00	-1.76	0.52	-6.88	0.00	**I(1)**
Trade expansion	-7.06	0.00	NA	NA	-6.68	0.00	NA	NA	**I(0)**
Capital growth	-6.67	0.00	NA	NA	-5.13	0.00	NA	NA	**I(0)**
Urban population	-0.67	0.88	-4.05	0.01	-1.91	0.45	-10.46	0.00	**I(1)**
Industry (% of GDP)	-7.33	0.00	-8.77	0.00	-1.41	0.69	-8.22	0.00	**I(1)**
Agriculture (%GDP)	-4.81	0.05	NA	NA	-7.42	0.00	NA	NA	**I(0)**

H_0: Unit root　　H_0: Unit root
H_1: No unit root　　H_1: No unit root

Table 2A: CO2 emissions (Air pollution)

	95%		**90%**	
F-statistic	*Lower Bound*	*Upper Bound*	*Lower Bound*	*Upper Bound*
4.287808	3.003968	4.713216	2.348992	3.855872
W-statistic	*Lower Bound*	*Upper Bound*	*Lower Bound*	*Upper Bound*
25.72467	18.04448	27.84518	14.32896	23.13958

Table 2B: Biological Oxygen Density (Water pollution)

	95%		**90%**	
F-statistic	*Lower Bound*	*Upper Bound*	*Lower Bound*	*Upper Bound*
3.1527964	2.20879748	3.465596049	1.727198031	2.8351968
W-statistic	*Lower Bound*	*Upper Bound*	*Lower Bound*	*Upper Bound*
18.915178	13.2679849	20.47437666	10.53598799	17.014381

Table 2C: Deforestation (Land pollution)

	95%		**90%**	
F-statistic	*Lower Bound*	*Upper Bound*	*Lower Bound*	*Upper Bound*
5.6798612	2.208797482	3.465596049	1.727198031	3.855872
W-statistic	*Lower Bound*	*Upper Bound*	*Lower Bound*	*Upper Bound*
34.0762848	13.26798487	20.47437666	10.53598799	23.139584

Also, as reported in Tables 2A – 2C, the ARDL bounds tests indicate that there is a consistently and stable cointegration among the variables which implies a long-run relationship exists among the variables employed for the study during the sample period. In particular, it is evident from the ARDL bounds cointegration results reported by Tables 2A – 2C that both the F-statistic and W-statistic estimated are higher than their respective upper bounds at 10%. Hence, the null hypothesis of no cointegration between the environment (CO2, BOD and deforestation) and energy consumption has been rejected by both statistics. This further means that energy consumption and the three selected environmental variables alongside with the set of other included explanatory variables are cointegrated in the long run and that energy consumption can be treated as the 'long-run forcing' variable explaining environmental degradation.

4.2. Discussions of main findings

After long run cointegration relationships have been properly established, the study proceeds to estimate the error correction mechanism (short run analysis) and compare the results with the long run dynamics of the phenomena. The study first present and discusses the short run findings, followed by discussion of the long run findings. Other related findings as well as evidence on the EKC is also discussed. The final discussion is centred on the test for the existence of valid causal relationships between energy consumption and the indicators of environmental degradation.

4.2.1 Short run evidence

In the short run as reported by Table 3, it is evident that energy consumption drives all the three forms of environmental degradation. Industry sector activities and population growth also tend to increase CO2 emissions, BOD and deforestation as well. Agricultural sector activities increase CO2 emission and deforestation but not BOD. The remaining regressors have no systematic influence on any of the three indicators of environmental degradation. Also, no evidence of EKC is established for any of the three environmental degradation indicators. In addition to the short run evidence, valid error correction mechanisms exist for all environmental degradation variables which is additional evidence of the existence of a long-run relationship. These speed of convergence coefficients indicate that the model does not return immediately to its equilibrium state after a shock pushes it away from the steady state. In particular, the speed of adjustment to CO2 emissions and BOD shocks with respect to economic growth are 49.00%and 29.1% respectively whiles that of deforestation is 37.3%. Thus, it takes more than a couple of years for distortions to be fully corrected along the balanced growth path.

