Towards Economic Growth and Development in Sub-Saharan Africa: Does That Mar the Environment?

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Abstract

Ensuring environmental sustainability amidst the quest to stimulate growth in Sub Saharan Africa (SSA) remains an issue of great concern. In spite of this, the evidence for SSA is sparse, both at the theoretical and empirical level as literature has not adequately interrogated the effects of economic growth process on the sustainability of the environment in SSA. Using a panel dataset from 1985-2010 covering 35 Sub Saharan Africa (SSA) countries this study examined the environmental impact of economic growth and growth-enhancing factors such as trade openness, Foreign Direct Investment (FDI) and industrialization under the Environmental Kuznet Curve (EKC) framework. The environmental variables employed are CO_2 emissions, Adjusted Net Savings (ANS) and energy consumption per capita. Employing the system Generalized Method of Moment, trade openness was found to reduce pollution/degradation through reduced CO_2 emissions and energy consumption per capita while at the same time reducing environment sustainability of SSA through reduced ANS. Industrialization was also found to unambiguously harm the environment while rapid urbanization is revealed to increase pollution/degradation through increased CO_2 emissions and energy consumption. FDI is the only component found to be accompanied by a fall in pollution/environmental degradation through reduced CO_2 emissions and energy consumption and a rise in environmental sustainability through increased ANS. Finally, while the Environmental Kuznet Curve (EKC) is confirmed for ANS and energy consumption, it is not established for CO_2 emissions.

Keywords: Environmental degradation, Economic growth, Sub-Saharan Africa, System Generalized Method of Moment.

JEL Classification: F1, O4, Q4, Q5

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1. Introduction

Achieving sustainable development is considerably paramount and remains an issue of great concern to Sub Saharan Africa (SSA). Interestingly, the quest to achieve sustainable development does not only require the coordination of the various sectors of the economy but also entails the use of various policy tools. This is particularly imperative because beside the fact that sustainable growth is argued to depend on a number of factors including structural transformation, industrialization, trade openness, enhancing the competitiveness of the business environment, good governance, political stability, fiscal discipline among others; its promotion has several implications particularly for the sustainability and quality of the environment. Many countries in SSA have attempted several policies, many of which are intended not only to inject growth into their economies but also to ensure that sustainable growth without sacrificing the quality of the environment.

It is often argued that promoting economic growth and development requires the use of natural resources in economic activities which implies tampering with the environment. This argument however does not imply improper and inefficient utilization of environmental endowments but rather creates an urgent need for sound, efficient and sustainable utilization of the environment. Statistics available indicate that environmental degradation in the SSA region is still on the ascendancy (FAO, 2005; Naoto, 2006; Diarrassouba and Boubacar, 2009) at a time more efforts are being made to ensure growth in the region. In particular, it is estimated that the average Carbon dioxide (CO_2) emission, Sulphur dioxide SO_2 emissions (metric tons per capita) and Biological Oxygen Demand (BOD) per capita has been fairly high in the region though quite lower than their respective world averages (WDI, 2013). For instance, CO_2 emission (metric tons per capita) which averaged between 0.8 and 0.9 during the early 1990s remained fairly constant even in the late and early 1990s and 2000s, until 2010 where the average CO_2 emission (metric tons per capita) was estimated to have fallen marginally to 0.8 (WDI, 2013). Though, this represents some progress especially when compared to the 2010s world average of 4.9, there is more than enough room for the region to reduce the emission of CO_2 drastically considering its hazardous nature. Also, the level of deforestation in the region continues to increase annually (Food and Agriculture Organization, FAO, 2005). FAO (2005) reported that between 1990 and 2000 the net forest loss increased from about 8.9 million hectares per year to 7.3 million hectares per year from 2000 to 2005.

Naoto (2006) further revealed that between 1990 and 2000 Africa has the highest rate of deforestation of about 0.8% and this was substantially greater than the world average of 0.2% (FAO, 2005). Furthermore, Diarrassouba and Boubacar (2009) revealed that with the exception of 1999, the period between 1990 and 2004 witnessed a massive increase of the rate in deforestation in Africa and Sub Saharan Africa as well.

