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RESEARCH ARTICLE

Environmental quality vs economic growth in a developing economy: complements or conflicts

Oluwabunmi Opeyemi Adejumo [1]

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Abstract

An increase in economic activities which leads to economic growth has been adduced as a possible factor for environmental degradation. While some other studies have argued that as economies keep growing, there are possibilities for resource redistribution which could engender environmental balance, thus engendering the argument on the conflicting-complementary position of the environment-growth nexus. In the light of this, this study uses previous activities between economic activities and the environment to determine the conflicting or complementary relationship that exists between economic growth and the environment. Also, using Nigeria as a case study, the design of environmental growth nexus to achieving sustainable development is assessed. Annual time series data between 1970 and 2014 were sourced from the World Development Indicators. Following the neoclassical perspective on ecological growth and the Kuznets inverted U-hypothesis on the environment-growth relations, stationarity test was performed, and the autoregressive distributed lag estimates were employed. From the study, it is seen that factors like rainfall that promotes environmental quality in the long run promote economic growth (per capita and GDP growth) in Nigeria. Similarly, factors like natural resource utilization, which depletes environmental quality, increases economic growth but reduces economic growth per capita; thus, with questions for development, the possibility of a complementary relationship for environmental quality and economic growth is spotted if the right policies are ensured. Also, the study found evidence of a growing conflicting relation between environmental quality (CO_2) and economic growth (per capita and GDP growth). Meanwhile, these conflicts to a great extent find expression in the Kuznets hypothesis; such that, if policies that promote income per capita reduces pollution and pursues eco-efficiency via economic growth are properly harnessed, there are the prospects of meeting up with the goals of environmental sustainability in developing economies.

Keywords Environment · Growth · Pollution · Income · Complements

Introduction

The need to clearly understand the dynamics of the environment we operate in is paramount. This is because it is from the environment that human needs are catered for. Since the needs of human beings remain insatiable and dynamic, there will be a continuous increase in human activities. Given the increases in human activities, the issue on environmental quality vis-à-vis sustainability has become a global issue. Unlike Europe and North America, the apprehension for environmental degradation and hazards are not so overwhelming in Africa, which may be adduced to poverty, low state of industrialization or low preferences for environmental quality (Goodstein and Polasky 2014; Adejumo 2018).

In view of the continuous quest for development through technology and industrial advancement, the issue of environmental problems is becoming imminent in Africa. However, if human beings will improve on the existing structure of the earth or make it exquisite for habitation, environmental sustainability must be harmonized with development thoughts. Although, the capacity of human beings to adequately attend to certain needs from the environment is debatable; nonetheless, conscious attempts must be made to promote the positive effects of social actions on the environment and minimize negative effects.

Some studies have posited that an increase in national income as reflected in economic growth could serve as a

Responsible editor: Philippe Garrigues

✉ Oluwabunmi Opeyemi Adejumo
jumobum@gmail.com; adejumobum@oauife.edu.ng

[1] Institute for Entrepreneurship and Development Studies, Obafemi Awolowo University, Ile-Ife, Nigeria

determinant for assuring quality environment (Matinez 1995; Ozturk and Acaravci 2013; Saidi and Hammami 2015). While from economic literature, the relationship between increased economic activities leading to environmental degradation has been ongoing. For instance, some studies have postulated that population increase vis-à-vis the desire for economic growth may aggravate the exploitation of natural reserves and resources that could cause environmental pollution and degradation (Kuznets 1955; Grossman and Krueger 1993; Awan 2013). This phenomenon has been evident in Nigeria, increases in consumption demand has brought about overutilization of natural resources, especially with regard to oil wealth (Nnanna et al. 2003). Classic examples of economic activities that have challenged the Nigerian environment are the mining activities within the Niger-Delta areas. Crude oil production, which accounts for over 90% of foreign income in Nigeria, has recorded exports from about 548,000 barrels per day in the mid-1980s to about 1.8 million barrels in 1990 and an average of 2.4 million barrels per day between year 2004 and 2014 (CBN 2005; NBS 2015). Some attendant effects of crude exploration have resulted in environmental pollution problems in Nigeria. These problems include destruction of top soil which hampers agricultural activities, which is the primary occupation of local dwellers where mining activities take place. These activities have resulted in criminal activities such as gas flaring, vandalisms of pipeline by hoodlums, oil spillages and pipe leakages which have heightened the challenge of pollution. These pollutants have had severe negative implications for water bodies and the atmosphere in Nigeria.

Despite the incredible role economic activities play in creating economic wealth, environmental preservation cannot be downplayed, especially in the context of sustainable health and wealth. Although measures have been taken to check environmental pollutions and distortions in Nigeria, through the enactment of laws, institutions, and accession to international treaties, plans and programmes like the National Environmental Standards and Regulations Enforcement Agency (NESREA) (2011), there is still a dearth of studies on the environment-growth direction in ensuring sustainability as far as economic activities that create economic growth are concerned in Nigeria. Also, regardless of the environmental challenges brought about by economic growth via economic activities, some studies have noted that wealth redistribution strategies that emanate from economic growth could result in economic balance, thus indicating some form of complement between economic growth and environmental quality (Andrei et al. 2016; Grossman and Krueger 1995). Following this, an assessment of the trade-offs or otherwise of the environmental-growth nexus can be articulated using Nigeria as a case study.

Literature review

Some previous studies argued that the fastest road to environmental improvement is along the path of economic growth or economic wealth (Beckerman 1992; Pinkovskiy 2017), while others hypothesized that the relationship between economic growth and environmental quality, whether positive or negative, is not fixed along a country's development path. This is because as an economy evolves, there may be a change of expected outcomes from positive to negative or otherwise depending on the income level attained by the economy. (Shafik and Bandyopadhyay 1992; Panayotou 1993; Grossman and Krueger 1994). Furthermore, the environmental Kuznets curve (EKC), in an inverted U-hypothesis, argued that accumulated economic wealth can be used to combat environmental degradation, while the neoclassicals argued that at low levels of development, it is expected that both the quantity and the intensity of environmental degradation will be limited to the impacts of low or subsistent economic activity. But as economic activities rise via increased agricultural activities, mining and industry, it is expected that resource depletion and waste generation may accelerate. This caused some studies to argue that economic policies geared towards achieving economic growth and assuring high-quality environment have always been in conflict (Panayotou 1993, 2016).

Meanwhile, the traditional view that economic growth and development in connection with environmental quality are conflicting goals reflects the scale effect. Studies have identified the issue of scale effect in production which increases pollution and other degradation and overwhelms the time effect in low- and middle-income countries, but in wealthy countries, where growth is slower, and pollution reduction efforts can overcome the scale effect. Thus, the implication is that the bigger the plant, there is expected to be more pollution, which is the origin of the apparent EKC effect, (Panayotou 1993; Dasgupta et al. 2002). While increase in economic activities is seen as danger signal for the environment if unchecked, likewise, stringent environmental policies can hamper the freedom of economic activities, thus affecting economic growth. Thus, the complementary-conflicting perception of the environment-growth relation is capable of challenging the stance of the neoclassical growth doctrines.

Balibey (2015), a proponent of sustainable economic growth, noted that economic growth leads to degradation of the environment and depletion of natural resources. Thus, he posited that the major aim of sustainable economic growth should be in pursuit of less environmentally friendly products (carbon) and consume less energy. In a bid to explain the nexus between environment quality and output levels, Martinez (1995) classified environmental goods into two categories: the environment-luxury which is low in demand income elasticity and the environment-necessary which when is higher, the income distribution gap rises. Martinez noted that from either situation, luxury or necessity, some of the following would likely occur as growth occurs:

- The demand of the environment -luxury goods would increase.
- The supply would also increase because the poor tend to sell cheap.
- The imbalance of income distribution is detrimental to the improvement of environmental quality. He therefore emphasized that the concerns for environmental quality and economic development have a lot to do with income level of people.