Table 3: Error Correction Representation and short run analysis

Regressors	CO_2 emissions		Dependent variables Biological Oxygen Density		Deforestation	
	Coeff.	*Std. Err*	*Coeff.*	*Std. Err*	*Coeff.*	*Std. Err*
Lag of dep. variable	0.007	0.091	0.002	0.036	0.024	0.036
Energy consumption	0.100**	0.049	0.088**	0.029	0.080*	0.054
Income	0.092*	0.018	0.032	0.035	0.098	0.084
Income intensity	0.005	0.099	0.087	0.067	0.009	0.068
Trade openness	0.050	0.127	0.049	0.063	0.063	0.055
FDI	-0.048	0.211	0.381	0.523	0.065	0.060
Capital growth	0.047	0.072	-0.022	0.044	-0.022	0.055
Urbanization	0.060	0.151	-0.072	0.491	-0.026	0.035
Population growth	0.076**	0.016	0.091*	0.044	0.044**	0.029
Industry (% of GDP)	0.049**	0.017	0.031**	0.015	0.042**	0.027
Agric. (% of GDP)	0.100**	0.027	0.049	0.068	0.076***	0.013
Constant	0.073*	0.011	0.034	0.069	0.081**	0.048
Error Correction term	0.490***	0.034	0.291***	0.045	0.373***	0.084
F - Statistic	0.0000		0.0044		0.0031	
Adjusted R^2	0.4452		0.5719		0.4167	

Note: *, ** and *** correspond respectively to 10%, 5% and 1% level of significance

4.2.2 Long run evidence

Energy consumption and CO2 emissions (air pollution): The evidence reported in Table 4 render support to the assertion that energy consumption in Ghana is linked with rise in CO2 emissions and thereby contributing to the increase in global greenhouse gases. For instance, given the elasticity coefficient on the energy consumption variable, a 1% growth in Ghana's energy consumption is accompanied by a proportionate increase in CO_2 emissions, by approximately 0.24%. This finding implies that energy consumption in Ghana could be blamed for both domestic and global air pollution as measured by CO2 emissions. These findings are broadly consistent with Aboagye (2017), Aboagye and Kwakwa (2016), Kwakwa et al. (2014), Dlamini and Joubert (1996) Wang et al (2013), Wang et al, (2011), Zhang (2012), Bouvier (2004).

Energy consumption and Biological Oxygen Density (water pollution): The evidence reported in Table 4 demonstrates the linkages between energy consumption and water pollution. With a statistically significant and positive elasticity coefficients on the energy consumption variable in the BOD model, a 1% growth in Ghana's energy consumption is accompanied by a proportionate increase in BOD, by approximately 0.20%. This finding implies that energy consumption in Ghana could be blamed for both domestic and global water pollution as measured by BOD. These findings are broadly consistent with Aboagye (2017), Aboagye and Kwakwa (2016), Kwakwa et al. (2014), Dlamini and Joubert (1996) Wang et al (2013), Wang et al, (2011), Zhang (2012), Bouvier (2004).

Energy consumption and Deforestation (land pollution): Similarly, the results in Table 4 above shows that energy consumption and forest loss are interconnected. In particular, the elasticity coefficients on the energy consumption variable in the deforestation specification is positive and a statistically significant at 1%. Thus, a unit rise in Ghana's energy consumption is accompanied by a proportionate increase in BOD, by approximately 0.19%. This finding implies that energy consumption in Ghana could be blamed for both domestic and global land pollution as measured by deforestation. These findings are broadly consistent with Kwakwa et al. (2014), Dlamini and Joubert (1996) Wang et al (2013), Wang et al, (2011), Zhang (2012), Bouvier (2004).