Yet, the impact of economic growth and growth stimulating factors especially trade openness, FDI and industrialization on the environment in SSA is not well established in the literature. This could explain the non-existence of stringent environmental policies in many developing countries (Lee et al, 2005; Copeland and Taylor, 2003). From policy perspective, knowing the direction in which economic growth and growth-related policies such as greater openness to trade, massive FDI inflows, industrial activities and urbanization among others tend to affect the environment is very essential. This could improve the design and implementation of proper environmental policies as well as environmental – friendly growth policies. For instance, urbanization which usually accompanies industrialization and economic growth could lead to adverse climatic change, food insecurity and environmental degradation such as deforestation, soil erosion etc. Moreover, Zhang (2012) revealed that, although growth policies have contributed immensely to China's recent dramatic economic expansion, this rapid economic growth has also created series of social and environmental problems. Zhang (2012) further argued that if due consideration is not given to how the environment is depleted or improved per every growth policy in China; a time may come when the impressive Chinese growth will be no longer be sustained by the environment. This stands to reason that policies aimed at achieving growth that is sustainable should give due consideration to their effects on the environment and this can be done pragmatically if the exact effects of growth policies on the environment are known. It is against this background that the study seeks to examine the impact of economic growth and growth-enhancing factors of industrialization, trade openness, foreign direct investment and growth on the environment in SSA.

The paper contributes to literature and policy in two peculiar ways. Firstly, the discourse on environmental impact of economic growth in SSA appears to have given little attention to the use of an environmentally adjusted income variable as a measure of sustainable development, though the variable is a widely acceptable indicator of sustainable development (Kleemann and Abdulai, 2013). This paper therefore deals with this problem by incorporating environmentally adjusted income variable (Adjusted Net Savings) as a measure of sustainable development. Secondly, this paper offers useful evidence-based policy insights which are expected to shape the design and implementation of appropriate policy action that can pragmatically help in mitigating against the adverse effects of economic growth policies such as trade, industrial growth and FDI on the environment.

In the sections that follow, a brief review of salient theoretical and empirical aspects of the relationship economic growth and the environment is carried out in section two. In section three, methods, modeling and data issues used are discussed while section four presents and discusses results generated from estimating the empirical models specified within the framework of the EKC in section three. Section five concludes and highlight some theoretical and policy implications of the results/findings obtained in section four.

2. Literature Review

The effect of economic growth on environmental degradation is explained by the Environmental Kuznets Curve (EKC) hypothesis that stems from Kuznets' (1955) economic growth and income inequality argument. The economic growth and income inequality argument argues that at low level of income, a country's environmental degradation is high but as income increases, environmental degradation falls giving an inverted U-shaped relationship between income and environmental degradation. Following this it has argued that there is an inverted U- shaped curve or bell shaped curve between income and environmental degradation. The reason is as income increases individuals become conscious of the environment and begin to demand for goods that will not harm the environment that match.

The debate on the environmental impact of industrial activities can be grouped into two main sides. One breadth of the debate is that industrial development end up polluting the environment and excessive use of natural resources while the other breadth says that industrial development increases income which makes individuals demand for environmental friendly goods and services (See Industrial Development Report, 2004). Also, the effects of FDI and trade can be explained by the argument that low income countries in their quest to attract more FDI and trade may utilize lax environmental regulations. This situation could however create the tendency for these lower income countries to attract highly pollution-intensive FDI and thereby reducing environmental quality of these economies. However, if the inflow of FDI results in an increase income in the host countries, the citizens of the host countries may demand for cleaner environment which can eventually ensure that environmental quality is restored or improved. Further, it is often 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 (see Mabey and McNalley 1999). Urbanization affects the environment through a number of avenues like creation of slum conditions, land insecurity, worsening water quality, excessive air and noise pollution (due to Growth in motor vehicles and industries) and the problems of waste disposal (Maiti and Agrawal, 2012; Uttara et al. 2012).

Empirically, studies linking the effects of economic growth, trade openness, foreign direct investments, industrialization, and urbanization on the environment have shown mixed results. For instance, Xing and Kolstad (2002) explored the environmental impact of FDI in both developed and developing economies and found a weak evidence for the pollution heaven hypothesis which asserts that developing countries tend to utilize lax environmental regulations as a strategy to attract dirty industries from developed countries. In a related study in Ivory Coast Mexico, and Venezuela, foreign owned plants are found more energy efficient and use cleaner type of energy than domestically owned (Eskeland and Harrison, 2003). He (2006) explored the FDI-environment nexus between 1994 and 2001 using a panel data on 29 Chinese provinces' industrial SO_2 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, Agarwal (2012) found evidence to prove that the importation of foreign capital or foreign technology has led to an increase in pollution intensity in China but no evidence to suggest that trade liberalization has led to a significant rise in environment pollution. In a related study, Abdulai and Ramcke (2009) found that there are signs that trade liberalization might be beneficial to sustainable development for rich countries, but harmful to poor ones considering the adverse effect of trade openness on the environment poor countries. The authors used a panel data from both rich and poor economies for the period of 1980 to 2003. Cole and Elliot (2003) also found that trade increases emissions. Antweiler et al. (2001) showed that an increase in GDP tends to increase S02 concentration, while SO_2 concentration decreases as per capita GDP rises. They also estimated that trade liberalization reduces pollution. The findings of Dasgupta et al. (2002) however contrasted that of Antweiler et al. (2001) as they found the contrary to exist.