Magnani and Tubb (2007) obtained empirical results on the nexus between environmental quality and economic growth by estimating a country specific and time-varying measure of government R&D investment in pollution abatement. Two alternative measures that proxy the tightness of the government budget constraint were used; these variables include government surplus over GDP ratio (*budget*) and a dummy variable (*fiscally troubled*)—which take value one if a country is fiscally troubled. It was revealed that public investment in pollution abatement has a non-linear (indirect) relationship with GDP per capita. The estimated relationship between the variable *budget* and the government expenditure in pollution abatement R&D is somehow counterintuitive. With its negative impact on the GDP per capita, it suggests that fiscally troubled countries may spend more for the environment. With a strong indication presence that there may be *reverse causation*, they assessed the plausibility of environmental protection impacting negatively on the government fiscal position. They found that indeed there is the tendency for a country to run a significant deficit upon its allocation of public funds in favour of pollution abatement.

Some other studies have assessed if rising per capita income will ultimately induce countries to clean up their environments, such that economic growth itself can be regarded as a remedy to environmental problems. As distributional concerns were subordinated to growth by proponents of 'trickle-down' economic development, so environmental concerns may be downplayed as a temporary issue which growth will cater for after a while. Grossman and Krueger (1995) provided a strong link between income and pollution. Given the increases in conusmption of citizens they argued for more stringent and strictly enforced environmental standards. In doing this, they emphasized Kuznets's (1955) original conclusion with respect to income distribution as a plausible outcome for mitigating environmental challenges.

Although, beyond the issues of growth, some other economic factors may be responsible for environmental degradation. This could include changes in the structure or technology of the economy. While market signals have been adduced to contribute to the inducement process, rising resource costs may encourage resource conserving technological change, and a 'greening' of consumer demand may prompt firms to adopt cleaner technologies. More so, studies have revealed that government policies such as regulatory standards, pollution taxes and the creation of tradable emission permits have been the most potent in stimulating pollution-reducing technological change.

It is evident that previous studies have identified some environmental issues that could determine the relationship between environmental quality and economic growth. Typically, issues such as scale effect, technology, market phenomenon and preferences have been spotted as determining the conflicting or complementary relationships on economic growth. Thus, given some of these factors, this study aims to assess the income-growth nexus in Nigeria; this is with a view of drawing implications for sustainable development.

Methodology

Conceptual framework: neoclassical perspective of the environment and growth

The mainstream economists have a particular conception of the natural environment, including how it should be managed. The conception emanates from the classical and neoclassical dominant approach to economic analysis since about the 1870s.

The neoclassical world view of environmental economic relationship is anthropocentric. This means that the humans are treated as pre-eminent in the natural environment. Consequently, the human economy is rated above natural environment and humans are regarded as the universe's most important entity. The natural environment therefore is seen to exist to serve the human economy and environmental resources have no intrinsic value. Following this line of thought, the economy is assumed to depend on the environment for three distinctive purposes as shown in Fig. 1.

a) The extraction of non-renewable resources (such as iron ore, fossil fuels) and the harvest of renewable resources (such as fish of various species, agricultural products, forest products) to be used as factors of production (*arrow 1*)
b) The disposal and assimilation of wastes (*arrow 2*)
c) The consumption of environmental amenities (such as bird watching, canoeing, hiking national park trails, observing a morning sunrise or an evening sunset) (*arrow 3*)

Thus, broadly viewed, the economy is assumed to be completely dependent on the natural environment for raw materials, the disposal of waste material and amenities.

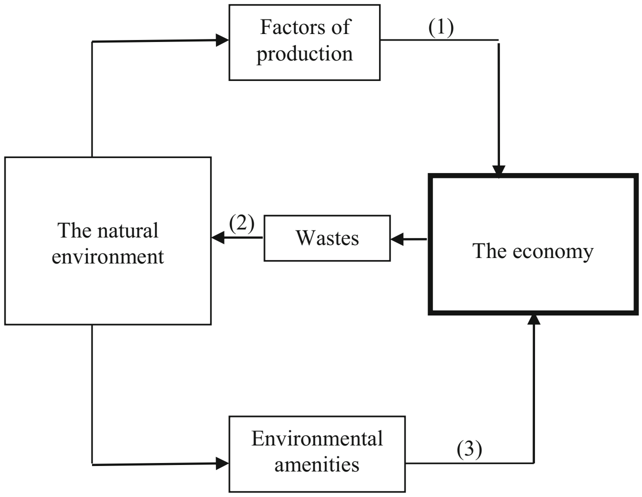

Fig. 1 A Schematic Representation of the Neoclassical Perspective on Environment

Basically, the neoclassical perspective makes clear strict interrelationship between the environment and economic growth. It is silent about the role of humans in shaping environmental quality through its economic activities; but in order to clarify the interrelations among the environment, environmental quality and economic growth, the effects of human beings cannot be overemphasized. This has caused some other studies, like the Kuznets inverted U-hypothesis, to see the human factor as an intermediary or intervening variable between environmental quality and economic growth, which is the cardinal principle of the ecological perception of economic growth. The Kuznets hypothesis posits that despite the initial damages caused to the environment by human beings, as long as it brings about economic growth and especially income per capita, there is the optimism that there will be a reversal in environmental damages. This reversal is expected to be brought about by increases in the demand or preferences for environmentally friendly products (Kuznets 1955).

Model of the relationships between environmental quality and economic growth

Following the neoclassical growth model, Drabo (2011) expanded the model to show environmental quality as a function of growth per capita. This implies that theoretically, Drabo (2011)[1] was able to specify a relationship between the environment and growth.

According to the model, $\left(\frac{Y_t^*}{L_t}\right)$ is expressed as GDPC_t (growth per capita), a modified version of the inputs which included rate of investment in physical capital and the rate of growth of labour force, environment, education and technology are replaced by some other determinants of output per capita. These determinants include variables that determine environmental quality (env) and other growth determinants like inflation rate (infl) and population growth rate (popu).

Thus, based on the neoclassical augmented growth model, the effect of environment on economic growth can be specified as follows:

$$\mathrm{GDPC}_t = C + \alpha_1 \mathrm{GDPC}_{t-1} + \alpha_2 \mathrm{env}_t + \alpha_{3k} X_{kt} + v_t \qquad (1)$$

where GDPC_t and env_t represent the logarithimic form of GDP per capita and the environment quality in Nigeria in period t, since it is a country-specific study. X is the matrix of the control variables introduced in the model and which have been used frequently in the empirical literature, while v_t is the error term. The coefficient α_1, which measures the past effects of growth on the present value, is expected to be superior to zero but less than 1 (i.e., $0 < \alpha_1 < 1$).

With the objective of confirming the competing or complementing nature of the growth-environment relation, the coefficient of the α_2 is expected to lie between 0 and 1 ($i.\ e, 0 < \alpha_2 < 1$) (Bassanini and Scarpetta 2001). Also, a positive parameter (α_2) shows a complementary relationship, while a negative parameter (α_2) shows a conflicting relationship. The EKC hypothesis already expects that the development level of any economy has significance on its level of pollution. Thus, in addition to some environmental variables, some other variables that address economic structure and technological advancement can be included in the model (Panayotu 2003).

The variables used for measuring environmental quality include rate of CO_2 in metric tons per capita (CO_2) and (RAIN), while control variables include inflation rate (INFL), population growth (POPU), natural resource utilization (NRES), and economic openness (ECO).

