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Investigating the pollution haven hypothesis in oil and non-oil sub-Saharan Africa countries: Evidence from quantile regression technique

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ABSTRACT

The deepening of global trade flows and world interconnectedness has its implications on several macroeconomic indices that stretches, to say the least environmental consequences. To this end, this study explores the dynamic interaction between energy consumption (renewable and non-renewable), foreign direct investment, carbon dioxide emission, real income and urbanization for both oil and non-oil countries for annual period from 1990 to 2016 in a carbon-income framework. To examine the nature of relationship between the outlined variables, we rely on a balanced panel econometrics analysis alongside panel quantile regression. Empirical analysis affirms the pollution haven hypothesis for both oil and non-oil countries under consideration. This suggests that foreign direct investment inflow has a detrimental effect on the host country. This is instructive to stakeholders and government officials. Further empirical results show that conventional energy from (fossil-fuel), urban population dampens environmental quality in the examined regions. However, renewable energy shows strong strength to improve environmental quality. This implies that renewables energy serves as a panacea to environmental sustainability target in both oil and non-oil dependent countries. Finally, these outcomes suggest the need to pursue low-carbon strategies for a cleaner and friendly environment.

1. Introduction

Air quality and carbon emission issues have gained much attention and has been discussed in depth by decision-makers currently. GHS pollution like CO_2, SO_2 and NO_2 emissions have intensify environmental degradation. However, according to empirical data and particular regular academic search reveals there is a broad analysis of literature that agree to the fact that CO_2 emissions contribute more pollutants than the other GHS pollution (Salehnia et al., 2020). After industrialization, the energy usage has increased with fiscal, commercial and cultural changes, contributing to a stable rise in CO_2 pollution. To evaluate this difficult circumstance, experts refer to carbon pollution and intensity outcomes. For instance, before the pre-industrial revolution, CO_2 emissions was 278 ppm (parts per million), it then recorded 316 ppm in 1959, 365 ppm in 1998, and 396 ppm in 2013 (Bilgili et al. . 2016). Economic experts and ecological advisors have over the past couple of years established a cost-benefit calculation that focuses on increased energy consumption and enhances economic resilience, especially in affluent underdeveloped countries. Economic prosperity gains greater precedence than environmental quality (Stern, 2004).

Globalization intensified in the 1990s, enabling international exchange and unregulated transfers of funds to extend FDI's in developing countries (Hao and Liu, 2015). There are different viewpoints for FDI on environmental quality and emissions, particularly for emerging economies. Consequently, the increase in the supply of foreign direct investment influence on the amounts of pollution being favorable or unfavorable cannot adequately be debated. Nevertheless, along with worries about anthropogenic global warming, rapidly increased literature, especially from ecological economists, proves that FDI may have adverse environmental impacts on host economies. The famous PHH indicates that MNC engaging in rigorous emissions operations incline to create or move firms to poor environmental legislation in emerging nations. Thus, higher FDI levels may contribute to even increase emissions in these areas. Several empirical investigation confirmed the relevance of the pollution haven theory for several emerging (Solarin et al., 2017; Salahuddin et al., 2018; Gorus and Aslan, 2019; Sarkodie and Strezov, 2019 among others) and concluded that greater stages of

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List of nomenclature/abbreviations

PPH	Pollution Haven Hypothesis
FDI	Foreign direct investment
AU	African Union
STIRPAT	Stochastic impact by regression on population, affluence and technology
GHS	Globally Harmonized System of Classification and Labelling of Chemicals
MNC	Multinational companies
CO_2	Carbon dioxide
SO_2	Sulfur Dioxide
NO	Nitrogen Oxide
FDI	Foreign direct investment
WDI	World Development Indicators
BRIC	Brazil, Russia, India, and China
ARDL	Autoregressive-Distributed Lag
NARDL	Non-autoregressive distributed lag method
ANS	Altered national Savings
FMOLS	Fully Modified ordinary least square
GCC	Gulf Cooperation Council
ASEAN-5	South-East Asian Nations Association
MENA	Middle and North Africa countries
SAARC	South Asian Association for Regional Cooperation
QR	Quantile regression
OLS	Ordinary Least squares
SSA	Sub-Sahara Africa

emissions were correlated with higher FDI inflows. In comparison, some researchers found that FDI played a significant part in host states' climate by encouraging the utilization of energy-proficient technology as well as sustainable ecological sustainability activities (Zhang and Zhou, 2016; Abdouli and Hammami, 2017; Waqih et al., 2019; Balsalobre-Lorente et al., 2019). Therefore, observed literature does not establish convincing accord on the impact of FDI on CO_2 pollution, which reinforces the necessity for additional exposure to this debate.