Grossman and Krueger (1995) examined the relationship between economic growth and environmental degradation and found evidence which confirmed the existence of EKC hypothesis (also see Abdulai and Ramcke, 2009). Cole and Elliot (2003) found that SO2 emission reduces as income increase and Arouri et al, (2012) confirmed the EKC hypothesis in most of MENA countries. However, Boopen and Vinesh (2011), Saboori et al (2012) and Akpan and Akpan (2012) did not confirm the EKC in Mauritius, Indonesia and Nigeria respectively.

Sharma (2011) in a study of the determinants of carbon dioxide emissions among 69 countries found among other things that urbanization is has a negative impact on CO_2 emissions in high income, middle income, and low income panels. On the other hand Cole and Neumayer (2004) in their study found that population increases with carbon dioxide emissions and also found a U-shaped relationship sulfur dioxide emissions and population growth. Also, Martínez-Zarzoso and Maruotti (2011) found an inverted-U shaped relationship between urbanization and CO2 emissions. Wang et al (2013) in their study found that factors such as population, urbanization level, GDP per capita, industrialization level and service level, can cause an increase in CO2 emissions. Wang et al, (2011) found that a positive relationship between the formation and development of Heavy Industrial Structure and carbon emissions in China.

3. Methods

3.1 Specification of Empirical model

The paper primarily focuses on the relationship between economic growth and environmental sustainability from selected Sub Sahara African countries. Thus the key variable is economic growth which is proxied by real Gross Domestic Product (GDP) per capita. To evaluate the Environmental Kuznet Curve in SSA, the squared term of real GDP per capita is added to the set of explanatory variables. In this case, the EKC is said to exist if the real GDP per capita is positively signed and real GDP per capita squared has a negative coefficient.

The choice of the other regressors such as FDI, trade openness and industrialization is premised on the evidence that for the past few decades, many economies in SSA in their quest to promote economic growth have sought to increase the attractiveness of their economies to FDI and trade. Furthermore, these countries are ensuring continuous structural transformation to promote massive industrialization. This is evident in the several infrastructural developments and a rise in interest in developing and implementing pragmatic industrial policy among others (World Bank, 2011; Morris, 2008; Ackah and Morrissey, 2005). For instance, Morris (2008) revealed that resulting from the massive growth rate witnessed by East Asian economies which was mainly as a result of their greater openness to international trade; many SSA economies are also set on economic policies that generally ensure greater trade openness and massive FDI. Urbanization is very crucial to environmental issues and it is thus used in this paper to control for potential changes in environmental quality caused by rise in rate of utilization of the environment due to rapid urbanization.

In line with the argument above, the starting point of the empirical model is stated as follows:
$EQ = f(Y, Y^2, F, T, I, U)$ …………………………………………………………………… (1)

Equation (1) states that Environmental Quality (EQ) is a function of economic growth (Y), economic growth squared (Y^2), Foreign Direct Investment (F) trade openness (T), industrialization (I) and urbanization (U).

Assuming a Cobb-Douglas environmental quality function of the form $EQ = AY^{\alpha}F^{\beta}T^{\chi}I^{\lambda}U^{\phi}$ ……………………………………………………………………… (2)

Where Y is economic growth, F is Foreign Direct Investment, T is trade openness, I is industrialization and U is urbanization. Taking log of both sides of equation (2) and writing the model in panel form yields equation (3) below:

$$\ln EQ_{it} = \ln A + \alpha \ln Y_{it} + \beta \ln FDI_{it} + \chi \ln TOP_{it} + \lambda \ln IND_{it} + \phi \ln URB_{it} + \ell_{it} \quad \text{………….... (3)}$$

To ensure that the empirical model is consistent with the EKC framework, the squared term of income (economic growth) is incorporated into equation (3) which yields equation (4)

$$\ln EQ_{it} = \ln A + \alpha \ln Y_{it} + \beta \ln FDI_{it} + \chi \ln TOP_{it} + \lambda \ln IND_{it} + \phi \ln URB_{it} + \ell_{it} \quad \text{……..…… (4)}$$

