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ENVIRONMENTAL QUALITY AND ECONOMIC GROWTH IN SOME SELECTED WEST AFRICAN COUNTRIES: A PANEL DATA ASSESSMENT OF THE ENVIRONMENTAL KUZNETS CURVE

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ABSTRACT
The relationship between environmental quality-as measured by carbon emission (CO_2) and economic growth- as measured by gross domestic product (GDP) is determined with the aid of the Environmental Kuznets Curve (EKC). West African Countries are economies that are increasingly dependent on energy for growth and development and are highly susceptible to climate change. Thus, the study on the relationship between GDP and carbon emission is crucial for realizing their future development objectives and guaranteeing a cleaner environment. The study tests the Environmental Kuznets Curve (EKC) hypothesis using panel data methodology to estimate the relationship between carbon emission and GDP in Ghana, Nigeria, and Sierra Leone over the period of 1970-2006. For the panel, as a whole, both pooled ordinary least square (OLS) and the fixed effects (FE) results were analyzed. The pooled OLS results were in consonance with EKC, while the FE results were at variance with the applicability of EKC in West Africa. The findings suggest that these countries should enact policy options to ensure efficiency in energy use and reduction in carbon emissions, increase investment in energy infrastructure to improve delivery efficiency, continue to promote alternative energy sources, and put in place energy conservation policies to reduce unnecessary wastage.

Keywords: Environmental Quality; Environmental Kuznets Curve; Carbon Emission; Economic Growth; Pooled Effects

INTRODUCTION

The search for a better environmental quality has surfaced as a topic worldwide, particularly within international organizations, such as the World Bank. The problems that developing economies face regarding their level of pollution, which is generated by their quest to survive, has adversely impacted on their economies, so, studies of this nature are, therefore, imperative.

Although, at present, the contribution of African countries to global greenhouse gas emissions is infinitesimal, but its share will grow over time, as poverty is eradicated by social and economic development (Omojolaibi, 2009). Also, all countries must cooperate and participate in carbon conservation strategies if the world is to avoid the possible adverse effects of climate change. Sensitive zones in Africa are among the world's most vulnerable areas (Intergovernmental panel on climate change, IPCC, 2007). The population of Africa is relatively vulnerable to damages brought by climate change due to its high dependence on natural systems for daily survival. Hence, African countries should participate actively in identifying the potential for greenhouse gas reduction. The relevance of the energy sector in reducing carbon emissions is self-evident, since it is the biggest single source of global carbon emissions. Although Africa contributes only about 3 percent of the total global carbon emissions (and Africans emit less than a quarter of the world average, on a per capita basis), its energy usage and greenhouse gas emissions will grow substantially. In order to understand whether the EKC provides the model to follow and whether it is applicable to any country, the methodology that support the EKC is discussed. The results derived from this study are pointed out, followed by the policy recommendations for growing economies, like Africa.

THEORETICAL BACKGROUND OF ENVIRONMENTAL KUZNETS CURVE

The environmental Kuznets curve is a hypothesized relationship between various indicators of environmental degradation and income per capita. In the early stages of economic growth degradation and pollution increases, but beyond some level of income per capita (which will vary for different indicators), the trend reverses, so that at high-income levels economic growth leads to environmental improvement. This implies that the environmental impact indicator is an inverted U-shaped function of income per capita. This is depicted in Figure 1, below.