Thus, Eq. (1) can be re-specified to include the other environmental and control variables to give the following:

$$\begin{aligned}\mathrm{GDPC}_t &= C + \alpha_1 \mathrm{GDPC}_{t-1} + \alpha_{21} \mathrm{CO2}_t + \alpha_{21} \mathrm{RAIN}_t \\ &\quad + \alpha_{31} \mathrm{INFL}_t + \alpha_{32} \mathrm{POPU}_{33} + \alpha_{34} \mathrm{NRES}_t \\ &\quad + \alpha_{35} \mathrm{ECO}_t + \quad + v_t\ . \qquad (2)\end{aligned}$$

To further examine the nature of relationship that exist between economic growth and environmental quality relations, environmental quality can be made the dependent variable by using a proxy variable to explain the nexus. Usually, since economic growth could cause deterioration to the natural environment, therefore, a cross-examination of this possibility is verified for Nigeria. But the analytical relation through which growth affects environment has

[1] In $\left(\frac{Y_t^*}{L_t}\right) = \ln A_0 + gt - \frac{\alpha}{1-\alpha}\ln(\hat{n}_t + \delta) + \frac{\alpha}{1-\alpha}\ln(s_k) + \theta_1 \ln(Q_t) + \theta_2 \ln (E_t)$

Specifically, $\left(\frac{Y_t^*}{L_t}\right)$ is expressed as $GDPC_t$. In the model, environmental quality represented by Q_t is explained as a determinant of per capita income among other variables such as productivity (E_0) and human capital (E_t).

been studied empirically (Grossman and Krueger 1995; Torras and Boyce 1998; Andreoni and Levinson 2001; Drabo 2011). Theoretically, it has been posited that income is linked to environmental quality through an inverted U-relationship. The environment-income relation of Eq. (1) can be re-specified to make env_t the subject and include explanatory variables like economic growth, per capita income (PCI) as specified by Kuznets (1955)[2], as well as other control variables:

$$env_t = c + \gamma_0 env_{t-1} + \gamma_1 gdp_t + \gamma_2 PCI_t^n + \gamma_3 Z_t + \omega_t \quad (3)$$

where γ_s represents the coefficient measures of the explanatory variables; while n is the degree of PCI to be included in the model which is 1 and 2; Z includes all other variables that could shape environmental quality outside growth. The control variables to be included in the study are population growth (POPU) and economic openness (ECO). Natural resource intensity accounts for the volume and consumption rate of natural endowments within Nigeria, while economic openness accounts for importation activities that can cause negative spillovers in Nigeria. But the measurement of economic activities in this case is current GDP and the linear and quadratic function of per capita income (that is PCI, PCI^2 and PCI^3), while CO_2 is used to represent the environmental quality performance in Nigeria (env).

Thus, by introducing the variables to be employed, Eq. (3), we have the following:

$$CO_2 = c + \gamma_0 CO_{2t-1} + \gamma_1 GDP_t + \gamma_{21} PCI_t + \gamma_{22} PCI_t^2 + \gamma_{31} PCI^3{}_t + \gamma_{32} POPU_t + \gamma_{33} ECO_t + \omega_t \quad (4)$$

It must be noted that the quadratic form of the per capita income introduced into the equation is based on the environmental Kuznets curve (EKC) hypothesis, where a further increase in PCI is expected to reduce environmental degradation. Specifically, the values of the current level of GDP employed. This was used to depict the level of economic activities within the Nigeria economy; because according to the EKC hypothesis, it is expected that as in the early stages of production, as economic activities rises, economic growth will rise and pollution will equally rise, thereby causing environmental quality to fall; therefore, γ_1 is expected to be positve. Also, to assess the responses for environmental quality, it was measured by the CO_2 emissions in Nigeria.

For robustness check

For the purpose of robustness, we introduce a different response variable into Eqs. (5) and (6). The gross domestic product (GDP) in its current form is introduced to verify the findings via the gross domestic product per capita (GDPC) that was used initially, while instead of using CO_2 which is measured in metric ton per capita, the growth rate of CO_2 emissions (kt) is used to verify the initial findings

$$GDP_t = C + \alpha_1 GDP_{t-1} + \alpha_{21} CO_2PC_t + \alpha_{21} RAIN_t + \alpha_{31} INFL_t + \alpha_{32} POPU_{33} + \alpha_{34} NRES_t + \alpha_{35} ECO_t + \quad + v_t. \quad (5)$$

$$CO_2PC = c + \gamma_0 CO_2PC_{t-1} + \gamma_1 GDP_t + \gamma_{21} PCI_t + \gamma_{22} PCI_t^2 + \gamma_{31} PCI^3{}_t + \gamma_{32} POPU_t + \gamma_{33} ECO_t + \omega_t \quad (6)$$

The hypothetical relationship between environment quality and growth

An increase in environmental quality will foster real economic growth. A direct measurement of the relationship between environmental quality and economic growth is the growth rate of rainfall (RAIN). It is expected that as rainfalls, it should foster productivity and economic growth; which in turn will improve GDP per capita. Hence, a complementary relationship is expected between annual rainfall and economic growth (Stern 2004).

In a different but related sense, an indirect measurement of environmental quality (CO_2) is also adopted. The hypothesis is stated such that there is an expected reduction in economic growth when there is an increase in environmental degradation through air pollutants (like carbon emissions); hence, any variable that decreases environmental quality will reduce economic growth (Srivastava 2009).

Estimation technique

The study employed quantitative method of analysis on a time series variable. The period under study is between the years 1970 and 2014.

The income-environment relationship was assessed through the introduction of pollution indicators in an augmented neoclassical growth model. In order to ascertain the relationship between economic growth and environmental quality along the development path in Nigeria, as well as the conflicting or complementary nature of both variables, we employed the autoregressive distributed lag (ARDL) modeling approach developed by Pesaran et al. (1999) and later extended by Pesaran et al. (2001) is introduced. To the best of our knowledge, it is most appropriate to capture the short

[2] Kuznet hypothesis states that "as an economy's per capita income increases, the total amount of environmental impact of economic activities initially grows, reaches maximum and then falls

run and long run estimations of our model and increase the reliability and predictive power of our result for forecasting. ARDL has numerous advantages in comparison with other cointegration approaches.[3]

Therefore, the estimable *ARDL* function of Eqs. (2) and (4) are expressed as Eqs. (7) and (8) respectively[4]:

$$\Delta GDPC_t = \rho_0 + \sum_{J=1}^{P} \alpha_j \Delta GDPC_{t-j} + \sum_{j=0}^{q} \beta_j \Delta CO2_{t-j} + \sum_{j=0}^{r} \tau_j \Delta RAIN_{t-j} + \sum_{j=0}^{S} \varnothing_j \Delta INFL_{t-j} + \sum_{J=0}^{T} \psi_j \Delta POPU_{t-j} + \sum_{j=0}^{U} \omega_j \Delta NRES_{t-j} + \sum_{j=0}^{V} \rho_j \Delta ECO_{t-j} + \lambda_1 CO2_{t-j} + \lambda_2 RAIN_{t-j} + \lambda_3 INFL_{t-j} + \lambda_4 POPU_{t-j} + \lambda_5 NRES_{t-j} + \lambda_6 ECO_{t-j} + \mu_t \quad (7)$$

$$\Delta CO2_t = \rho_0 + \sum_{J=1}^{P} \alpha_j \Delta CO2_{t-j} + \sum_{j=0}^{q} \beta_j \Delta GDP_{t-j} + \sum_{j=0}^{r} \tau_j \Delta PCI_{t-j} + \sum_{j=0}^{S} \varnothing_j \Delta PCI^2_{t-j} + \sum_{J=0}^{T} \psi_j \Delta PCI^3{}_{t-j} + \sum_{j=0}^{U} \omega_j \Delta POPU_{t-j} + \sum_{j=0}^{V} \rho_j \Delta ECO_{t-j} + \lambda_1 GDP_{t-j} + \lambda_2 PCI_{t-j} + \lambda_3 PCI^2{}_{t-j} + \lambda_4 POPU_{t-j} + \lambda_5 NRES_{t-j} + \lambda_6 ECO_{t-j} + \mu_t \quad (8)$$

Δ = the first difference operator

$\alpha, \beta, \tau, \varnothing, \psi, \omega$, ȹ, π and Ω = the coefficient estimates of the chosen variables

μ = error term

p, q, r, s, t, u, and v = the optimal lag lengths selected based on the optimal length selection criteria.