In equation (4), EQ represents three environmental quality variables namely CO_2 emissions per capita (CO_2), energy consumption per capita (EC) and Adjusted Net Savings (ANS)[2]. Energy consumption is used as capture pollution and environmental degradation caused as energy is consumed. Though, the use of energy consumption as a measure of pollution is usually indirect given that about a third of all energy consumed in developing countries comes from wood, crop residues, straw and dung, which is often burned in poorly designed stoves within ill-ventilated huts (Abdulai and Ramcke, 2009), the variable is expected to offer some useful insights. In addition, energy consumption is closely linked to the depletion of natural resources (Kleemann and Abdulai, 2013 and Abdulai and Ramcke, 2009). ANS, a widely accepted indicator for weak sustainability is used as a proxy of environmental sustainability consistent with the concepts of green national accounts and on the Hartwick rule for weak sustainability (see Kleemann and Abdulai, 2013) while CO_2 is employed as a measure of environmental pollution. Energy consumption per capita is employed as an indicator for indirect pollution/environmental degradation[3]. This implies that, in the ANS estimation, a positive coefficient indicate a move towards more environmental sustainability whereas in the CO_2 and EC regression, a positive coefficient on a variable indicates a move towards more pollution/environmental degradation.

[2] In the ANS specification lagged real GDP per capita are employed as the explanatory variable. This is due to the fact that ANS is measured as a percentage of GNI and as such, using current income (GDP per capita) could result in biased estimates. This is consistent with Costantini and Monni (2008) and Kleemann and Abdulai (2013).

[3] Though renewable energy sources are often environmentally friendly, energy emanating from the burning of fossil fuels/wood etc entails some pollution, especially air pollution. Abdulai and Ramcke, (2009) revealed that about a third of all energy consumed in developing countries comes from wood, crop residues, straw and dung, which are often burned in poorly designed stoves within ill-ventilated huts. In addition, energy consumption is closely linked to the depletion of natural resources. Thus, energy consumption per capita is employed as an indicator environmental degradation or pollution though we acknowledge that it could be an indirect form of pollution and environmental degradation (also see Kleemann and Abdulai, 2013).

Also, though urbanization and industrialization are closely both variables are added as separated regressors. Further, given that the paper seeks to examine the environmental effect of industrial activities (among other variables) while controlling for urbanization; it is very useful to maintain both variables as separate regressors in all specifications. Natural log of variables are taken to obtain elasticity coefficients of variables and also to avoid the potential adverse effect of outliers. Also, in all specifications, $\alpha, \omega, \beta, \chi, \lambda, \phi$ are the elasticity parameters of economic growth, square of economic growth, FDI, trade openness, industrialization and urbanization respectively.

3.2 Data

The study uses unbalanced[4] panel annual dataset from World Bank covering 35 SSA countries[5] 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). In the WDI, there hardly exist sufficient data on the relevant environmental variables (i.e. CO_2 emissions per capita, energy consumption per capita and Adjusted Net Savings) under study for many of the SSA countries. This is the main reason why the study uses unbalanced panel annual dataset covering 1985-2010 for 35 SSA. Though the panel dataset used is unbalanced it has considerably consistent data for all the 35 countries sampled for the study. Both the sample size and period are dictated by data availability. Further, since environmental quality has many dimensions and each of which may respond to economic variables differently, the study uses three different measures of environmental quality namely CO_2 emissions per capita and energy consumption per capita and ANS. CO_2 emissions per capita and energy consumption per capita measure pollution/degradation while ANS measures environmental sustainability. This is to provide a comprehensive picture of how economic growth, trade openness, FDI, industrialization, urbanization impact on the environment in diverse ways.

In this paper, CO_2 emissions are emissions stemming from the burning of fossil fuels, manufacture of cement and the consumption of solid, liquid, and gas fuels and gas flaring. When CO_2 emissions are divided by total population, it yields CO_2 emissions per capita. Energy consumption per capita is measured as primary energy consumption per total population (capita). ANS measures the rate of gross national savings in percentage of gross national income (GNI) after taking into account the depletion of fixed capital, education expenditures, the depletion of certain natural and pollution damages of carbon dioxide and particulate emissions.

Trade openness is the sum of exports and imports of goods and services measured as a share of GDP while FDI is the net inflows of foreign investment as a percentage of GDP. Trade and FDI are included to capture changes in environmental quality caused by influx of new technologies to

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[4] The panel dataset is described unbalanced in the sense that there are missing data for some variables in some years for almost all the countries and not that each country has its special range of years. Hence, we are unable to state the exact year range used for each country.

[5] See Appendix I for the list of the 35 SSA countries sampled for this study. Appendix II also provides exact year range you have used for each country

SSA. For instance, new, improved and efficient technologies are likely to reduce energy consumption. Industry, value added (% of GDP) serves as a proxy for industrial activities and controls for pollution/degradation caused through industrial activities. It comprises value added (net output) in mining, manufacturing construction, electricity, water, and gas. GDP per capita is used as a proxy of income/economic growth. Urbanization is a rise urban population (i.e. people living in urban areas) as a percentage of total population. Urbanization is only included to control for a potential change in environmental quality as a result of an increasing urban population.