African nations, such as Angola and Nigeria, are the main oil-producing economies with a daily production of 1.7 million and 1.5 million barrels from 2016 and continue to rise monthly. Thus, Nigeria produces 300 oil spills annually to damage the climate (U.S. Energy Information Administration, 2013). The African continent alone has deaths over 770,000 annually due to air pollution including Carbon pollution and this also has a detrimental impact on people's health. Pollution of biomass gasification greenhouse gases, food yield lefts, land gas, litter, and alcoholic fuels result in more than 40,000 deaths (Bauer et al., 2019). Amegah and Agyei-Mensah (2017) stated that, airborne pollution has triggered some degree of disability and decrease in overall years to more than 600,000 citizens in the sub-Saharan region. Industrial economies are in danger of generating more carbon dioxide, since figures show that industrial practices contribute more than 30 percent to global use of energy and generate 20 percent of global carbon Dioxide emissions that affect human health (Acar and Tekce, 2014; Sarpong and Bein, 2020; Sarpong et al., 2020). The African continent is also at risk of poor ecosystem quality as it continues to industrialize its economies.

Given the above highlights, this study is motivated to explore the Sub-Saharan Africa Pollution Haven Hypothesis (PHH) because of the aforementioned purposes. First, Sub-Saharan Africa have seen changes in both FDI inflow and CO_2 emission. According to the World Bank's World Development Indicators (WDI 2017), FDI inflows to Sub-Saharan Africa have increased, consistent with Assamoi et al. (2020) findings which states that FDI inflow from a member state, Cote d'Ivoire, has risen by almost five-fold from US$ 95 million to close to US$ 440 million in1980–2014, whereas gross carbon pollution since energy have increased from 4.01 million metric tons to 10.01 metric tons within the similar era as per report from Energy Information Administration, 2013). The dramatically increasing FDI rate growing result from countries' strategies and attempts to encourage FDI. These initiatives incorporated in a number of restructuring initiatives, tax cuts, and implementation of an Investment Promotion Act and the newly founded Investment Promotion Center. Next, as demonstrated by the ratification of the 2018 AU Global Agreement for the Atmosphere and the 2003 Amended African Convention on the Protection of Biodiversity and Natural Resources, sub-Saharan African authorities displayed determination and ability to minimize carbon dioxide emissions and conserve the atmosphere (Sarpong and Bein, 2020). Furthermore, empirical evidence on PHH for sub-Saharan Africa is scarce. The few studies exploring the FDI-CO_2 nexus in sub-Saharan Africa is multi-country base (Keho, 2015; Acheampong et al., 2019).

The available literature in Sub-Saharan Africa contest, which examined the pollution heaven hypothesis, pays much attention to the overall region as a bloc that encourages this study to offer policymakers recommendations. This present study aims at filling this void of scanty documentation to the pollution haven hypothesis for SSA and adding to the extant literature by not concentrating on Sub-Saharan African countries as a unit, and subsequently, disaggregating SSA into oil-producing countries from non-oil-producing countries to have a better view of pollution haven hypothesis (PHH). Therefore, this current study distinct from previous like the study of (Keho,2015,; Acheampong et al. 0.2019) in the sense they examine the dynamics of FDI on CO_2 emissions in the region's oil-producing and non-oil-producing countries and gave policymakers different recommendations depending on the outcomes. Furthermore, Our study employs a novel econometrics techniques in the framework of cross-sectional dependency test to identify either to go for the first generation or second-generation estimation approach which allow our study to utilize a more robust technique for this investigation. We utilize the Pesaran (2015) LM test, Pesaran (2007) CD and Breusch and Pagan (1979) LM test to evaluate for cross-sectional dependence as well as Pesaran (2007) and Im et al. (2003) panel root unit test to examine the integration features of variables. Subsequrntly, we utilize Westerlund (2007) test to analyze the long-run equilibrium relationship among highlighted variables. To evaluate the long-run coefficients of the variables, the ordinal least square (OLS) and the Quantile Regression (QR) tests are also applied. More attention was placed on the results from the Quantile Regression (QR) estimation technique for checking the long-term relationship between FDI, economic growth, renewable energy, non-renewable energy, and CO_2 emission for the period of 1990–2016. In summary, our study distinct interms of scope by considering SSA which have received less documentation disaggregated into oil and non-oil blocs which forms the divide in the region. Subsequrntly, we advance the literature by the used of recent and battery of econometrics techniques that are superior to traditional first-generational methods the presents more robust outcomes for crafting more policy direction.