Pesaran et al. (2001) suggest an F test for joint significance of the coefficients of the lagged level of variables. Therefore, the null and alternate hypothesis of cointegration of no long run relationship or otherwise among the variables is stated respectively as follows:

$$H_0 : \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = \lambda_6 = 0$$
$$H_1 : \lambda_1 \neq \lambda_2 \neq \lambda_3 \neq \lambda_4 \neq \lambda_5 \neq \lambda \neq_6 \neq 0.$$

As against the null hypothesis, the alternative hypothesis will be accepted if F-statistic from the result exceeds the upper critical value tagged I(I) and rejected if otherwise I(0); meanwhile, if it lies between the upper and lower bounds of either I(1) or I(0), the result will be inconclusive (Pesaran et al, 2001).

Model stability

The CUSUM and CUSUM sum of squares test (Brown, Durbin, and Evans, 1975) is based on the cumulative sum of the recursive residuals. This option plots the cumulative sum together with the 5% critical lines. The test finds parameter instability if the cumulative sum goes outside the area between the two critical lines. The ARDL model of Eq. 5, where GDPC (and GDP for the robustness test) is responding appears stable using both CUSUM and CUSUM sum of squares (see Figs. 2 and 4), while the ARDL model of Eq. 6, where $C0_2$ (metric tons per capita) (and CO_2 growth for the robustness test) is fairly stable as the model passes the CUSUM test but partially lies outside the bounds of the CUSUM sum of squares (see Figs. 3 and 5).

Variable sources and measurement

Table 1 below summarizes the sources and the measurements of variable.

Result

Prior the presentation of the result, there are some preliminary checks on the descriptive nature of the variables. The description of common sample statistics of the variables employed within the study. The descriptive statistics of data series gives information about on the mean, median, minimum value, maximum value and the distribution of the sample measured by skewness, kurtosis and the Jarque-Bera statistic. From Table 2, most variables show that all the series displayed a high level of consistency as their mean and median values are within the maximum and minimum values of the series. Besides, the deviation of most data in the series are not really different from their mean value, except for the PCI which is due to the presence of some negative values in the series.

The skewness and kurtosis statistics provide useful information about the symmetry of the probability distribution of

[3] This approach is found to be applicable irrespective of the order of integration of variables, evades the need for pre-testing the integration order of variables, allows the variables to have different optimal lag length of deriving a dynamic unrestricted error correction model from the approach via a simple linear transformation and it integrates both the short run dynamics and long run dynamics together without loss of any long run information (see Pesaran et al. 1999 and 2001; Narayan and Smyth, 2005; Akinlo, 2008 and among others)

[4] The same ARDL estimation technique is applied for robustness checks.

Table 1 Presentation of variable measurement and sources

Variables	Sources of variable	Measurement of variables
GDP per capita (GDPC)	World Development Indicator, 2015	Growth rate of real GDP per capita
Carbon dioxide emissions (CO_2) (metric tons per capita)	World Development Indicator, 2015	Carbon dioxide in the atmosphere
Carbon dioxide emissions per capita (CO_2G)	World Development Indicator, 2015	Growth rate of CO_2 emissions (kt)
Rainfall (RAIN)	Nigerian Meteorological Agency, 2015	Annual amount of rainfall for 32 major states out of 36 states, including the Federal Capital Territory as provided by NIMET, 2015
Inflation (INFL)	Central Bank of Nigeria Statistical Bulletin, 2015	Inflation rate
GDP	World Development Indicator, 2015	Nominal GDP estimates—to reflect current economic activities and growth rate-for robustness checks
Per capita income (PCI)	World Development Indicator, 2015	Income per head in Nigeria
National resource endowment (NRES)	World Development Indicator, 2015	Ratio of oil exports to total exports of Nigeria
Economic openness (ECO)	Central Bank of Nigeria Statistical Bulletin, 2015	Ratio of trade to GDP
Population (POPU)	World Development Indicator, 2015	Population growth rate

Source: Author

various data series as well as the thickness of the tails of these distributions respectively. The data shows that the distribution of the data is normal, given the skewness and kurtosis values. With regard to the skewness of the variable, the rule of thumb may be arbitrary, but the general threshold is one. Since all the variables lie within 1.0 and − 1.0, the skewness is not substantial and it can be said that all the distribution of the variables are symmetrical. Also, a Gaussian distribution is expected to have kurtosis of 3.0 (Wooldridge, 2013); thus, since all the variables lie within the range of 3, the distribution is normal.

Unit root test

Once the descriptive samples are in line within limits, the analysis is then carried out. However, for ARDL analysis, I(1) values are required of the variables as against the I(0) variables. The result of the unit root test using ADF, Phillip-Perron and KPSS tests are shown in Table 3.

From Table 3, the results of Augmented Dickey-Fuller, given the 5 and 10% significance level, revealed that the variables are stationary at first difference (GDPC, GDP and ECO), while some other variables were stationary at levels and first difference, i.e., I(0) and I(1) (CO2, RAIN, INFL NRES POPU and PCI). Also, the Phillip-Perron tests also showed that most variables are stationary at first difference (GDPC, CO2, GDP, PCI, ECO); while other variables were stationary at I(0) and I(1) (RAIN, INFL, NRES, POPU). Similarly, at 5% significance level, Kwiatkowski-Philips-Schmidt-Shin test showed that most of the variables were stationary at first difference; while a few variables such as ECO are stationary at levels.

Table 2 Descriptive statistics of the major variables

Statistics	GDPC	CO_2	RAIN	INFL	GDP	PCI	NRES	ECO	POPU
Mean	12.40124	0.959903	10.8096	19.113	25.0998	1.718193	0.94	43.71833	16.07104
Median	12.3909	0.951633	10.84295	12.94178	24.68763	1.957445	0.96	39.19629	16.13942
Maximum	12.82127	1.682166	11.09761	72.8355	29.79923	30.34224	0.99	98.78806	17.2341
Minimum	12.05759	0.47382	10.2854	3.45765	21.82097	− 15.4583	0.58	5.897203	14.16165
Std. dev.	0.228529	0.299285	0.187076	16.4584	2.527781	7.912524	0.073421	22.80571	0.866515
Skewness	0.215074	0.242553	− 0.96896	1.751241	0.393936	0.97047	− 3.36793	0.599939	− 0.51201
Kurtosis	1.646859	2.308075	3.505148	5.14259	1.913398	6.414563	15.39991	2.722636	2.406308
Jarque-Bera	3.696034*	1.309163*	7.352964*	30.90645**	3.302651*	28.2819**	365.0709**	2.780506*	2.568691
Probability	0.157549	0.51966	0.025312	0	0.191795	0.000001	0	0.249012	0.276832

Critical values of χ^2 at 5% and 1% levels are 5.99 and 9.21 respectively

* (**) denotes the acceptance of the null hypothesis that the variables are normally distributed at 5% and (1%) significant level