The various proxies for all the variables for the study are summarized in found in Table 1 below.

Table 1: Variables and Proxies

Variable	Proxy
CO2 emissions per capita (CO_2)	Natural log of CO_2 emissions per capita
Energy consumption per capita (EC)	Natural log of energy consumption per capita
Adjusted Net Savings (ANS)	Natural log of ANS (% GNI)
Income (Y)	Natural log of real per capita GDP (GDP per capita, PPP (constant 2005 international dollars),
Foreign Direct Investment (FDI)	Natural log of the share of FDI (net inflows) in GDP
Trade openness (TOP)	Natural log of (export + import)/GDP
Industrialization (IND)	Natural log of industrialization (industry, value added as a % of GDP).
Urbanization (URB)	Natural log of urbanization (measured by the fraction of the population living in urban areas)

Source: World Bank (2013)

4. Results and Discussions

4.1 Stationarity or Unit root test

To avoid the problem of spurious and unrelated regressions, there is the need to ensure that variables are stationary. In the literature, several panel unit root tests based on different assumptions have been proposed. However as earlier indicated, due to the non-existence of consistent and sufficient for the environmental variables under consideration, the study is compelled to test for the stationarity properties of the variables using the Fisher unit root test based on Augmented Dickey Fuller (ADF) and the Im–Pesaran–Shin (IPS) test which allow unit root test for unbalanced panels. Both the Fisher unit root test and the Im–Pesaran–Shin (IPS) tests rely on individual unit root process on the assumption that the autocorrelation coefficients vary across cross-sections. This assumption is particularly reasonable since imposing uniform lag length among different countries is likely to be inappropriate and thus slope heterogeneity is more reasonable when cross-country data are used and where heterogeneity could arise from different economic conditions and levels of development in each country. Moreso, both the Fisher test and the IPS allow for different orders of serial correlation. The Fisher (ADF) test is asymptotically chi-square distributed with 2N degrees of freedom ($Ti \rightarrow \infty$ for finite N) and with finite panels, Choi (2001) argues that the inverse χ^2 test is the most powerful and applicable statistic of the Fisher ADF test. A major drawback of the Fisher-type test is that the p-values have to be obtained by Monte Carlo simulations (Choi, 2001). However, the test is easily implemented in STATA econometric software package. The null hypothesis for both tests is that all the panels contain a unit root and hence, if the null hypothesis is rejected for the level variables, then at least one of the panels is regarded stationary or does not contain unit root. In both specifications (i.e. Fisher unit root ADF test and IPS), deterministic time trend is included and cross-sectional means are also subtracted in order to minimize problems arising from cross-sectional dependence. The Schwarz- Bayesian information criterion (BIC) is used to determine the country-specific lag length for the ADF regressions, with a maximum of one (1) lag for the IPS test. The test results of the Fisher and IPS test for the variables in levels are shown in Table 2.

Table 2: Unit root test [6]

	Fisher ADF (Inverse $\chi 2$)		**IPS (W-t-bar stat)**	
Variables	Statistic	Prob.	Statistic	Prob.
CO_2 emissions per capita	210.25	0.000	-4.098	0.061
Energy consumption per capita	134.20	0.000	8.371	0.000
Adjusted Net Savings	158.45	0.000	-2.421	0.073
GDP per capita	343.73	0.000	-2.001	0.085
Trade (%GDP)	212.69	0.000	-2.921	0.001
FDI (%GDP)	287.62	0.000	-2.449	0.070
Industry, value added(%GDP)	207.03	0.000	-2.854	0.045
Urban (% total population)	211.21	0.000	11.31	0.000

H_0: All the panels contain unit roots/non-stationary

H_1: Some panels are stationary/has no unit

As a measure of robustness, two different unit root test tests (i.e. Fisher ADF and IPS) are computed for the variables at level. Both tests reject the null hypothesis that all the panels contain unit roots. In particular, the Fisher ADF (Inverse $\chi 2$) strongly rejects the null hypothesis of unit root at 1% while the IPS (W-t-bar stat) shows moderate rejection of the null hypothesis of unit root at 10% for most variables. Thus though the IPS rejects the null hypothesis of no unit root at 10% significance level for most of the variables, the evidence is that both tests show that all the variables stationary in level implying the variables are integrated of order zero *[i.e. I(0)]*. When variables are not stationary in level, they are normally differenced till stationarity is established in which instance a cointegration test is required to examine if a long run relationship could be established. However, if the variables are stationary in level like those established in Table 2, then their long run relationship could be estimated without performing any cointegration test. This conclusion has two main implications for estimating the empirical model of this study. Foremost, it suggests that given that all variables are *I(0)* the long run