The rest of this study is organized as: literature overview in section 2, and then the analysis of the econometric methods and description is outlined in the third section. The fourth section focuses on results and discussion. final section presents the conclusion and recommendations for policy and implementation.

2. Literature review

Several empirical findings exist on the nexus between FDI and CO_2 emission based on the hypothesis of pollution haven. Multinational companies engaged in rigorous-pollution fields prefer to create or move their operations in developing countries with less strict ecological laws base on the concept of PHH. The PHH indicates FDI influxes lead toward emissions in emerging nations. The pollution Halo theory, on the other hand, suggests that FDI may result in decreasing CO_2 pollution promoting energy-efficient technology usage improved sustainability techniques (Grossman & Krueger 1991; Keho, 2016). Discussing Grossman and Krueger (1991), foreign direct investment could influence the ecosystem of the home states through economic size (scale effect), production technology improvements (technical effect) and manufacturing design changes (structure impact). The scale impact indicates that increased amounts of FDI streamflow gain further output and energy production and usage, leading to increased emission of carbon (Cole and Elliott, 2003). This technological impact would improve the protection of the ecosystem by utilizing advanced and renewable technologies through FDI (Liang, 2008). The compositional influence reveals how FDI might have direct or indirect ecosystem effect on the basis on why FDI would contribute towards socioeconomic structural improvements in the more or less harmful sectors of the environment (Pazienza, 2019). The experimental literature upon haven hypothesis of pollution also contributed either to special or multi-national findings. Most experiments support PHH, while some rejected PHH credibility. Moreover, when studying the relation around FDI and CO_2 pollution, most analyses involved economic growth as well as energy usage in the study.

In this section, we concentrate on single-country studies that lend support to the PHH credibility. Solarin et al. (2017), for example, establish a favorable association among Foreign Direct Investment as well as CO_2 pollution's in Ghana, implying changes in Foreign Direct Investment contribute towards increased CO_2 emissions. Their research employed the ARDL method with systemic breaks on data from 1980 to 2012. They disclosed that Ghana attracted intense emissions enterprises through FDI due to lower environmental legislation. They mentioned upgrading environmental protections. Likewise, in 1980–2013, Salahuddin et al. (2018) utilized ARDL technique towards examine the interaction regarding Foreign Direct Investment as well as CO_2 pollution in Kuwait. The findings showed that by rising carbon dioxide, more FDI inflows damage the atmosphere. They stressed the significance of taking account on the necessity of Foreign Direct Investment reducing CO_2 pollution for this oil-rich region, as a decrease in the prices of oil arising from the continued decline of the supplies of oil could support further FDI inflows by reducing production costs. Rahman et al. (2019) as well examined and validated PHH's validity in Pakistan utilizing Data from 1975 to 2016 for the non-autoregressive distributed lag method (NARDL). They observed that high foreign direct investment capital flows lead to increased carbon outputs through rising CO_2 emissions. They proposed the Pakistani government focused on sustainable FDI to decrease carbon pollution. Similar findings were also reported in Rana and Sharma (2019) research which investigated then authenticated India's emissions harbor hypothesis by using the Toda Yamamoto technique on data from 1982 to 2013. They considered FDI a significant source of emission in India.

Apart from previous research, certain single-country experiments questioned PHH credibility. Tang and Tan (2015), for instance, observed an undesirable association regarding Foreign Direct Investment alongside CO_2 pollution happening in Vietnam utilizing integration as well as causality approaches over the duration of 1976–2009. This results in FDI improvements leading to lower CO_2 emission. They promoted neo-liberalism opinion that flows from Foreign direct investment improve environmental sustainability by moving energy-efficient technology and strategies from advanced nations to emerging nations such as Vietnam. Likewise, Agboola and Bekun (2019) reported an adverse association regarding foreign direct investment plus CO_2 pollution happening Nigeria by adapting ARDL technique information between 1981 and 2014. Its outcome indicates that FDI rises boost energy sustainability by dealing with climate change in this agricultural nation. A potential reason is that Nigeria's investment opportunities are healthier to environmentally sustainable. This finding indicated attracting additional foreign direct investment towards reducing carbon pollution. In a recent article, Salahuddin and Gow (2019) analyzed effect of foreign direct investment in Qatar around 1980 and 2016 on 3 ecological efficiency metrics, CO_2 emissions, energy consumption, and altered national Savings (ANS). The ARDL perspective's long-run findings suggested a detrimental impact of foreign direct investment upon this three ecological efficiency metrics, however the effect of energy intensity alone was relevant. These results in increased FDI boost ecological efficiency by increasing energy intensity.