The EKC evidence: It is observed that in Table 4 while the elasticity coefficients on the income variable are statistically significant and positive significant in all the specifications its quadratic terms are not. This implies that the EKC hypothesis which predicts an inverted U-shaped relationship between CO_2 and economic growth (income) is not supported by empirical data on CO_2, BOD and deforestation in Ghana. This empirical work on the EKC greatly casts significant doubt on the possible existence of a predictable relationship between environmental degradation and per capita income. This observation is a major point of concern as the evidence does support the view that Ghana can grow out of pollution problems with wealth within the context of energy consumption. These findings are broadly consistent with Aboagye (2017), Aboagye and Kwakwa (2016), Kwakwa et al. (2014).

Other Findings[2]: Some other findings emerging from the study as seen in Table 4, some of which are worth-highlighting. For instance, the elasticity coefficients on industry is positive and statistically significant in the CO_2 emissions and BOD specifications and that a 1% rise in industrial activities triggers a proportionate increase in CO_2 emissions and BOD by approximately

[2]Given the focus of this study, population growth, urbanization, trade expansion, FDI, Industry growth, Agricultural growth and Capital growth are included as explicit regressors only as control variables whiles income and its quadratic terms are included to examine the EKC hypothesis.

 ISSN 1927-033X

0.22% and 0.11% respectively. Similarly, rapid urbanisation and population growth are associated with a rise in all three indicators employed in this study. In terms of magnitude, a 1% rise in population increases CO_2 emissions, BOD and deforestation by about 0.17%, 0.12% and 0.15% respectively while for urbanisation, an incidence of 0.08%, 0.09% of CO_2 emissions and BOD result for every 1% rise in urban population whiles for deforestation, a fall of 0.11% is expected. Also, the qualitative effects of population growth on the environment is similar to that of agricultural sector growth as both tend to CO2 emissions and deforestation but no systematic effect on water pollution. More so, the influx of FDI is also associated with a fall in CO_2 emission and a rise deforestation levels in the region whiles trade expansion is accompanied by rise in both CO_2 emission and deforestation. The coefficient in the BOD specification for both trade and FDI are not statistically significant implying that both trade and FDI do not have and systematic influence on water pollution measured by BOD. Furthermore, Capital growth is found to reduce CO2 emissions (air pollution) and increase deforestation (i.e. environmental sustainability) but has no systematic effect on BOD (water pollution) implying that capital growth is necessary catalyst to environmental sustainability in the region. These findings are broadly consistent with Kwakwa (2016), Kwakwa et al. (2014), Dlamini and Joubert (1996) Wang et al (2013)

Table 4: Long run analysis of the energy consumption and environmental quality nexus

	Dependent variables					
	CO_2 emissions		**Biological Oxygen Density**		**Deforestation**	
Regressors	*Coeff.*	*Std. Err*	*Coeff.*	*Std. Err*	*Coeff.*	*Std. Err*
Lag of dep. variable	0.009	0.003	0.016	0.003	0.014	0.003
Energy consumption	0.241**	0.106	0.208**	0.158	0.191***	0.051
Income	0.020**	0.012	0.192**	0.012	0.176*	0.110
Income intensity	0.019	0.131	0.020	0.038	0.009	0.052
Trade openness	0.201**	0.055	0.095	0.088	0.095*	0.015
FDI	-0.210***	0.021	-0.110*	0.083	-0.192**	0.094
Capital growth	-0.122**	0.052	-0.130***	0.034	-0.089	0.034
Urbanization	0.079**	0.009	0.085**	0.009	0.114	0.067
Population growth	0.173**	0.100	0.123	0.100	0.145**	0.080
Industry (% of GDP)	0.218***	0.013	0.112**	0.073	0.094	0.113
Agric. (% of GDP)	0.096*	0.044	0.052	0.144	0.191***	0.074
Constant	0.013	0.322	0.068	0.006	0.033	0.302
F - statistic	0.0000		0.0000		0.0000	
Adjusted R^2	0.57781		0.49103		0.519827	

Note: *, ** and *** correspond respectively to 10%, 5% and 1% level of significance

Causality results: The Engel and Granger Causality (1987) test is employed to examine the existence of causal relationships between the three indicators of environmental quality (i.e. CO2, BOD and Deforestation) and the results of these estimations are reported in Table 5. It is noticeable that, there is unidirectional causality running from energy consumption to all the environmental degradation variables under examination in this study. This further implies that the long run relationships established between energy consumption and the three environmental degradation variables are actually causal and not a case of mere association. Given the motivation of the current study, the reverse of the causal relationships are however not examined. These findings are broadly consistent with Aboagye (2017), Aboagye and Kwakwa (2016), Kwakwa et al. (2014), and Sharma (2011) among others.