[6] For purposes of comparison and robustness of the unit root test using unbalanced panel datasert, we conduct a separate stationarity using a balanced panel dataset. The result confirms the variables are indeed I(0) even for the balanced panel dataset though stationarity is established rather at a higher level of significance than was established in the case of unbalanced panel dataset. See appendix II

relationships between the environmental variables and the set of explanatory variables could be estimated directly without facing the problem of spurious or unrelated regressions and (2) this further implies that testing for potential existence of cointegration may be less useful given that a cointegration test is required when level variables are non-stationary (see Costantini and Martini, 2009; Baltagi and Kao 2000; Pedroni, 1999, Pedroni, 2004).

4.2 Estimation of empirical model

The empirical model specified in equation (4) is characterized by endeogenity and collinearity of some regressors. For instance, the income (GDP per capita) serving as a proxy for economic growth is highly endogenous as it is also determined by the dependent variables (environmental quality) (see Zhang, 2012; Asici, 2011). Further in equation (4), economic growth is highly correlated with regressors such as FDI, trade openness, industrialization (Jawaid and Raza, (2012). Similarly, industrialization and the urbanization variables are highly correlated. As a result the empirical model is estimated using the two-step system Generalized Method of Moment (GMM) developed by Arrelano and Bond (1991). The choice of the system GMM is justified on the grounds that it is able to overcome endogeneity and collinearity of regresssors which characterize the basic model of this paper. In addition, the technique is able to overcome econometric problems such as cross-sectional dependence of countries and multi-correlation which are prevalent in macro panel models (Arrelano and Bond, 1991). Furthermore, the technique produces efficient parameter estimates than many techniques such as Ordinary Least Squares (OLS), Random and Fixed Effects particularly in instances of endogeneity, multicollinearity. Thus, The choice of the system GMM over other techniques such as Ordinary Least Squares (OLS), Random and Fixed Effects goes beyond the *I(0)* nature of the variables. In particular, the system GMM is able to overcome endogeneity and collinearity of regresssors which characterize the basic model of this paper. In addition, system GMM is able to overcome econometric problems such as cross-sectional dependence of countries and multi-correlation which are prevalent in macro panel models (Arrelano and Bond, 1991).

The vital diagnostic tests for system GMM estimation include but not limited to first and second-order autocorrelation test and a Sargan test statistics of over-identification of instruments employed (Baltagi, 2008; Arrelano and Bond, 1991). The results of the two-step system GMM estimations of the environmental effect of the relevant growth-enhancing factors are presented in Table 3

Table 3: System GMM estimations[7]

Regressors	CO_2 emissions		Energy consumption per capita		Adjusted Net Saving	
	Dependent variables					
	Coefficient	**Std. Err**	**Coefficient**	**Std. Err**	**Coefficient**	**Std. Err**
Lag of dependent variable	0.0045 **	0.0023	0.0011*	0.0006	0.0013*	0.0007
Urbanization	0.0102***	0.0039	0.0179**	0.0091	0.0015**	0.0008
Industrialization	0.1041**	0.0531	0.1246***	0.0153	-0.1105**	0.0055
Income	0.1091***	0.0096	0.2114***	0.0181	-0.0751**	0.0375
Income squared	0.0063	0.0055	-0.0120***	0.0043	0.0041***	0.0003
Trade openness	-0.0041*	0.0021	-0.1509**	0.0769	-0.0919**	0.0464
Foreign Direct Investment	-0.0125**	0.0063	-0.1001**	0.0510	0.1151**	0.0576
Constant	0.00037*	0.0002	0.0062	0.0059	0.0028	0.0019
Prob.>F	0.000		0.000		0.000	
AR (1) test (p-value)	0.191		0.238		0.250	
AR (2) Test (P-value)	0.217		0.401		0.191	
Sargan Test	18.995		11.512		22.15	

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

In the CO_2 emissions and energy consumption per capita regressions, a positive coefficient on a variable means that an increase in environmental deterioration or a fall in environmental quality and the vice versa. However, in the ANS estimations a positive coefficient on a variable represents a move towards a rise in environmental sustainability and the converse is also true.