Furthermore, other studies includes multi-national analyzes that validates the PHH. Pao and Tsai (2011), for example, confirm the PHH for BRIC by analyzing co-integration as well as causal association involving FDI, monetary development, energy utilization, and CO_2 pollution over the duration 1980–2007. They observed a high FDI contribute to higher CO_2 emissions. They also established two - way causality involving FDI and CO_2 emissions. This finding means FDI and pollution are influenced and evaluated concurrently. To prevent ecological disruption, they proposed concentrating for developing countries on the form of FDI encouraging technology development. In a separate research, Shahbaz et al. (2015), using a completely updated ordinary least square (FMOLS) method to document from 1975 to 2012 eras and found that changes in FDI increase CO_2 emissions and worsen ecological efficiency in Low-income and middle-income economies. They reported that higher foreign direct investment are primarily due to poor ecological laws in pollution-intensive industries. In 14 Latin American nations utilizing fixed-and-random-effect techniques for data from 1980 to 2010, Sapkota and Bastola (2017) verified the precision of PHH. Their results revealed that a lot of FDI arrivals support sustainable development, albeit at the cost of the climate. They reported that through FDI, selected Latin American countries are implementing reforms to attract healthy and energy-efficient companies. In 15 developed and emerging Asian countries, Hanif et al. (2019) examined FDI's impact on CO2 emissions. They disclosed that FDI is an essential basis of pollutants in designated Asian nations by using the ARDL approach to data covering the 1990–2013 period, and advised the authorities responsible for introducing firmer ecological principles and improving the regulate of pollutants from external and internal industries. Subsequent multi-country research have verified the validity of PHH (amongst others, Omri et al., 2014; Gorus and Aslan, 2019; Nasir et al., 2019; Sarkodie and Strezov, 2019).

Instead, the emission haven hypothesis is disproved by several multi-country studies. For instance, Al-Mulali and Tang (2013) identified that, further FDI arrivals add to the reduction of pollution in Gulf Cooperation Council (GCC) nations by facilitating the usage of energy-efficient technology using FMOLS estimation technique. In these countries, they have rejected the authority of PHH. Their research spans the years 1980–2009. Likewise, Zhu et al. (2016) confirmed an adverse correlation in the South-East Asian Nations Association (ASEAN-5) between 1981 and 2001 utilizing a panel quantile regression approach for FDI and CO_2 emissions. Their findings showed that in high-emission nations, increased FDIs helps to lessen carbon pollution, reinforcing the theory of the pollution halo. In high-emission states, climate regulations have been found more stringent compared to low-emission systems. To explore the causal association involving FDI, economic progress as well as ecological sustainability in 17 MENA nations, Abdouli and Hammami (2017) used a vector-autoregressive (VAR) model. Their analyses indicated negative causality for global panel CO_2 pollution from FDI inventories. This result indicates that changes in FDI stocks decrease CO_2 emissions, indicating lawmakers in these nations have been environmentally aware when encouraging measures to encourage FDI. Waqih et al. (2019) identified an undesirable correlation in South Asian Association for Regional Cooperation (SAARC) nations regarding foreign direct investment and CO_2 emissions. This result means that FDI rises have lowered carbon pollution. They disclosed that FDI in these nations leads to the implementation of new technology and techniques in the manufacturing sector, enhancing environmental efficiency.

From the highlighted literature survey, it is apparent that most studies on the theme are modelled on the carbon-income function in view of the PHH in SSA in traditional static and linear models. If this assumption of static modelling fails, it then means that policy drafted from such funding are spurious and misleading due to model misspecification. Therefore, this study deviates from previous documented studies by augmenting the conventional carbon-income function with FDI inflow and by incorporating other macro-economic indicators like urbanization, real income and disaggregating energy into renewable and non-renewable energy consumption for SSA countries for oil and non-oil divide. Additionally, this study provided dual analysis into the theme on PHH by use of second-generation panel estimators which are superior and presents robust findings relative to panel first generational modelling. This study is supported by Quantile regression that shows different characterization across tails of data for soundness of study analysis. We hopeful that this study findings will serve as policy document for government officials in SSA blocs and energy experts to formulate appropriate energy and environmental strategies that will foster clean trade, energy and environmental sustainability in line with United Nations Sustainable Development Goals.