 ISSN 1927-033X

Table 5: Engel and Granger Causality

Null Hypotheses	F-Statistic	P-values
Energy consumption does not Granger Cause CO_2 emissions	7.358	0.0036
Energy consumption does not Granger Cause BOD	8.1118	0.0023
Energy consumption does not Granger Cause Deforestation	7.0076	0.0083

5. Conclusions

Energy is a strategic resource that influences the outcomes of economic development. However, no matter the way energy is used (such as power generation, industrial use, transportation, and residential use), it constitutes a basis for economic growth and prosperity. As Ghana grows and wealth increases, demand for energy-based inputs increases as well. The rapid growing demand for energy and the heavy dependence of Ghana on energy indicate that energy could be a major problem in the next century. Another major point of concern relates to detrimental effect energy consumption in the country can potentially have on the environment given that energy consumed in developing countries like Ghana comes from wood, crop residues, straw and dung, which is often burned in poorly designed stoves within ill-ventilated huts. Thus, energy consumption influences pollution of the environment

The main finding of this empirical study is that energy consumption in Ghana could be blamed for both domestic and global air, water and land pollutions as measured respectively by CO2 emissions, BOD and deforestation since a rise in energy demand/consumption tends to increase all these three indicators of environmental degradation. In addition, the EKC hypothesis which predicts an inverted U-shaped relationship between environmental degradation and economic growth (income) is not supported by empirical data on $CO_{2,}$ BOD and deforestation in Ghana implying the economic expansion or increase in wealth does not guarantee that Ghana can growth out of environmental degradation. The study also established a unidirectional causality running from energy consumption to all the environmental degradation variables under examination. Other findings emerging from the study are that rapid urbanisation and population growth are associated with a rise in all three indicators employed in this study. The influx of FDI is also associated with a fall in CO_2 emission, BOD and deforestation levels whiles trade expansion is accompanied by rise in only CO_2 emission and deforestation. Capital growth which is employed to proxy for technological advancement is found to reduce CO2 emissions (air pollution) and deforestation but has no systematic effect on BOD (water pollution).

Given that energy consumption account for a large proportion of anthropogenic greenhouse gas (GHG) emissions, environmentally sustainable economy is therefore important to preserve the long term interest of the communities who depend on the growth of the economy as well as the communities whose livelihood are affected because of pollution. It is very urgent to frame some strategies towards achieving that optimal sustainable development and sustainable environment mix in Ghana. In terms of policy, increases in renewable energy sources/consumption, energy consumption reduction and energy efficiency improvement must constitute absolute national priorities in Ghana in the context of a green economy and sustainable development. More so, following the other findings of the study, increasing the attractiveness the Ghanaian economy to FDI and the adoption of progressive technology are necessary catalyst to enhance the quality of the environment by reducing CO2 emissions, water pollution as well as deforestation. Thus, even

 ISSN 1927-033X

while policy battles to control environmentally-harmful energy consumption sources in the quest to ensure sustainable environment and growth, FDI and the adoption of progressive technology could be embraced as a way to at least forestall the continual rise in the level of CO2 emissions, BOD and deforestation in Ghana.

References

Abdulai, A. and Ramcke, L. (2009). The Impact of Trade and Economic Growth on the Environment: Revisiting the Cross-Country Evidence, Kiel Working Paper No. 1491.

Aboagye S. (2017). Economic Expansion and Environmental Sustainability Nexus in Ghana, *African Development Review*, 29(2):155–168.