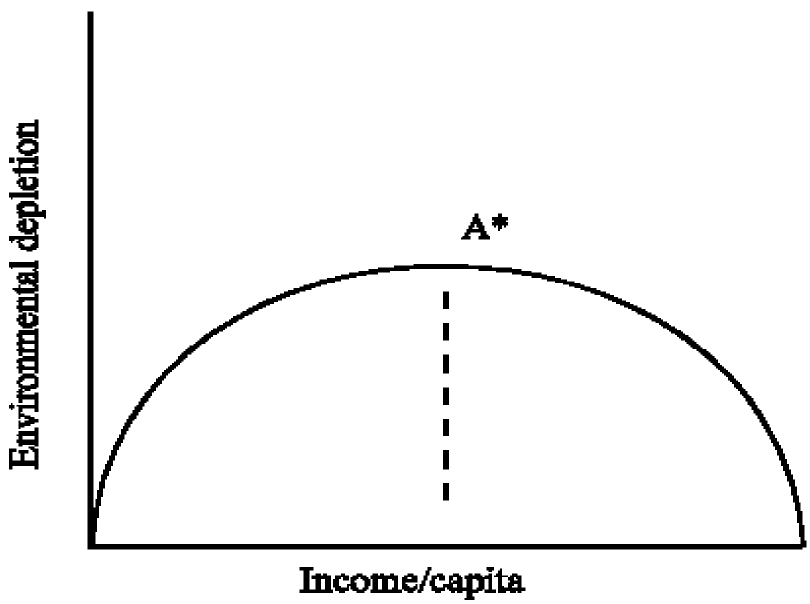

Figure 1: Environmental Kuznets Curve

Source: Omisakin (2009)

The EKC concept was introduced in the early 1990s by Grossman and Krueger (1991). The idea that economic growth is necessary in order for environmental quality to be maintained or improved is an essential part of the sustainable development argument promulgated by the World Commission on Environment and Development (1987) in *Our Common Future*.“The view that greater economic activity inevitably hurts the environment is based on static assumptions about technology, tastes, and environmental investments” (Omojolaibi, 2009). As incomes rise, the demand for improvements in environmental quality will increase, as will the resources available for investment. Others have expounded this position even more forcefully, with Beckerman (1992) claiming that, “there is clear evidence that, although economic growth usually leads to environmental degradation in the early stages of the process, in the end the best – and probably the only – way to attain a decent environment in most countries is to become rich".

The traditional view that economic development and environmental quality are conflicting goals reflects the scale effect, alone. Proponents of the EKC hypothesis argue that, "at higher levels of development, structural changes towards information-intensive industries and services, coupled with increased environmental awareness, enforcement of environmental regulations, better technology, and higher environmental expenditures, result in leveling off and gradual declining of environmental degradation" (Panayotou, 1993).

Most of these studies can generate an inverted U-shape curve of pollution intensity, but there is no inevitability about this. The result depends on the assumptions made and the values of particular parameters. Lopez (1994) and Selden and Song (1995) assumed infinitely lived agents, exogenous technological changes, and that pollution is generated by production and not by consumption. John and Pecchenino (1994), John and Pecchenino (1994), and McConnell (1997) developed models based on overlapping generations where pollution is generated by consumption, rather than by production activities. It seems fairly easy to develop models that generate EKCs under appropriate assumptions, but none of these theoretical models has been empirically tested. Furthermore, if, in fact, the EKC for emissions is monotonic, as more recent evidence suggests, the ability of a model to produce an inverted U-shaped curve is not necessarily a desirable property.

REVIEW OF STUDIES ON EKC

The key features differentiating EKC studies for different pollutants, data, etc., can be displayed by reviewing a few of the early studies and examining a single indicator (CO_2) in more detail. The early EKC studies appeared to indicate that local pollutants were more likely to display an inverted U-shape relation with income, while global impacts, like carbon dioxide, did not. This picture fits the environmental economics theory – local impacts are internalized in a single economy or region and are likely to give rise to environmental policies to correct the externalities on the victims of pollution before such policies are applied to globally externalized problems.

Grossman and Krueger (1991) produced the first EKC study as part of a study of the potential environmental impacts of NAFTA. They estimated EKCs for sulphur oxide (SO2), dark matter (fine smoke), and suspended particles (SPM) using the global entrepreneurship monitor (GEM) dataset. They estimated EKCs for ten different indicators using three different functional forms. Lack of both clean water and urban sanitation was found to decline uniformly with increasing income, and overtime. Both deforestation regressions showed no relation between income and deforestation and river quality tended to worsen with increasing income. Local air pollutant concentrations, however, conformed to the EKC hypothesis, both municipal waste and carbon emissions per capita increased unambiguously with rising income.

In the initial stages of economic development, urban and industrial development tends to become more concentrated in a smaller number of cities, which also have rising central population densities, with the reverse happening in the later stages of development. It is, therefore, possible for peak ambient pollution concentrations to fall as income rises, even if total national emissions are rising (Stern, Common and Barbier, 1996).