3. Data and methodology

3.1. Methodology

To identify the right analytical technique(s) to employ, the authors used the cross-sectional dependency (CD) test. The outcome from the CD test helps in either going for the first-generation or second-generation panel data econometric technique to apply. The analysis will be bias, meaningless and inconsistent if CD test is not carried out (Dong et al., 2018; Nathaniel et al., 2020a, 2020b). To make sure the mention problems does not occur, this study employs three CD test which are the Pesaran (2007) CD test and the Pesaran (2015) scaled LM test for the sake of robustness check. More attention was place on the Pesaran (2015) scaled LM test because of how our dataset is shows i.e., the time frame (T) figure is larger than that of the cross-sections (N) number. The CD test equation is shown in Eq. (1) as:

$$\sqrt{\left(\frac{2T}{N(N-1)}\right)}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\widehat{p}_{ij}\right) \tag{1}$$

Whereas from equation (1), $\widehat{p}_{ij}$ is the pairwise cross-sectional correlation coefficient of the residual from the ADF regression. T and N are the sample and panel scope separately for the cross-sectional as well as time period.

3.2. Panel stationarity technique

The proof of CD make in the estimation brings out inefficiency in the first-generation stationarity technique (e.g., Im et al., 2003). Therefore, the authors employed a second-generation stationarity technique (CIPS) to solve the problem of inefficiency in the estimation. Pesaran (2007), uses the following Cross-sectional augmented Dickey-Fuller (CADF) regression is expressed as follows:

$$\Delta Y_{it} = \phi_i + \rho_i^{*} Y_{i,t-1} + d_0\overline{Y}_{t-1} + \sum_{j=0}^{p} d_{ij}\Delta\overline{Y}_{t-j} + \sum_{j=1}^{p} c_{ij}\Delta Y_{i,\,t-j} + \varepsilon_{it} \tag{2}$$

where Δ shows first differences, Y is analyzed variable, $\overline{Y}_t$ is the average at time t of all N observations, ε_{it} present the error term. After running this CADF regression for each unit i in the panel, the CIPS statistics can be calculated by the following equation:

$$CIPS = \frac{1}{N}\sum_{i=1}^{N} CADF_i \tag{3}$$

A second-generation cointegration test is performed in the proximity of first differences stationary variables, to assess the long run effects of the factors under consideration.

3.3. Panel cointegration estimation

The findings related to the Westerlund (2007) experiment to obtain proof of co-integration between the parameters. The error rectification method (ECM) of the estimation is shown as:

$$\Delta Y_{it} = \delta_i^{'} d_t + \varphi_i Y_{it-1} + \lambda_i^{'} X_{it-1} + \sum_{j=1}^{pi}\varphi_{ij}\Delta Y_{it-j} + \sum_{j=0}^{pi}\gamma_{ij}\Delta X_{it-j} + \varepsilon_{it} \tag{4}$$

Thus, $\delta_t = (\delta_{i1}, \delta_{i2})$, dt = (1, t)′, and φ are the vector of parameters, deterministic mechanisms, as well as the error correction parameter correspondingly. To identify cointegration existence, four test was carried out. These four test was built on the OLS technique of φi in Eq. (3). Group mean statistics was made up of two out of the four estimations and shown as;

$$G_\tau = \frac{1}{N}\sum_{i=1}^{N}\frac{\hat{\propto}_i}{SE\left(\hat{\propto}_i\right)} \tag{5}$$

$$G_{\propto} = \frac{1}{N}\sum_{i=1}^{N}\frac{T\hat{\propto}_i}{\hat{\propto}_i(1)} \tag{6}$$

Thus, $\hat{\propto}_i$ is denoted by $SE(\hat{\propto}_i)$ as the standard error. The semi-parametric kernel technique of $\propto_i(1)$ is $\hat{\propto}_i(1)$. Two of the four remaining panel mean estimations proof that the entire panel is co-integrated is shown as;