The elasticity coefficient on urbanization is significant and positive in all specifications. In particular, a 1% proportionate rise in urban population increases CO_2 emission and energy consumption by about 0.010% and 0.002% respectively indicating that rapid urbanization leads to more pollution and environmental degradation. Further, 1% proportionate rise in urban population increases ANS by about 0.018%. Thus, it can be concluded that urbanization tends to enhance sustainability as measured ANS while at the same time, destroys the environment through increased CO_2 emissions and energy consumption. Hence, the net effect of urbanization the environment would depend on whether the gains generated from ANS and outweigh the harmful effects generated through greater energy consumption and CO_2 emissions.

However, the elasticity coefficient on industrialization is positive for CO_2 emissions and energy consumption but negative for ANS suggesting that a rise in industrial activities is accompanied by a decline in ANS and an increase in both CO_2 emissions and energy consumption per capita. Specifically, a 1% proportionate increase in industrial activities respectively increases CO_2

[7] AR (1) and AR (2) respectively are first-order and second-order autocorrelation test. P-values > 0.05 fail to reject the null hypothesis of the presence of both first and second-order autocorrelation in all specifications. The Sargan test is a test of over-identification of instruments used by the GMM technique. The Sargan test statistics shown in Table 3 indicate that over-identification of instruments used is invalid. These two diagnostics unequivocally confirm the robustness of the model and the results as well.
Also, as indicated earlier in section 3.2, in the ANS regression, lagged income and lagged income squared are used instead of income and income squared to avoid biasedness in the parameter estimates.

emission and energy consumption by about 0.104% and 0.125% while at the same time leads to a decline in ANS by about 0.111%. This is an indication that industrialization in SSA leads to a reduction in environmental sustainability (i.e. ANS); increase energy consumption and leads to greater CO_2 emissions implying decline in environmental quality. Thus, industrialization unambiguously deteriorates the quality and sustainability of the environment.

Furthermore, both income and its squared (serving as a proxy for economic growth and its squared respectively) are significant in all the specifications. For every 1% change in income, there is about 0.109% and 0.211% rise in pollution caused by increased CO_2 and energy consumption respectively while there is about 0.075% fall in environmental sustainability caused reduced ANS. However, the elasticity coefficient on income squared is negative for energy consumption and positive for ANS while that of CO_2 remains positive. This implies that at higher levels of income, every 1% change in income is associated by about 0.0058 rise in CO_2 0.001% fall in energy consumption and a further 0.003% rise in ANS. Thus CO_2 emissions continue to rise even at higher levels of economic growth which is in contrast with the EKC hypothesis for CO_2 which predicts an inverted U-shaped relationship between CO_2 and economic growth (income). But for energy consumption and ANS the EKC is robustly established in SSA.

Also, the estimated elasticity coefficient on FDI is significant and negative for CO_2 emission and energy consumption but positive for ANS. Every 1% proportionate rise in FDI in SSA is associated with about 0.013% and 0.115% in CO_2 emission and energy consumption respectively while a 1% proportionate rise in FDI results in about 0.100% rise in ANS. Thus FDI is accompanied by a fall in pollution and environmental degradation through reduced CO_2 emissions and energy consumption and a rise in environmental sustainability through increased ANS. Thus, FDI is unambiguously friendly to the environment in SSA. This finding is consistent with Eskeland and Harrison (2003) but contrasts with He (2006).

Also, the elasticity coefficient on trade is negative in all specifications. There is about 0.004%, 0.092% and 0.151% proportionate decline in CO_2 emission, energy consumption and ANS respectively per every 1% proportionate increases in trade in SSA. Thus, greater openness to trade is associated with a reduction in CO_2 emissions, energy consumption per capita as well as ANS indicating that despite the fact that trade reduces pollution through reduced CO_2 emissions and energy consumption; it tends to reduce the sustainability of the environment through reduced ANS. The relationship between trade openness and CO_2 established in this study agrees with Antweiler et al. (2001) but contrasts that of Dasgupta et al. (2002).