Table 3 Unit root test for environmental quality and economic growth

Variables	ADF		*d*	PP		*d*	KPSS		*d*
	Intercept and no trend	Intercept and trend		Intercept and no trend	Intercept and trend		Intercept and no trend	Intercept and trend	
GDPC	−0.15251	−0.04779		−0.262600	−0.239471		0.212609	0.196220	
ΔGDPC	−5.77036	−6.40731	I(1)	−5.847613	−6.404826	I(1)	0.349977	0.138411	I(1)
CO_2	−1.92355	−3.0115		−1.85599	−3.033445		0.523153	0.113968	I(0)
ΔCO_2	−8.13129	3−8.06662	I(1)	−8.168986	−8.094495	I(1)	0.114166	0.103664	I(1)
RAIN	−2.07416	−4.6826	I(0)	−1.77272	−4.572651	I(0)	0.808117	0.1911901	I(0)
ΔRAIN	−10.4409	7−7.67791	I(1)	2−12.77374	−13.40147	I(1)	0.245486	0.200091	I(1)
INFL	−3.24025	−3.22163	I(0)	−3.199678	−3.199678	I(0)	0.153504	0.147043	I(0)
ΔINFL	−6.65746	−6.62565	I(1)	−6.625646	6.313404	I(1)	0.500000	0.50000	I(1)
GDP	1.774472	−1.74019		1.62906	−1.794192		0.818206	0.177642	I(0)
ΔGDP	−4.92019	−5.2717	I(1)	−4.866175	−5.177763	I(1)	0.390066	0.058645	I(1)
PCI	−0.15628	−0.26134		−0.529462	−0.461986		0.202140	0.195525	I(0)
ΔPCI	−5.58412	−6.06767	I(1)	−5.638035	−6.066968	I(1)	0.316392	0.131306	I(1)
NRES	−9.62187	−10.1620	I(0)	−10.16209	−14.06129	I(0)	0.59390	0.16830	I(0)
ΔNRES	−7.00172	−7.08393	I(1)	−7.594651	−7.642427	I(1)	0.43390	0.15070	I(1)
ECO	−1.43542	−2.06032		−1.352630	−2.074307		0.497362	0.119459	I(0)
ΔECO	−7.43229	−7.34153	I(1)	−7.455886	−7.363946	I(1)	0.088057	0.084058	
POPU	−2.65034	−1.17987	I(0)	−3.22163	−3.199678	I(0)	0.346864	0.218938	
ΔPOPU	−1.66282	−4.19234	I(1)	−6.62565	−6.395505	I(1)	0.708312	0.100955	I(1)
Critical regions for unit root test									
Mackinnon critical values:							**Asymptotic critical values**	**Asymptotic critical values**	
Level									
1%	−3.61045	−4.21186		−3.610453	−4.211868		0.739000	0.216000	
5%	−2.93898	−3.52975		−2.938987	−3.529758		0.463000	0.146000	
10%	−2.60906	−3.19831		−2.607933	−3.196411		0.347000	0.119000	
1st Difference									
1%	−3.61558	−4.21912		−3.615588	−4.219126				
5%	−2.94114	−3.53308		−2.941145	−3.533083				
10%	−2.60906	−3.19831		−2.609066	−3.198312				

Source: Self-computation using Eview 9.0. Notes: *d* denotes decision about the order of integration respectively

Hence, from Table 3, it can be said basically that given the behaviour of variables in their levels and first difference, it could be seen that most of the series could said to have a random walk when they are in levels but refer to their mean level after first difference.

From Tables 4 and 5, with the significance of all the response variables employed via the *F* test, it can be deduced that all the response variables together with their explanatory variables have a long-run relationship in the models in which they are specified.

Bounds test—test for long-run relationship

The bounds test is usually employed to determine the existence of a long-run relationship within a model. Using the *F*-statistic, the significance and cointegrating relations among variables in a model are established. For the model in focus, that is Eqs. (7) and (8), the bounds test is presented in Table 4, while the bounds test for the robustness estimate is presented in Table 5.

Table 4 Bounds test

Variable	*F*-statistic
GDPC	5.7299*
CO_2	3.8445*

*Significance at 5%, which implies a long-run relationship

Table 5 Bounds test (robustness analysis)

Variable	*F*-statistic
GDP	2.9497*
CO_2G	3.2314*

*Significance at 5%, which implies a long-run relationship

ARDL estimates: the environmental quality-economic growth Nexus in Nigeria

Table 6 presents the result of the effects of environmental quality on economic growth (GDPC), as well as the effects of economic growth on environmental quality (CO_2) both for the short run and the long run.

In the second pane, where CO_2 is the response variable, growth proxies which are GDP and PCI revealed interesting results. In the short run, current GDP had significant positive effects on CO_2 (0.4866, $p < 0.05$) which implies that increases in economic activities and growth increases CO_2 emissions significantly. Although the lagged values 1and 4 showed insignificant negative effects, the lagged values of 2 and 3 maintained a positive significance. However, in the long run, these mixed results smoothen out in the long run, as the long-run coefficients depict reducing relations of GDP on CO_2. The implication of this is that negative effects of economic activities (GDP) on the environmental performance and sustainability (CO_2) are more of short-run effects. This position is further complemented by the inclusion of the EKC component vis-à-vis the income effects as depicted by the PCI relations. With the exception of the lagged 2, 3 and 4 of PCI^2, PCI^1 and PCI^2 had significant positive relationships with CO_2 both in the current and lagged periods. This indicates that an increase in PCI increases CO_2. But as the EKC postulates, the preferences for clean environment begins to creep in the PCI^2, although this appears insignificant in lag 4, but it is significant in lags 2 and 3 and in the current period of lag PCI^3. This result is clearer with the long-run estimates where PCI had an increasing significant effect on CO_2, while the PCI^2 had insignificant increasing effects, and the PCI^3 now has significant decreasing effect on CO_2. This implies that preferences for clean environment through per capita income will come in Nigeria is more of a medium to long-run effects than the short run, thus emphasizing the conflicting-complementary relations in the movement from growth to the sustaining quality environment (Adejumo 2018).

The control variables used in the second pane are POPU and ECO, while NRES was dropped.[5] POPU which represents population growth had mixed insignificant effects on CO_2 in the short run. While the current period lag 2 and lag 3 had insignificant reducing effects on CO_2, lag 1 and lag 4 showed insignificant increasing effects of POPU on CO_2. Meanwhile, the long-run analysis depicted that POPU increases CO_2 significantly, such that 1% increase in population growth increases CO_2 by 2.65%. Meanwhile, ECO, except for the current period and lag 2 estimate, increases CO_2 insignificantly in the short run, and in the long run, ECO had a significant reducing effect on CO_2.

The statistical properties of the estimates in the both pane revealed that the R^2 and the adjusted R^2 were over 70%. Specifically, using the adjusted R^2, 96% and 76% of the variations in GDPC and CO_2 in Nigeria can be explained by the combined effect of all variables considered. Also, the freedom from serial correlation is buttressed by the Durbin-Watson statistic which revolves around 2 by the rule of the thumb. Also, the *F*-statistic of both models, which is also above 2, indicates the overall significance of the variables employed in both models.

Robustness check

In the first pane, GDP growth is the independent variable, and the effects of environmental variables on GDP growth are shown. In the short run, the relationship between the GDP and CO_2 revealed that apart from the lagged two period where CO_2 had a significant negative effect on GDP growth, all other periods including the current period had positive insignificant effects on GDP growth, while the current period was even significant showing that increases in CO_2 emissions by 1% results in increases in GDP growth by 1.4%. Narrowing on the long-run analysis of both estimates of the effect of CO_2, although there were mixed estimates from the short-run analysis for GDP growth, the long-run analysis of insignificant increasing effects for both GDPC and GDP growth is consistent—thus, we conclude a growing conflicting relation from environmental quality for economic growth (Table 7).

Meanwhile, just like the case of the GDPC, both the current and lagged values of the increases in annual rainfall (RAIN) had positive effects on CO_2 and in both cases were significant, which implied that an increase in rainfall by 1% causes GDP per capita to increase by 2.5% and 4.5% respectively. But in the long run, unlike the main estimates, increases in RAIN had a positive significant positive effect on GDP.