$$P_\tau = \frac{\hat{\propto}}{SE(\hat{\propto})} \tag{7}$$

$$P_{\propto} = T\hat{\propto} \tag{8}$$

3.4. Ordinary least square (OLS) and quantile regression (QR)

The analysis used to rationalize the relationship between the outlined avroables are the techniques of OLS and QR. The existence of cointegration assesses a long-term connection utilizing the OLS econometrically rational. They use the OLS with standard errors made by Driscoll and Kraay (1998). This method allows (1) heteroscedasticity, (2) serial interaction and (3) cross-sectional dependency to be considered. Nevertheless, the QR was the chosen as econometrics technique based on its superior to the OLS for different reasons. Because, unlike ordinary regression analysis, quantile regression uses the calculation of sequence variables that point to the least absolute deviation (LAD) to minimize the sum of the actual numbers of balanced sequences (Koenker and Bassett, 1978; Powell, 1984). However, compared with OLS, the LAD method has some advantages, including tolerance and exposure to external data. This is because only marginal instructions are used in this process. The projection is usually more stable than the average, and in the case of heterogeneity, the quantile regression is more accurate than the ordinal least squares regression. However, the standard circulation as well as the zero mean approval of the OLS error concept is rather unrealistic, since there may be multiple distribution models for socio-economic measures (De Silva et al., 2016). The QR reinforces this deficit (Salman et al., 2019; Nathaniel and Khan, 2020). The methodology (QR) does not presume the function of the period (Zhu et al. 2016a, 2016b, 2016b). In the case of outliers (Bera et al., 2016), forecasts remain robust. No predictions for distribution (Sherwood and Wang et al., 2016) have been made. The technique for QR is shown as;

$$Quant_{\theta}(yi\,/\,xi) = x\beta_{\theta} + \mu_{\theta}, \tag{9}$$

Where x is the exogenous factors, while y is the endogenous factors. The equilibrium place and disruption word of the explicit vector are θth, and μ simultaneously. We use the contingent quantile regression that explores the effect of the regressors to be used in our econometric analysis on the foundation of the preliminary factors values. In the past, the QR-technology was utilized in Hübler (2017), Xu and Lin (2018), and Nathaniel and Khan (2020) and other studies.

3.5. Model

The STIRPAT structure is the foundation of this analysis. The STIRPAT hypothesis notes that the destruction of the ecosystem is both economic and social.

$$I_t = \vartheta_o P_t^{\xi 1} A_t^{\xi 2} T_t^{\xi 3} \mu_t \tag{10}$$

From Eq. 10, I is a pointer of ecological deprivation, P, A, and T represents inhabitants, wealth, and innovation correspondingly. ϕ1 - ϕ3 as well as μ are the factor evaluators and the error term correspondingly. T may be broken down based on the purpose of the study (Bello et al., 2018; Anser, 2019; Nathaniel and Khan, 2020). Base on the analysis of Solarin and Al-Mulali studies (2018) and Nathaniel and Khan (2020), I, in this analysis is identified as environmental factors as stated earlier. From a different perspective, P and A are denoted by economic sustainability and Foreign Direct Investment respectively. The authors then adopted Gross Domestic Product (GDP), renewable energy (REC), non-renewable energy (NREC) and urbanization (UB) as a proxy T. The extended layout is shown as:

$$I_{2t} = \vartheta_o FDI_t^{\xi 1} GDP_t^{\xi 2} REC_t^{\xi 3} NREC_t^{\xi 4} UB_t^{\xi 5} \mu_t \tag{11}$$

By taking the logarithm of each of the variables, the formula is further formulated as;

$$\ln I_t = \vartheta_o + \xi_1 FDI_t + \xi_2 LnGDP_t + \xi_3 LnREC_t + \xi_4 LnNREC_t + \xi_5 LnUB_t + \mu_t \tag{12}$$

Where FDI, GDP, REC, NREC and UB denote foreign direct investment, economic growth, renewable energy consumption, non-renewable energy consumption and urbanization. I, on the other hand represent the environmental indicator used in this analysis, thus, CO_2 emission. To analysis the impact of FDI, GDP, REC, NREC and UB on I at the selected quantile level, the authors formulated Eq. (12) which is shown as;

$$Q_{\tau}(\mathrm{LnCO2})_t \;=\; \vartheta_{\tau} + \xi_{1\tau}\mathrm{FDI}_{it} + \xi_{2\tau}\mathrm{LnGDP}_{it} + \xi_{3\tau}\mathrm{LnREC}_{it} + \xi_{4\tau}\mathrm{LnNREC}_{it} + \xi_5\mathrm{LnUB}_t + \mu_t \tag{13}$$

Whereas the remaining variables maintain their original description, CO_2 represent CO_2 emission. Moreoer, for the sake of different groups with emphasis on oil and non-oil countries, Eq. (13) is expanded to accommodate dummy variable and interactive variable in Eq (14). With dummy represents 1 and 0, where 1 is equal to oil country and 0 is equal to non-oil country. Because of the interest of this study as it concerns foreign direct investment, Dummy and FDI were grouped as interactive variable for clear insight on the influence of FDI on the regions. Environment. Hence, Eq. (14) is stated as:

$$Q_{\tau}(\mathrm{LnCO2})_t = \vartheta_{\tau} + \xi_{1\tau}\mathrm{FDI}_{it} + \xi_{2\tau}\mathrm{LnGDP}_{it} + \xi_{3\tau}\mathrm{LnREC}_{it} + \xi_{4\tau}\mathrm{LnNREC}_{it} + \xi_{5t}\mathrm{LnUB}_t + \mu_t + \xi_{6\tau}\mathrm{Dum} + \xi_{7\tau}\mathrm{Dum} * \mathrm{FDI}_t \tag{14}$$