Aboagye S. and Alagidede P. (2016). Energy consumption efficiency in Sub- Saharan Africa: evidence and policies, *Ghanaian Journal of Economics*, 4:116-138

Aboagye S. and Nketiah-Amponsah E. (2016). The implication of economic growth, industrialization and urbanization on energy intensity in Sub-Saharan Africa, *Journal of Applied Economics and Business Research*, 6(4):197-211.

Aboagye S., Nketiah-Amponsah E., and Barimah A. (2014). Disaggregated Growth and Environmental quality in developing countries: Some evidence from Sub Saharan Africa *Review of Social Science*, 9(8):17-30.

Agras and Chapman (1999). A dynamic approach to the Environmental Kuznets Curve hypothesis, *Ecological Economics*, 28 (2):267-277.

Al-Mulalia U., Saboori B. Ilhan Ozturk I., (2015). Investigating the environmental Kuznets curve hypothesis in Vietnam, 76:123-131.

Antweiler W, Copeland B. R., and Taylor S. M., (2001). Is Free Trade good for the Environment, *American Economic Review* 91:877-908.

Beckerman, W. 1992. Economic growth and the environment: Whose growth? Whose environment? *World Development* 20:481-496.

Bouvier, A.R., (2004). *Air Pollution and Per Capita Income: A Disaggregation of the Effects of Scale, Sectoral Composition, and Technological Change*, Working Papers wp84, Political Economy Research Institute, University of Massachusetts at Amherst.

Coderoni, S., and Esposti, R., (2011). Long-Term Agricultural GHG Emissions and Economic Growth: The Agricultural Environmental Kuznets Curve across Italian Regions, 2011 International Congress, August 30-September 2, 2011, Zurich, Switzerland 114426, European Association of Agricultural Economists.

Codjoe, N. A. S. and M. F. Dzanku (2009). Long-term Determinants of Deforestation in Ghana: The Role of Structural Adjustment Policies, *African Development Review*, 21(3):558-88.

Cole, M.A. and Elliot R.J.R., (2001). Factor Endowments or Environmental Regulations? Determining the Trade-Environment Composition Effect, the University of Birmingham, Department of Economics Discussion Paper 01-06:1-38.

Costantini V., and Monni S. (2008). Environment, human development and economic growth, *Ecological Economics*, 64:867-880.

Costantini, V. and C. Martini (2010). The Causality between Energy Consumption and Economic Growth: A Multi Sectoral Analysis Using Non-stationary Cointegrated Panel Data, *Energy Economics*, 32:591-603.

Cropper M. and Griffiths, C. (1994). The Interaction of Population Growth and Environmental Quality, *American Economic Review*, 84:250-254.

Diarrassouba M., and Boubacar I., (2009). Deforestation in Sub Saharan Africa, Selected Paper presented at the Southern Agricultural Economics Association, Annual Meeting, Atlanta, Georgia, January 31-February 3.

Dinda, S. (2004). EKC Hypothesis: A Survey, *Ecological Economics*, 49:431-455.

Dlamini K. D. and Joubert P. N. (1996). Industrial Development, Pollution and Disease: The Case of Swaziland, *Botswana Journal of African Studies*, 10(1):71-83.

Dogan E. and Turkekul B., (2016). CO2 emissions, real output, energy consumption, trade, urbanization and financial development: testing the EKC hypothesis for the USA, *Environmental science and pollution research international*, 23(2):1203-1213.

Engle, R.F. and Granger, C.W.J., (1987). Cointegration and error correction representative. Estimation and Testing: *Econometrica* 55:251-276.

Grossman G., M., and A.B Krueger (1995). Economic growth and the environment, *Quarterly Journal of Economics*: 110:353-377.

Halicioglu, F. (2009) An Econometric Study of CO2 Emissions, Energy Consumption, Income and Foreign Trade in Turkey. *Energy Policy* 37:1156-1164.

Hamilton, K. (2000). *Genuine Saving as a Sustainability Indicator*, World Bank Environment Department Papers, No. 77, Environmental Economics Series, Washington, DC.

He J., (2006). Pollution Haven Hypothesis and Environmental impacts of Foreign Direct Investment: The case of Industrial emission of Sulphur Dioxide (SO2) in Chinese provinces, *Ecological Economics* 60:228-45.