The recent studies that use more representative samples of the data find that there is a monotonic relation between carbon dioxide and income. Interestingly, Dijkgraaf and Vollebergh (1998) estimated a carbon EKC for a panel data set of organization for economic corporation and development (OECD) countries finding an inverted-U shape EKC in the sample, as a whole. Lopez (1994) uses a fairly general theoretical model to show that if producers pay the social marginal cost of pollution, then the relationship between emissions and income depends on the properties of technology, as well as preferences. If preferences are homothetic, so that percentage increases in income lead to identical percentage increases in what is consumed, then an increase in output will result in an increase in pollution. But if preferences are non-homothetic, so that the proportion of household spending on different items changes as income rises, then the response of pollution to growth will depend on the degree of relative risk-aversion and the elasticity of substitution in production between pollution and conventional input.

Susmitta, Benoit, Hua, and Wheeler (2002) also review the arguments and the evidence on the position, shape, and mutability of the EKC. Their results suggested that the level of the curve is actually dropping and shifting to the left, as growth generates less pollution in the early stages of industrialization and pollution begins to fall at lower income levels. A study by Schmalensee, Stoker, and Judson (1998) also applies a within-sample turning point for carbon for high-income countries. All these studies suggest that the differences in turning points that have been found for different pollutants may be due, at least partly, to the different samples used. The only robust conclusion from the EKC literature appears to be that concentrations of pollutants may decline from middle income levels, while emissions tend to be monotonic in income.

Carbon Emissions Scenarios

West Africa forms about a fifth of Africa's land area, but has about a third of its population, a third of which live in urban areas. Although the sixteen West African countries are socially and economically diverse, their economies are dominated by a few sectors which can promote sustainable energy use.

Energy Production and Use

Except for hydroelectric resources (which are found in most countries), only Nigeria has significant fossil energy resources. Energy consumption varies greatly among West African countries depending on their levels of economic development. These countries remain highly dependent on bio fuels, especially in the residential sector. Over 70 percent of the total energy used in the region is from biomass, mostly in the form of firewood and charcoal. Biomass fuels are cheap and easy to use and reduce the oil import bills for some countries. Biomass conversion technologies, however, are very inefficient (about 20 percent). The region also faces an acute and increasing scarcity of biomass fuels. About half of the non-desert areas in West Africa are projected to suffer from fuel wood scarcity by the end of the century (Gallagher, 2003). Environmental and health concerns also pose problems with expanding biomass fuel supplies.

Demographic and Economic Assumptions

The annual population growth rate in Africa is more than 3 percent, which is the highest rate in the world. The population in West Africa grows at a rate only slightly lower than that of the whole African continent (World Bank, 1992). However, the scenarios assumed a slower growth rate in recognition of regional family planning activities, improved education, and the recent adoption of a population policy in Nigeria, the most populous country in Africa. The scenarios assume that populations in the region will increase between two-and-a-half to three times between 1985 and 2025 (World Bank, 1992).

Table 1: Demographic and Economic Data: Ghana, Nigeria, and Sierra Leone

	Ghana		**Nigeria**		**Sierra Leone**	
	1987	**2025**	**1985**	**2025**	**1985**	**2025**
Population (millions)	13.4	42.7	96	317	4	9
Population AAGR (%)	-	2.9	-	3.0	-	2.3
GDP (US$ billion)	4.59	22.76	75.0	373.0	0.87	2.88
GDP/capita (US$)	343.0	533.0	788.0	1176.0	247.0	327.0
GDP AAGR (%)	-	4.0	-	4.0	-	3.0
GDP/capita AAGR(%)	-	1.2	-	1.0	-	0.7

Sources: World Bank, 1992, World Development Report and Energy Information Administration (EIA)

AAGR (Annual Average Growth Rate)

In contrast to rising population, economic growth in the region has fallen in the last two decades. High oil imports and low export commodity prices, combined with poor local response strategies, were responsible for this poor economic performance. In addition, Ghana suffered from serious drought in the early 1980s, which crippled agricultural production. The drought also lowered the water level of the Volta dam that generates over 97 percent of Ghana's electricity. In Nigeria, the oil price boom, since the mid-1970s, led to spurts of unprecedented GDP growth. The subsequent decline in oil prices and weak internal policies left the Nigerian economy floundering. In Sierra Leone, excessive public spending, between 1979 and 1981, and reduced foreign exchange earnings, since the mid 1970s, have reduced its ability to import oil. The resultant energy shortages have been disastrous.