For the explicative variables, the reference point is **τ**. Q**τ** corresponds to the **τ**th distributional point regression analysis that can be determined using the formulae in Eq. (11)

$$Q_{\tau} = \underset{Q_{\tau}}{argmin} \sum_{k=1}^{q} \sum_{t=1}^{T} \sum_{i=1}^{N} \left(\left| y_{it-}\alpha_{i-}x_{it}^{'} Q_{\tau} \right| \omega_{it} \right) \tag{15}$$

Where q, T, N and ω_{it} and stand for the number of quantiles, years, cross-sections, and weight of the ith country in the ith year respectively. The Sub-Sahara Africa countries were for this analysis and were divided in to two folds, ie. 15 oil production and 28 non-oil countries summing up to a total of 43 (list of countries in appendix) from the period of 1990–2016. The period of time for this analysis was based on availability of data. The time period was sorely based on data availability. All data utilized in this analysis were obtained from World Development Indicators (WDI, 2020) (see. Appendix Table 1). All variables expect FDI were transform to logarithm in this analysis.

4. Empirical results and discussion

4.1. This section concentrates on a stylized analysis of the empirical result

From Table 1 which is a summary of statistics, the highest mean from the non-oil countries was renewable energy with 4.2812 and the lowest mean was CO_2 with −1.7257 indicating a mean of emission per year. Again, the highest maximum was obtain again from renewable energy which indicate that, the non-oil sub-Sahara African economics clean energy maximise by 4.5823 metric tons per year. Nevertheless, from the median perspective, the highest is again renewable energy which indicate growth of 4.4045 and the lowest was CO_2 with −1.7369 realize per year. From the oil countries analysis, it was observed that, the highest mean was Urbanization with 15.667% of growth wiles the lowest mean was CO_2 with −0.1553 metric tons realize per year. The highest maximum was again obtain from Urbanization, indicating that the oil sub-Sahara African urban grow on the maximum of 18.321% per year whiles the lowest maximum was CO_2 with realize of 2.4162 metric tons per year. The median indicated that, the highest was again Urbanization with 15.816% growth per year whiles the lowest was again CO_2 with −0.3198 realizes per year. From the combine countries, it was observed that, Urbanization was the highest mean of 7.5079% growth per year whiles CO_2 obtain the lowest mean of −1.1903 emission per year. The highest maximum was again Urbanization with 18.321% growth per year whiles the lowest was again CO_2 with 2.4162 metric tons emission per year. But the highest median change to cleaner energy with 4.3634 increase in cleaner power accessibility which the lowest median was again CO_2 with −1.4179 metric tons per year. Nevertheless, it was observed that, the parameters are distributed in a skewed manner, and kurtosis values indicate that the distributions of five variables are further clustered, unlike confidence interval. The analyses of Jarque-Bera also deny the zero normality assumptions.

Outcome from Table 2 shows that, CO_2 was positively correlated with FDI, GDP, non-renewable energy and Urbanization but negatively correlated with renewable energy for the non-oil countries. However for

Table 1
Descriptive statistics.

NON-OIL COUNTRIES						
	$LnCO_2$	FDI	LnGDP	LnNREC	LnREC	LnUB
Mean	−1.7257	0.1128	6.4913	1.0165	4.2812	3.28729
Median	−1.7369	0.4957	6.4180	0.0000	4.4045	3.3961
Maximum	0.4575	4.6379	8.1696	4.0103	4.5823	4.1710
Minimum	−3.8674	−13.183	0.0000	0.0000	0.0000	1.6893
Std. Dev.	0.9144	1.9893	0.6679	1.3907	0.3669	0.4783
Skewness	0.3222	−2.2817	−2.1278	0.8300	−4.8498	−0.6584
Kurtosis	2.3873a	13.656a	24.537a	2.0201a	49.571a	2.8821a
OIL COUNTRIES						
Mean	−0.1553	0.7224	7.7872	3.2440	3.2444	15.667
Median	−0.3198	0.7331	7.7206	3.4687	4.1701	15.816
Maximum	2.4162	5.0865	9.9297	4.6049	4.5880	18.321
Minimum	−4.7725	−13.121	6.1361	0.0000	−2.8309	11.888
Std. Dev.	1.3697	1.8733	0.8577	1.4262	1.6486	1.2894
Skewness	−0.0736	−3.2383	0.4961	−1.3223	−1.4882	−0.5869
Kurtosis	2.3945b	24.388a	2.6416a	3.8206a	4.4491a	3.1476a
COMBINATION OF OIL AND NON-OIL COUNTRIES						
Mean	−1.1903	0.3346	6.9331	1.7759	3.9278	7.5079
Median	−1.4179	0.6778	6.8012	1.8821	4.3634	3.6523
Maximum	2.4162	5.0865	9.9297	4.6049	4.5880	18.321
Minimum	−4.7725	−13.183	0.0000	0.0000	−2.8309	1.6893
Std. Dev.	1.3206	1.9748	0.9602	1.7556	1.1205	5.9318
Skewness	0.6397	−2.5185	0.1092	0.2039	−3.0626	0.7058
Kurtosis	2.9099a	16.047a	7.5915a	1.4097a	12.994a	1.5796a