Also, from the robustness estimates, unlike the initial estimate, the current value of NRES revealed significant positive effects on GDP growth ($\alpha = 11.5835$; $p > 0.05$); although, the lagged 1 and 2 values revealed significant negative effects of NRES in driving GDP growth, the findings of the NRES effects on GDP growth are substantiated more with the long-run coefficients which is positive and significant, thus indicating the utilization of natural resource (and particularly oil) as a major driver of GDP growth in Nigeria. Comparing, NRES

[5] The variable NRES was removed from the presentation after several iterations revealed explosive and insignificant estimates.

Table 6 The relationship between environmental quality and economic growth

	Gross domestic product per capita (GDPC)	Environmental quality (CO_2)
Short-run analysis		
C	17.946(0.00)	
GDPC(−1)	0.2103(0.30)	
GDPC(−2)	−0.3234(0.12)	
GDPC(−3)	0.0635(0.76)	
GDPC(−4)	−0.7335(0.00)*	
CO_2	0.1632(0.12)	
CO_2(−1)	0.0544(0.62)	0.1318(0.56)
CO_2(−2)	0.186(10.12)	
CO_2(−3)	0.1755(0.12)	
CO_2(−4)	−0.1608(0.06) * *	
RAIN	0.2580(0.17)	
INFL	0.0008(0.311)	
INFL(−1)	0.0015(0.15)	
INFL(−2)	0.0008(0.41)	
INFL(−3)	0.0019 (0.06)	
POPU	6.0226(0.00)*	−0.7444(0.83)
POPU(−1)	−7.7614(0.04)*	4.8825(0.63)
POPU(−2)	3.531(0.01)*	−3.1259(0.81)
POPU(−3)		−3.0247(0.73)
POPU(−4)		4.3146(0.15)
NRES	0.9926(0.31)	
NRES(−1)	−1.6997(0.01)*	
NRES(−2)	−3.2487(0.00)*	
ECO	0.0039(0.02)*	−0.0044(0.25)
ECO(−1)	0.0046(0.01)*	0.0019(0.43)
ECO(−2)	0.0055(0.01)*	−0.0077(0.06) * *
ECO(−3)	0.0033(0.00)*	0.0021(0.23)
ECO(−4)		0.0039(0.34)
GDP		0.4866(0.05)*
GDP(−1)		−0.3716(0.23)
GDP(−2)		0.0375(0.89)
GDP(−3)		0.2503(0.35)
GDP(−4)		−0..4416(0.03)*
PCI		0.0295(0.000)*
PCI(−1)		0.0140(0.13)
PCI(−2)		0.0153(0.01)*
PCI(−3)		0.0168(0.00)*
PCI(−4)		0.0142(0.02)*
PCI^2		0.0009(0.09) * *
PCI^2(−1)		0.0004(0.36)
PCI^2(−2)		−0.0005(0.01)*
PCI^2(−3)s		−0.0003(0.03)*
PCI^2(−4)		−0.0002(0.33)
PCI^3		$-6.39E-05$(0.02)*
PCI^3(−1)		$-3.71E(-05)$(0.17)
Long-run analysis		
CO_2		
RAIN		

Table 6 (continued)

	Gross domestic product per capita (GDPC)	Environmental quality (CO_2)
INFL	0.0378(0.53)	
POPU	0.1447(0.18)	
NRES	0.0029(0.00)*	
ECO	1.0055(0.00)*	2.6517(0.04)*
GDP	−2.2174(0.00)*	
PCI	0.0092(0.00)*	−0.0093(0.32)
PCI^2		−0.0446(0.54)
PCI^3		0.1037(0.01) * *
		0.0002(0.76)
		−0.0001(0.02)*
Error correction	− 1.78(0.00)	− 0.868(0.00)
R^2	0.98	0.93
Adjusted R^2	0.96	0.76
Durbin-Watson stat	2.406	2.393
F-stat	46.73(0.00)	5.51(0.002)

Source: Self-computation using Eview 9.0. Note: *t* values of 5% and 10% levels are 2 and 1.6 respectively and are denoted by * (**)

revealed a significant negative effect on GDPC which implies that an increase in natural resource utilization diminishes growth per capita—this implies that while natural resource utilization result in economic growth, its effects for development (through growth per capita) remains questionable. These findings further illustrate that resources or wealth from the environment have little bearing for GDPC (in terms of trickling effects or resource redistribution) and impacts GDP growth more. Thus, from the mixed effects via resource utilization (NRES), it can be inferred that as far as economic activities are concerned, environmental quality has a complementary movement for economic growth and a conflicting movement for growth per capita. Hence, we can submit that economic activities that have bearing with environmental degradation, that is oil utilization, have varying consequences not only for growth but for growth sustainability in Nigeria.

Just like the initial findings on GDPC, apart from environmental variables, there are other variables that explain GDP growth in Nigeria. For instance, population growth has positive significant effects on GDP growth in Nigeria, especially in the long run and the current period of the short-run analysis. Although, there were mix effects of positive effects in current period. Also, while ECO in both the current and lagged periods had significant positive effects on GDPC, a significant negative effect was found for GDP growth both in the long-run and in the short-run current estimates.

In the second pane, where the growth rate CO_2 emission (CO_2G) is the response variable, growth proxies which are GDP and PCI also revealed interesting results. In the short run, GDP had mixed and insignificant positive effects on CO_2 ($\beta = 0.3352, p > 0.05$). This implies that increases in economic activities increases CO_2 emissions insignificantly. Although the lagged values 4 showed significant negative effects ($\beta = -0.82080$, $p < 0.050$), the long-run analysis showed a negative but insignificant effect. The implication of the short-run positive effects of economic growth (GDP) on the environmental quality confirms the growing conflicting relations of environment-growth nexus which was seen in the first pane, while the long-run analysis lends credence to the EKC hypothesis on the plausibility of utilizing growth effects (GDP) to ensuring environmental quality.

This position is further complemented by the inclusion of the EKC component vis-à-vis the income effects as depicted by the PCI relations. With the exception of PCI^1 and lagged values of PCI^3, which showed a positive relationship with environmental quality, PCI^2 and PCI^3 had although insignificant negative relationships with CO_2 both in the current and long-run periods. This indicates that an increase in PCI initially increases CO_2. But as the EKC postulates, the preferences for clean environment begins to creep in the PCI^2 and PCI^3 which reduces CO_2 growth in the short and long run estimates. Meanwhile, the effects of PCI^3 and PCI^3 further indicate improvement in environmental quality both in the short run and in the long run—thus confirming income per capita as a veritable instrument towards achieving environmental sustainability.