Jalil, A., and Mahmud, S.F. (2009). Environment Kuznets curve for CO2 emissions: a cointegration analysis. Energy Policy, 37: 5167-5172.

Kleemann L., and Abdulai A., (2013). The impact of Trade and Economic growth on the Environment: Revisiting the cross-country evidence *Journal of International Development*, 25:180–205.

Kuznets S., (1955). Economic Growth and income Inequality, *American Economic Review* 45: 1-28.

Kwakwa P. A, Arku F. S. and Aboagye S. (2014). Environmental degradation effect of agricultural and industrial growth in Ghana, *Journal of Rural and Industrial Development*, 2(1):1-8

Kwakwa P. A., Aboagye S., and Alhassan H., (2015). Towards energy sustainability in Ghana: a review of the empirics and determinants of energy consumption. In Wiafe E. D. and Arku F. S. (eds.) *Sustainable Utilization and Management of Natural Resources in the era of Climate Change* (pp. 93-113) New York: Nova Science Publishers

Kwakwa, P. A. (2012). Disaggregated energy consumption and economic growth in Ghana. *International Journal of Energy Economics and Policy*, 2(1):34-40.

Mabey, N. and R. McNalley (1999). *Foreign Direct Investment and the Environment: From Pollution Haven to Sustainable Development*, Surrey: WWF UK.

Managi, S., Hibiki, A., and Tsurumi, T., (2009). Does trade openness improve environmental quality? *Journal of Environmental Economics and Management*, 58(3): 346-363.

Panayotou, T. (1993). *Empirical Tests and Policy Analysis of Environmental Degradation at Different Stages of Economic Development*, Working Paper WP238, Technology and Employment Programme.

Rayner A. J., and Bates J. M., (1997) The environmental Kuznets curve: an empirical analysis, *Environment and Development Economics*, 2(4):401-416.

Roberts J. T., and Peter E. Grimes E. P., (1997). Carbon intensity and economic development 1962-1991: A brief exploration of the environmental Kuznets curve, *World Development*, 25(2):191-198.

Rock T. M., (1996). Toward More Sustainable Development: The Environment and Industrial Policy in Taiwan, *Development Policy Review*, 14(3):255-272.

Selden, T.M. and Song, D. (1994). Environmental Quality and Development: Is There an Environmental Kuznet's Curve for Air Pollution? *Journal of Environmental Economics and Management*, 27:147-162.

Shafik, N., 1994. Economic development and environmental quality: An econometric analysis. *Oxford Economic Papers*, 46: 757– 773.

Shafik, N., Bandyopadhyay, S., 1992. *Economic growth and environmental quality: time-series and cross-country evidence* (Vol. 904). World Bank Publications.

Sharma, S. S. (2011). Determinants of carbon dioxide emissions: Empirical evidence from 69 countries, *Applied Energy* 88:376–382.

Suri V., and Chapman D., (1998). Economic growth, trade and energy: implications for the environmental Kuznets curve, *Ecological Economics*, 25(2):195-208.

Wang Z., C., Shi, Q, Li, and G. Wang (2011). Impact of heavy industrialization on the Carbon emissions: An empirical study of China, *Energy Procedia*, 5:2610–2616.

Wang, P. W. Wu, B. Zhu and Y., Wei, (2013). Examining the impact factors of energy-related CO2 emissions using the STIRPAT model in Guangdong Province, China, *Applied Energy*, 106(c):65-71.

World Bank (2013). World Development Indicators 2011, Washington DC (www.worldbank.org).

Xing Y, Kolstad C., (2002). Do lax regulations attract foreign investment, *Economics of Finance and Trade*, 1:76-81.

Zaleski, P. (2001). Energy and Geopolitical Issues. In: Rao, D. B., and Harshyita, D., (Eds.). *Energy Security, Discovery Publishing House*, New Delhi.

Zhang J., (2012). Delivering environmentally sustainable economic growth: The case of China, *Asian society*, 1-25.

 ISSN 1927-033X