Analysis of Carbon Emission and Conservation

As shown in Table 2, High Emission Scenario (HES) by 2025, Ghana, Nigeria, and Sierra Leone will emit 4.4, 54 and 1.2 million tons of carbon, respectively. These projected emissions are a seven- six- and four-fold increase over current emissions for each of these countries. These emissions, in 2025, can be reduced by 36 percent, 25 percent and 13 percent, respectively, if measures to conserve carbon are introduced as assumed in the Low Emission Scenario (LES) (Energy Information Administration). In all the countries, carbon emissions increase much faster than energy consumption during the four decades because of the shift from biomass to petroleum fuels. In the HES for Ghana and Nigeria, energy demand increases by factors of 2.2 and 2.5, respectively, while carbon emissions increase 6 and 7 times. This shift is less dramatic in

Sierra Leone, where energy use slightly more than doubles, but carbon emissions increases almost four-fold. In the LES, energy efficiency and carbon conservation measures lower the ratios of energy consumption to carbon emissions in all countries. Growth in carbon emissions surpasses even the high population growth rates of these countries, resulting in increases in carbon emissions per capita between 1985 and 2025. This outcome varies among the countries. It is most pronounced in Nigeria, where dependence on fossil fuels increases per capita annual carbon emissions to 171 kg. Ghana's greater reliance on hydropower keeps its per capita carbon emissions down to 104 kg.

Table 2: Carbon emissions from Ghana, Nigeria and Sierra Leone

	Ghana			***Nigeria***			***Sierra Leone***		
	1987	***2025***		***1985***	***2025***		***1985***	***2025***	
		HES	***LES***		***HES***	***LES***		***HES***	***LES***
Carbon emissions (mt)	0.6	4.4	2.7	9	5.4	41	0.3	1.2	1.0
Residential (%)	15	47	51	21	34	34	19	28	22
Industrial (%)	8	18	10	18	36	37	15	19	20
Transport (%)	59	23	27	53	22	22	65	52	58
Services (%)	7	5	5	2	1	1	1	*	*
Agriculture (%)	4	*	*	1	2	2	*	*	*
Losses	6	6	6	5	5	4	*	*	*
CO_2/capita (kg)	48	104	64	99	171	129	93	140	111
CO_2/commercial energy(kg/GJ)	3	5	4	6	13	13	6	10	9

: Non-Availability of data

Sources: World Bank, 1992, World Development Report and Energy Information Administration (EIA)

Carbon emitted per unit of commercial energy used also increases between 1985 and 2025, due to the increased use of petroleum based fuels. This feature is well illustrated by Nigeria, which will use more and more carbon intensive fuels. The HES and LES indicate that as countries in the region develop economically, the ratio of energy to GDP will fall. This outcome is the result of substituting more efficient energy forms for inefficient biomass fuels. Under these scenarios, the primary energy per unit GDP declines between the base year and 2025 by 24 percent (HES) and 38 percent (LES) in Ghana; 44 percent (HES) and 56 percent (LES) in Nigeria; and 34 percent (HES) and 46 percent (LES) in Sierra Leone. Also, as Table 2 reveals, the primary energy supply more than triples in the HES and falls only by 20 percent on average in the LES in all the countries. Moreover, the scenarios show that power sector investment grows faster than GDP. This result implies that financial resources will have to be diverted from other non-energy sectors.

MODEL SPECIFICATION

The earliest EKCs were simple quadratic functions of the levels of income. However, economic activity inevitably implies the use of resources and, by the laws of thermodynamics, the use of resources inevitably implies the production of waste.

Regressions that allow levels of indicators to become zero or negative are inappropriate, except in the case of deforestation where reforestation can occur. This restriction can be applied by using a logarithmic dependent variable. The standard EKC and Panel regression models are formulated as thus:

$$ln(CO_2/P)it = \beta_i + \Omega_t + \beta_2\, ln(GDP/P)it + \beta_3\, ln(GDP/P)^2 it + \varepsilon_{it} \qquad (1)$$

$$ln(CO_2/P)it = \beta_1 + \beta_2\, ln(GDP/P)it + \beta_3\, ln(GDP/P)^2 it + u_{it} \qquad (2)$$