Discussion of result

The results obtained on the relationship between economic growth and environmental quality revealed some interesting outcomes. For instance, increases in carbon dioxide emissions had mixed effects on growth per capita and GDP growth in the

Table 7 The relationship between environmental quality and economic growth (Robustness Check)

	Gross domestic product (GDP)	Environmental quality (CO_2G)
Short-run analysis		
C	− 88.1144(0.01)*	6.2201(0.00)*
GDP		0.3352(0.13)
GDP(−1)	1.4045(0.00)*	−0.5461(0.11)
GDP(−2)	−0.1097(0.69)	0.6852(0.10)
GDP(−3)	0.06623(0.05)*	0.2430(0.54)
GDP(−4)	− 1.1908(0.01)*	−0.8208(0.01)*
CO_2	1.2070(0.01)*	
CO_2(−1)	0.4082(0.235)	
CO_2(−2)	− 0.4650(0.29)*	
CO_2(−3)	0.0384(0.65)	
CO_2G(−1)		0.5827(0.00)*
RAIN	2.5751(0.01)*	
RAIN(−1)	4.3480(0.00)*	
INFL	0.008(0.07)**	
INFL(−1)	0.00003(0.99)	
INFL(−2)	0.0047(0.20)	
INFL(−3)	0.008(0.04)	
POPU	30.934(0.00)*	0.1436(0.68)
POPU(−1)	−51.6594(0.01)*	
POPU(−2)	22.0664(0.29)	
POPU(−3)	14.7529(0.36)	
POPU(−4)	-11.062(0.10)	
NRES	11.5835(0.01)*	
NRES(−1)	−0.1871(0.95)	
NRES(−2)	−9.0988(0.00)*	
NRES(−3)	−1.3090(0.49)	
NRES(−4)	4.173(0.04)*	
ECO	−0.0029(0.00)*	−0.0051(0.17)
ECO(−1)	− 0.01(0.02)*	−0.005(0.17)
ECO(−2)	0.0265(0.00)	−0.005(0.13)
ECO(−3)	0.0041(0.52)	0.0102(0.01)*
ECO(−4)	0.0042(0.00)*	0.0051(0.16)
PCI		0.0297(0.00)*
PCI(−1)		0.0080(0.45)
PCI(−2)		0.0080(0.37)
PCI(−3)		0.0150(0.01)*
PCI(−4)		
PCI^2		0.0007(0.33)
PCI^2(−1)		−0.0004(0.40)*
PCI^2(−2)		−0.0014(0.03)*
PCI^2(−3)		−0.0009(0.02) **
PCI^2(−4)		−0.0005(0.09)**
PCI^3		−0.000001(0.08)**
PCI^3(−1)		0.00003(0.95)
PCI^3(−1)		0.00003(0.17)
Long-run analysis	2.9931(0.21)	
CO_2	29.6781(0.00)*	
RAIN	0.0903(0.05)*	

Table 7 (continued)

	Gross domestic product (GDP)	Environmental quality (CO_2G)
INFL	21.5385(0.09) **	0.3416(0.66)
POPU	22.0958(0.22)*	
NRES	−0.0309(0.49)	0.0245(0.04)*
ECO		−0.2480(0.10)
GDP		0.1459(0.04)*
PCI		−0.0054(0.21)
PCI^2		−0.00003(0.66)
PCI^3		
Error correction	− 0.234(0.03)*	− 0.417(0.02)*
R^2	0.99	0.93
Adjusted R^2	0.98	0.82
Durbin-Watson stat	2.408	2.393
F-Stat	424.82(0.00)*	8.643(0.000)*

Source: Self-computation using Eview 9.0. Note: *t* values of 5% and 10% levels are 2 and 1.6 respectively and are denoted by * (**)

short run and an increasing effect in the long run; however, most of these effects are insignificant. Since the robustness analysis revealed a similar estimate, and even significant increases in the current period, the implication of the findings is that the consumption of products that emits CO_2 is still a positive driver of income growth in Nigeria as shown by Chindo et al. (2015) and Mensah (2017). Therefore, CO_2 pollutants for production of goods and services will persist except there is another cost-reducing alternative for production and consumption purposes (as shown by the GDP index).

Meanwhile, an increase in the quantity of rainfall brings about income and by implication economic growth. This explains the factor that promotes or enhances environmental quality (such as average rainfall) that will significantly boost economic growth—thereby indicating complementary relationship possibilities from environmental quality to economic growth. Also, for the Nigerian case, the carbon emissions, which is still within limits, does not have adverse effects growth; although this is conflicting relation, economic growth is not affected significantly. Meanwhile, given the peculiarity of Nigeria as an oil-dependent economy, the natural resource utilization, which is measured as the ratio oil export to total export, revealed negative significant effects of oil exploration on economic growth per capita, while a significant positive effect is recorded from the long-run estimate for GDP growth. Therefore, if the natural resource (oil) will be harnessed for sustainable development in Nigeria, there will be other channels for which oil will divested for welfare advancement in Nigeria.

In a reverse analysis, the findings of the study also highlight the effects of economic growth variables (as represented by GDP and PCI) on the environment. The findings from the results indicate the presence of EKC in Nigeria. Firstly, GDP which is a measure of economic activities shows that increases in economic activities increase environmental pollution (Nnaji et al. 2013). Although these effects are insignificant especially in the long run, it is still an indication of a growing conflict between the economic growth and the environment. Furthermore, the study revealed that the significantly low preferences of consumption for clean environment as current increases in per capita income do not translate into improvements in environmental quality partially in the short run and fully in the long run, thus reiterating the conflicting relationship (Chuku 2011). Meanwhile, as income grows vis-à-vis economic growth, certain periods in the quadratic and cubic functions of per capita income revealed positive reducing effects for environmental degradation, which is a complementary effect. Specifically, this finding is consistent with the findings of the Kuznets hypothesis of an inverted u-shape on the income-growth relationship and the expectation for sustainable development (Li Barrens and Grijalva, 2007; Magnani, 2006; Alege and Ogundipe (2015). However, these findings are not fully consistent with the position of the neoclassicals who argued that significant improvements in environmental quality are fully compatible with economic growth. Specifically, the neoclassicals expect that high per capita income will increase the demand for environmental quality; this in turn will engineer improvement in pollution abatement technologies; and this does not necessarily increase the cost of environmental clean-up to go up without bounds, given an expected increase in per capita income and the demand for cleaner environment (Hussen 2000).

From the forgoing, through innovative green economic activities and appropriate utilization of resources, economic growth can be used to achieve environmental sustainability. Given the findings of cubic function of per capita income (PCI^3) both in the short run and long run (and PCI^2 in the case of robust estimates), there are indications that income growth which translates into per capita income has prospects for resource distribution in favour of sustaining the environment in Nigeria. This position is in consonance with the findings of Beckerman (1992), Balibey (2015) and Ahmed et al. (2012), who encouraged environmental preservation while promoting and sustaining economic growth, as well as level of economic activities (Panayotu, 1993; 2003).

Conclusion and recommendation

Unlike previous studies that consider a uni-directional cause-effect relations, this study has been able to contribute on the dual nexus between environmental quality and economic growth. Also, it articulates that the nature of relationship from environmental quality to economic growth in Nigeria. Therefore, despite the quest for economic growth and development, preserving and sustaining environmental quality should remain a major policy issue for achieving sustainable development in Nigeria. Also, activities that pursue or encourage economic growth at the expense of environmental quality should be minimized or eradicated in Nigeria.

Specifically, some policy measures to reduce pollution and make developing economies environment healthier, wealthier and better could include:

- Continuous public awareness/enlightenment on the need for environmental preservation and the consequences of environmental pollution. For instance, people believe in traditional approach to consuming whatever resources are available, regardless of the long-term ecological damage. Therefore, people should be enlightened on the need to pursue eco-friendly practices both in consumption and production.
- Policy drivers and stakeholders are advised to continue on policies that restrict carbon-intensive products. Also, opportunities in green economies via building, renewable energy, sustainable agriculture, recycling business and green financing should be harnessed. Therefore, a redirection of economic activities in this regard will boost sustainable economic development.
- Similarly, institutions and firms need to be innovative to achieve environmental sustainability via production processes.
- Where indigenous economic activities are not consistent with eco-sustainability, there is the need to encourage and enlighten on the need to adopt best practices in economic activities (such as mining, cultivation, recycling, smelting and the likes) and stimulate the need to prefer cleaner technologies so as to enhance productivity and promote posterity.