5. Conclusions and Recommendations

Using a panel dataset from 1985-2010 covering 35 Sub Saharan Africa (SSA) countries this study examined the environmental impact of economic growth and growth-enhancing factors such as trade openness, Foreign Direct Investment (FDI) and industrialization under the Environmental Kuznet Curve (EKC) framework. The environmental variables employed are CO_2 emissions, Adjusted Net Savings (ANS) and energy consumption per capita. Employing the system Generalized Method of Moment, trade openness was found to reduce pollution/degradation through reduced CO_2 emissions and energy consumption per capita while at the same time reducing environment sustainability of SSA through reduced ANS. Industrialization was also found to unambiguously harm the environment while rapid urbanization is revealed to increase pollution/degradation through increased CO_2 emissions and energy consumption. FDI is the only component found to be accompanied by a fall in pollution/environmental degradation through reduced CO_2 emissions and energy consumption and a rise in environmental sustainability through increased ANS. Finally, while the Environmental Kuznet Curve (EKC) is confirmed in for ANS and energy consumption, it is not established for CO_2 emissions. The conclusion only implies that beyond a certain income level ANS will rise while energy consumption will fall but for CO_2 emissions, this relationship is not established. This conclusion does not imply in any way that CO_2 is a weak or poor environmental indicator. What can be said is that as far as SSA is concern beyond a certain income level, economic growth is associated with rising ANS and falling energy consumption while CO_2 emissions is unaffected by this level of economic growth. Perhaps, CO_2 emissions will fall beyond a different (possibly, a higher) level of economic growth. In other words, the economic growth level necessary to ensure a rise in ANS and a fall in energy consumption does not ensure fall in CO_2 emissions. Furthermore, we argue that this conclusion does not imply inconsistency but rather a reflection of the assertion that different environmental variables may respond to economic variables differently. For instance, industrial activities or even urbanization may influence deforestation, SO_2 and CO_2 differently. At the theoretical and even policy levels, the conclusions of the paper have stern implications for the validity of the EKC for CO_2 especially for SSA. Following these broad conclusions, the following policy recommendations are offered.

Firstly, industrial activities (industrialization) are found to unambiguously harm the environment. Thus, policy instruments that would make industrialization friendly to the environment are very essential and imperative to halt and possibly reverse the detrimental effect of industrial activities (industrialization) on the environment in SSA.

The EKC is found to exist for energy consumption and ANS indicating that after a certain level of economic growth, any additional growth would imply a positive move towards more environmental sustainability and decline in pollution through reduced energy consumption. However, for CO_2 emissions, a linear positive monotonic relationship was established. This implies that, there are still some aspects of the growth process of the region's economy that tend to cause severe increase in CO_2 emissions. In this regard, it is recommended that in the region's quest to achieve higher economic growth, it is also very crucial that these destructive aspects of growth are carefully identified and specific policies are tailored to deal with them ruthlessly so as to halt their damaging effect to the environment.

As long as the desire to ensure environmental quality and sustainability remains paramount for the region, any attempts by SSA countries to increase the attractiveness of their economies to FDI would be steps in the right direction.

To reduce the destructive effect of urbanization this paper recommends that specific policies geared towards reducing the massive influx of people especially those in the rural into the urban are particularly pertinent and imperative if the region wants to ruthlessly deal with rising energy consumption caused by urbanization. Governments should be committed to developing the rural areas so that the rural folks are not compelled to move to the urban areas.

Moreso, the findings of this paper are in sharp contrast with the famous EKC hypothesis which postulates that there is an inverted U-shaped relationship between CO_2 and income (economic growth). The findings also reveal the possible existence of EKC for ANS (a proxy for environmental sustainability) and energy consumption (a proxy for indirect pollution) in SSA. This could be investigated thoroughly by future research.

Finally, modeling and estimation with balanced panel dataset is highly useful but given that considerable consistent data do not exist for many environmental variables for many SSA countries sampled for the study, this study has to rely on unbalanced panel data. While we acknowledge this as a potential limitation of the paper, the findings reveal many insightful and relevant implications on the relationship between economic growth and environmental sustainability in Sub Sahara Africa.

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Appendix I

List of the 35 SSA countries sampled for the study

Angola	Congo, Dem. Rep.	Lesotho	Nigeria	Central African Rep.
Benin	Congo, Rep.	Liberia	Rwanda	Niger
Botswana	Cote d'Ivoire	Madagascar	Senegal	Tanzania
Burkina Faso	Ethiopia	Malawi	Sierra Leone	Togo
Burundi	Gabon	Mali	South Africa	Uganda
Cameroon	Gambia, The	Mauritania	Sudan	Zambia
Cape Verde	Ghana	Mauritius	Swaziland	Zimbabwe

Appendix II: Unit root test[8]

Variables	Fisher ADF (Inverse $\chi 2$)		IPS (W-t-bar stat)	
	Statistic	Prob.	Statistic	Prob.
CO_2 emissions per capita	80.971	0.000	-4.491	0.000
Energy consumption per capita	77.120	0.000	8.414	0.000
Adjusted Net Savings	48.903	0.087	-2.419	0.073
GDP per capita	48.610	0.099	-2.001	0.084
Trade (%GDP)	54.444	0.020	-3.771	0.018
FDI (%GDP)	48.691	0.097	-2.449	0.070
Industry, value added(%GDP)	58.030	0.081	-2.850	0.022
Urban (% total population)	59.921	0.079	6.079	0.000

H_0: All the panels contain unit roots/non-stationary
H_1: Some panels are stationary/has no unit

[8] Unit root test based on a balanced panel dataset