Where (CO_2) denotes carbon emissions; P denotes population; l*n* indicates natural logarithms; β_i and Ω_t in model (1), represent the individual (country) and time fixed effects, respectively; β_i shows that the mean varies across countries (*i*) and years (*t*), β_1,in model 2, indicates the intercept parameter in the classical pooled effects model, β_1 shows that the countries have a common mean value for the intercept, while β_2 and β_3 are the slope parameters; *GDP/P* and $(GDP/P)^2$ are the income per capita and the square of income per capita, respectively; and ε_{it} and u_{it} are the error terms. The assumption is that although the levels of emission per capita may differ among countries at any particular income level, the income elasticity is the same in all countries at a given income level. The time specific intercepts are intended to account for time varying omitted variables and stochastic shocks that are common to all countries. Model (1) is estimated and analyzed within the fixed panel data framework, whereas model (2) represents classical pooling.

Table 3: Descriptive statistics of Per-Capita GDP (GDPPC) and Per Capita Carbon Emission in Ghana, Nigeria and Sierra Leone (1970-2006)

COUNTRY	*STATISTICS*	GDPPC (*US $*)	CO_2 PC (MT)
Ghana	Mean	**496.3611**	**0.2699**
	Standard Deviation	64.7567	0.04482
	Minimum	380	0.19
	Maximum	611	0.36
Nigeria	Mean	**1589.4444**	**0.6653**
	Standard Deviation	64.75675	0.23875
	Minimum	380	0.32
	Maximum	611	1.08
Sierra Leone	Mean	**23150**	**0.1463**
	Standard Deviation	4782	0.04526
	Minimum	13400	0.08
	Maximum	28900	0.27
Total	Mean	**8411.9352**	**0.3605**
	Standard Deviation	10831.06	0.26351
	Minimum	10831.06	0.26351
	Maximum	380	0.08

Source: Author's computations; underlying data from WDI, 2007

Table 3 depicts the descriptive analysis of *GDPPC*-CO_2 relationship in Ghana, Nigeria, and Sierra Leone. The mean of *GDPPC* (CO_2) in Ghana is 496.3611 (0.2699), Nigeria is 1589.4444 (0.6653), and Sierra Leone has the value of 23150 (0.1463). Sierra Leone has the highest mean in terms of *GDPPC*, followed by Nigeria, then Ghana. But in terms CO_2 emission, Nigeria has the highest mean, followed by Ghana, and then Sierra Leone. The intuition here is that both *GDPPC* and CO_2 are functions of population growth (population has an inverse relationship with *GDPPC*, while there is a positive relationship between population and CO_2).

Panel analysis of EKC: Results and Interpretations

Using the panel regression framework, we consider two different FE models, namely, the individual/ FE and the time effects, in the CO_2-*GDPPC* analysis for each country. However, the battery of diagnostic tests performed, including the F-tests for the relevant FE, the F-tests for pooling, and the adjusted R^2 measure of goodness-of-fit, resulted in the selection of the following individual FE model as the preferred model for each of the three countries. The FE model is appropriate in the present context given that the entire population of the 3 West African countries are considered, in which case the assumption of fixed intercept is justified, as suggested in the literature (e.g., Greene, 2000).

To verify the impact of carbon emission on economic growth in these countries, Table 4, below, presents the estimation results of equations (1) and (2).

Table 4: Fixed Effects and Pooled Effects Regression Results

Regresssors	Model 1 (Country Fixed Effects) (A)	Model 2 (Pooled) (B)
Constant	**-13.67820** (0.0402**)	**-17.60428** (0.0000***)
Log(GDPPC)	**0.262091** (0.0812*)	**0.436939** (0.0000***)
Log (GDP PC)^2	**-0.126976** (0.1212)	**-0.279435** (0.0000***)
Obs	**102**	**102**
$\bar{R}^2$	**0.814241**	**0.696384**
F-ratio	**109.002** (0.0000***)	**116.0049** (0.0000***)
Log-Likelihood	**72.36111**	**81.29812**
SIC	**-121.5976**	**-113.3985**
D-W	**1.01**	**1.99**
Test of Fixed effect ($F_{2, 97}$)	**39.1928** (0.0000***)	

Note: P-value in parentheses, and *,**, depicts significance at 10%, 5% and 1%, respectively.***