Appendix 1

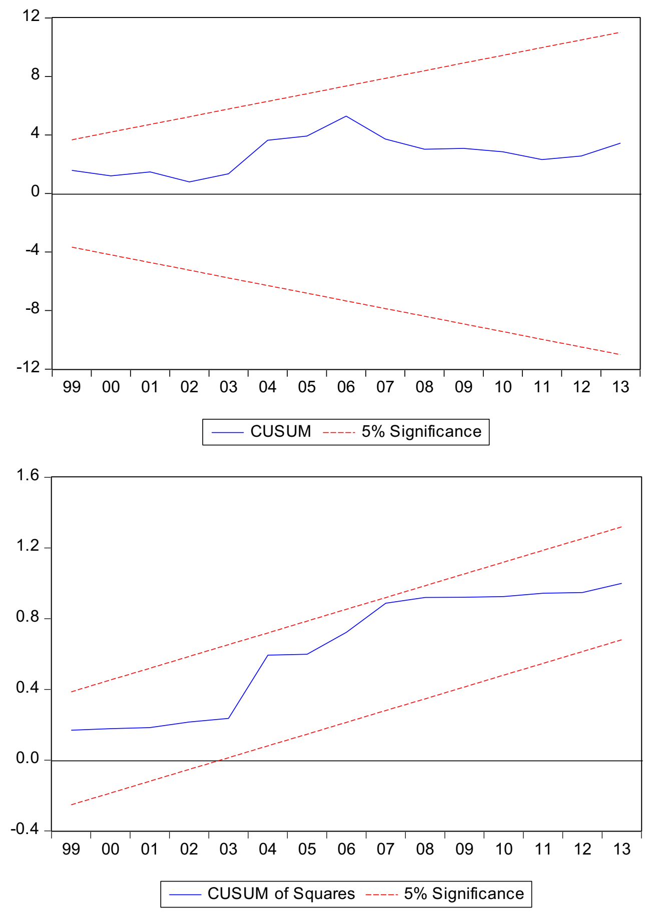

Fig. 2 Model I (where GDP per capita (GDPC) is the response variable)

Appendix 2

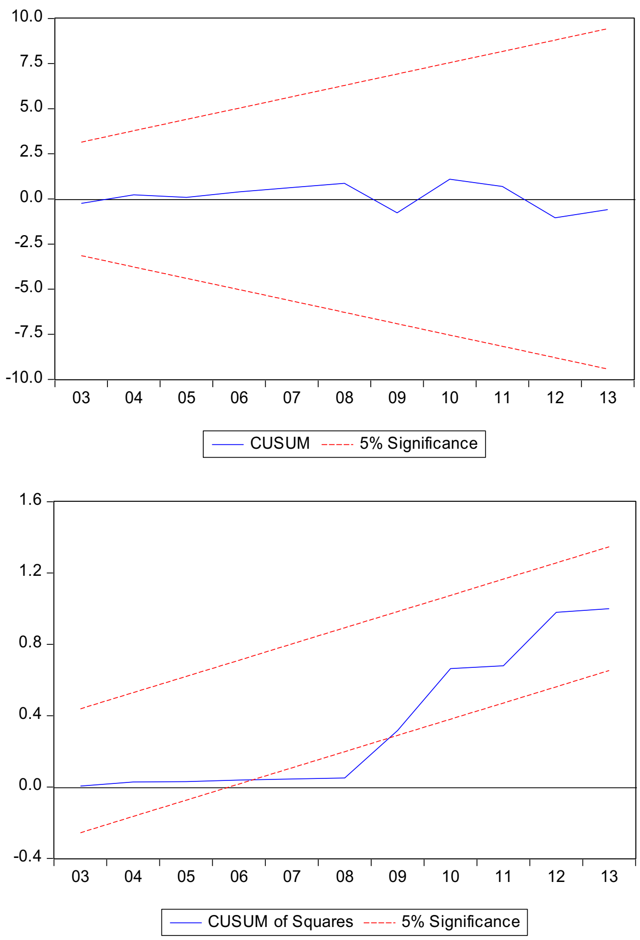

Fig. 3 Model II (where CO_2 (metric tons per capita) is the response variable)

Appendix 3

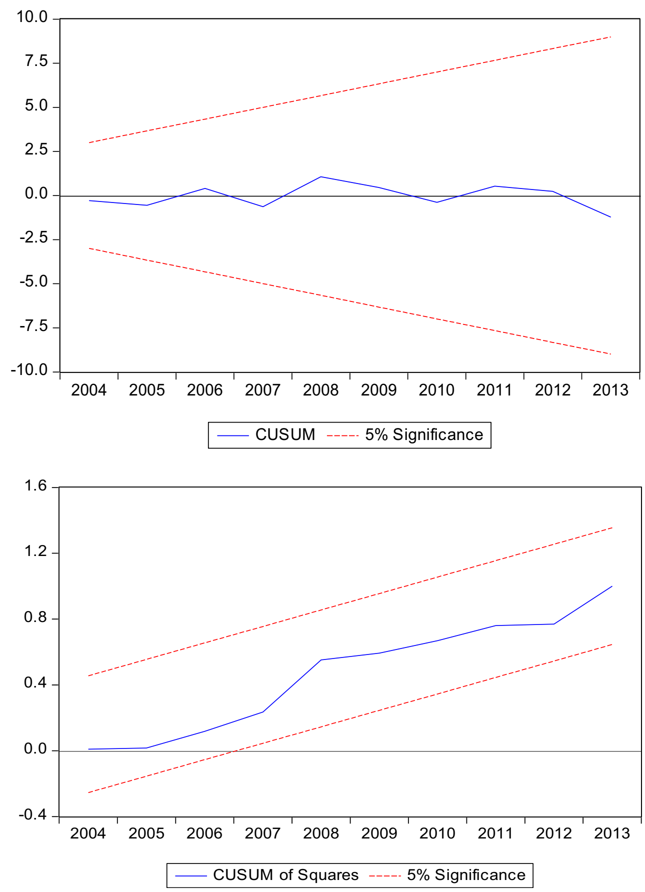

Fig. 4 Model III (where GDP (growth rate of GDP) is the response variable)

Appendix 4

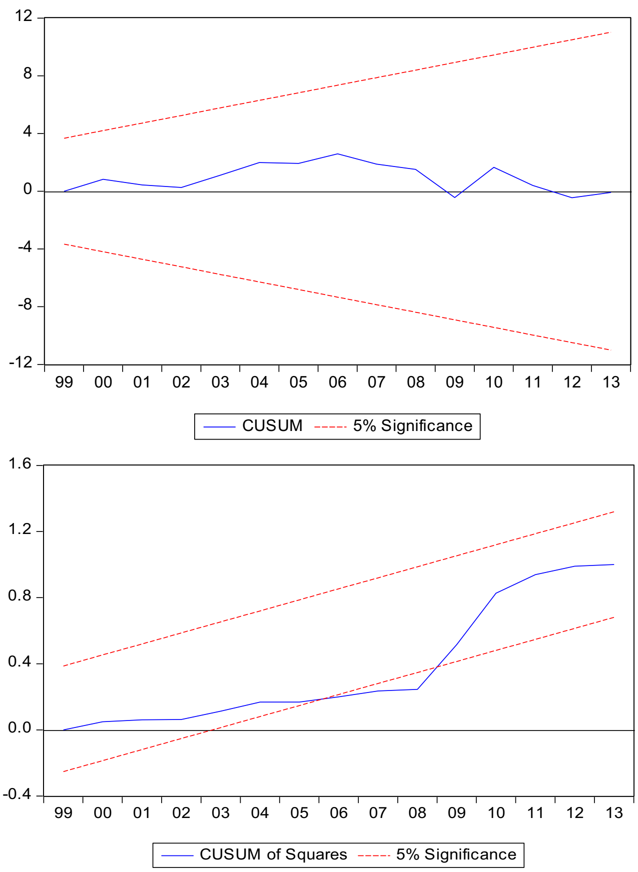

Fig. 5 Model III (where CO_2 (growth rate of emissions) is the response variable)

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