Source: Author's computations; underlying data from WDI, 2007

In the FE model, we assumed that the intercept and slope coefficients are constant across time and space and the error term captures differences overtime and countries. Although the intercept may differ across countries, each country's intercept does not vary over time. The results in Table 4 (a) revealed that higher per capital income, indeed, leads to higher CO_2 emission in the countries under consideration. On a closer look, individual country effect does not conform to EKC hypothesis, which is evident in the non-significance of the (*GDPPC).* The results above are contrary to our a priori expectations, however, the slope coefficients have the expected signs, ln (*GDPPC*) is positively related to CO_2, while ln$(GDPPC)^2$ has a negative correlation with CO_2.

Digging further, 1% increases in ln (*GDPPC)* leading to a 26.2% increase in CO_2, while 1% increase in $ln\ (GDPPC)^2$ results in a 10.3 decrease in CO_2. The result is at variance with most of the findings of EKC studies in determining the relationship between growth and environmental quality; however, the study conforms to Aldy's (2004) analysis, where he found that an Environmental Kuznets Curve hypothesis of U.S state-level carbon dioxide varies with the inverted U income-emissions relationship. Notwithstanding, R^2 values were as high as 0.81, meaning that about 81% percent of the variation in CO_2 is accounted for by the explanatory variables, it can be deduced from the result that estimated EKCs appear to vary by countries. Therefore, this empirical study calls into question the robustness of the inverted U-shape of the per capita carbon dioxide EKC. The only theory of the EKC that appears plausible for per capita carbon dioxide emissions focuses on the shifts in energy-intensive production associated with various stages of economic development.

Following the result of pooled regression analysis in estimating the relationship between carbon emission (CO^2) and per capita *GDP* is shown in Table 4. The results satisfy our a priori expectation in that all the coefficients are statistically significant, the slope coefficients have the expected signs, i.e. *ln(GDPPC*) is positively related to CO_2, while $ln(GDPPC)^2$ has a negative relationship with CO_2. On a closer look, a 1% increase in $\ln(\text{GDPPC})^2$ leads to 43.7% increase in CO_2, while 1% increase in $ln(GDPPC)^2$ results in 20.8% decrease in CO_2. The results are in consonance with the findings of Panayotou (1993), Dijkgraaf, and Vollebergh (1998), where they estimated a carbon EKC for a panel data set of OECD countries finding an inverted-U shape. The R^2 value is reasonably high, as expected, that is about 70% percent of the variation in CO_2 is accounted for by the explanatory variables.

The Durbin Watson Statistics indicated that the models are free from autocorrelation, meaning that the estimated models are well specified and the results are well behaved. On the whole, the pooled effect regression results indicated that pooling countries, together, may not reveal the true characteristics of each country as it relates to modeling of the CO_2-Income relationship.

Policy Recommendations for Efficient Energy Use and Carbon Conservation in West Africa

Based on the results of the study, the following policy options are recommended to ensure efficiency in the use of energy and reduction in carbon emissions.

(a) Development of fossil fuel resources

West Africa has abundant exploitable energy reserves, including more than 2.3 billion tons of crude petroleum; about 90 billion cubic meters of natural gas; some high and poor quality coal deposits; vast hydropower resourcesuranium; and large quantities of renewable sources of energy. It will be easier to attract the requisite external development capital for oil and gas.

(b) Fuel substitution

Fuel substitution is possible in households and in the electrical supply system. In the Sahelian countries, liquified petroleum gas (LPG) substitutes for wood fuels as a cooking fuel in urban households. Countries with such programs include the Gambia, Senegal, Burkina Faso, Mali, and Niger. Ghana promotes widespread use of LPG in households and institutional users. Replacing wood fuels with petroleum based fuels may increase carbon emissions, unless the biomass is produced on a renewable basis. In any case, shifting to gas will likely reduce the pressure on forests that have not been cut by wood fuel suppliers. Natural gas offers a more attractive substitute than coal. Not only is natural gas less carbon-intensive, but gas-fuelled combined gas turbines can be built at lower total cost than other fossil fuel power plants, and even large hydropower plants.

(c) **Renewable energy sources**

Modern renewable energy sources that emit little or no carbon have great potential in the region, especially for small and decentralized applications and to meet the needs of dispersed and vulnerable groups. At present, some mature renewable energy technologies have proven their viability in the region. Solar energy devices for household use and stand-alone power systems, especially for communication and water pumping, are very promising. However, technical and pricing problems remain. Recent studies show that wind speeds equivalent to those exploited in Denmark exist along the coast of Senegal and Mauritania. The falling cost and increasing technological maturity of wind generators offer the possibility of integrating wind-power into a national distribution grid.

(d) Biomass energy

Biomass energy utilization in the region is limited to small-scale energy applications, except for a few agro-based industries. Recent work has shown that this energy source can be used in large-scale end uses and can compete with other modern fuels. If these systems (referred to as biomass integrated gas turbines) are well planned, then their net carbon emissions can be minimized by replanting programs.

(e) Energy efficiency technologies

Energy efficiency technologies offer the region many opportunities to increase energy services from existing and new energy transforming capital stocks. Energy efficiency, therefore, should be treated as equivalent to supply options at the margin. The potential for using energy efficiency technologies in developing countries is great. The most attractive sectors for implementing these technologies are the most carbon-intensive in the long-term scenarios of this study, namely, the residential, transport, and industrial sectors.

On a related front, transmission and distribution (T&D) losses offer additional potential to conserve carbon. Up to 15 percent improvement in overall T&D efficiency is easily achievable in Nigeria and Ghana by the year 2025. Most of the technical measures needed to reduce T&D losses are not expensive and are quickly recovered by utilities, as occurred in Sudan where the benefits were 12 times the installed cost of efficiency measures. Improving the thermal efficiency of the whole power system, which can drop as low as 22 percent, as in Benin, can also slow the growth of emissions in the regional power sector. Improved wood fuel stoves and charcoal kilns have great technical potential to reduce energy consumption and to conserve carbon, especially in urban areas. These devices, however, have limited acceptability in rural areas because of social and financial constraints.

(f) Energy pricing

Energy pricing is a useful instrument for controlling the quantity and type of energy used. However, prices are also used to promote welfare goals in many poor countries by inter-fuel and cross-consumer subsidies. Nonetheless, cost recovery, rather than social equity guides energy pricing policy in most of the region today. Reforming electricity prices is linked to changing billing and revenue collection practices. The failure to bill and collect revenue has left many utilities unable to realize revenues based on nominal high tariffs. Biomass fuels are largely unregulated and suppliers often use their market power to exploit consumers. Prices for energy services in the region badly need to be adjusted to reflect real economic and environmental costs. The analysis that should underlie a price reform strategy should consider several innovative measures, including carbon taxes.

Events at the global level affect the macroeconomic environment of countries in West Africa. Carbon taxes are one recent method proposed to fund collaboration between developed and developing countries for carbon conservation. Revenues from carbon taxes could fund businesses with minimal adverse environmental effects in developing countries that would use equipment and expertise supplied by the developed countries.

(g) Economic opportunities for implementation

The region's poor economic prospects accentuate the need to take advantage of least cost energy strategies and foreign funds available to support such programs. The technology choice model used by energy planners should be selected carefully to ensure that the least cost investment strategy that minimizes foreign exchange requirements is selected. It is essential that this model places efficiency improvements at end use on an equal footing with additional supply options.

CONCLUSIONS

In this paper, we assessed, using panel data analysis, the robustness of the income-emissions nexus in the case of Ghana, Nigeria, and Sierra Leone. The choice between the fixed effect and pooled effect is made via the F- test. The test favors the fixed effect modeling. The fixed effects results presented in column (A) of Table (4) shows that the Environmental Kuznets Curve does not apply in the case of West Africa, hence, it is not a good depicter of the income- CO_2 relationship in the region.

Although West Africa's contribution to global carbon emissions is small, its role in a global carbon abatement strategy is imperative. It is inevitable that energy consumption and carbon emissions will increase as the region develops. To exploit these opportunities, West African countries must develop strong regional initiatives. The EKC is more of an instrument of analysis than prediction, in which case, it will probably only apply to the rich and the developed countries that have already surpassed the turning point; however, the growing economies are also constrained by the environmental standards that have been imposed on their slow progress. The outcome of the results shows that the EKC is definitely not a convincing tool that is able to explain how an economy deals with its environmental quality, while growing.

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