NOTE: a, b, c represents 1%, 5% and 10% significant levels.

Table 2
Correlation matrix.

NON-OIL COUNTRIES						
	$LnCO_2$	FDI	LnGDP	LnNREC	LnREC	LnUB
$LnCO_2$	1.0000					
LnFDI	0.1390a	1.0000				
LnGDP	0.6477a	0.1456a	1.0000			
LnNREC	0.2841a	−0.0131	0.1226a	1.0000		
LnREC	−0.6057a	−0.0839b	−0.2385a	0.0499	1.0000	
LnUB	0.4598a	0.3203a	0.3939a	0.1345a	−0.3210a	1.0000
OIL COUNTRIES						
$LnCO_2$	1.0000					
LnFDI	0.0442	1.0000				
LnGDP	0.8924a	0.1239b	1.0000			
LnNREC	0.4783a	−0.1553a	0.2450a	1.0000		
LnREC	−0.6918a	0.1513a	−0.4968a	−0.4574a	1.0000	
LnUB	0.0100	−0.2390a	−0.2514a	0.6114a	−0.2249a	1.0000
COMBINATION OF OIL AND NON-OIL COUNTRIES						
$LnCO_2$	1.0000					
LnFDI	0.1647a	1.0000				
LnGDP	0.8478a	0.2064a	1.0000			
LnNREC	0.5791a	0.0410	0.4900a	1.0000		
LnREC	−0.6972a	−0.0077	−0.5388a	−0.4415a	1.0000	
LnUB	0.5758a	0.1528a	0.6313a	0.6379a	−0.4643a	1.0000

NOTE: a, b, c represents 1%, 5% and 10% significant levels.

Table 3
Cross-sectional dependency test results for combine countries.

	Pesaran (2007) CD Test	Pesaran (2015) LM Test	Breusch-Pagan LM
$LnCO_2$=f (FDI, LnGDP, LnREC, LnNREC, LnUB)	2.925a	−2.158b	6303.75a

NOTE: a, b, c represents 1%, 5% and 10% significant levels.

the oil countries, CO_2 was positive correlated with GDP and non-renewable energy and negatively correlated with renewable energy. Evidence from the combine countries proofs that, CO_2 was positively correlated with FDI, GDP, non-renewable and Urbanization but negatively correlated with renewable energy. After the proof of correction among the variable with the non-oil, oil and combination of countries with in the Sub-Sarah Africa countries, we proceed to access the presence of cross-section dependency which will help the authors to either

Table 4
Panel IPS and CIPS unit root test.

NON-OIL COUNTRIES								
Variables	IPS (Im et al., 2003)				CIPS (Pesaran, 2007)			
	Intercept		Intercept & trend		Intercept		Intercept & trend	
	Levels	1st Diff	Levels	1st Diff	Levels	1st Diff	Levels	1st Diff
$LnCO_2$	−0.8278	−5.0009a	−1.9736	−5.1071a	−1.559	−5.054a	−2.598	−5.029a
FDI	−3.0318c	−7.0897a	−3.8116b	−7.0793a	−3.624a	−5.482a	−3.678a	−5.904a
LnGDP	−0.8811	−4.7004a	−2.3232a	−4.9828a	−1.686	−4.479a	−2.344	−4.711a
LnREC	−1.1977	−4.9257a	−2.4811	−4.8849a	−1.384	−4.593a	−2.403	−5.102a
LnNREC	−1.690	−3.4373a	−1.730	−5.5702a	−0.652	−3.106a	−0.003	−2.668b
LnUB	−1.1089	−2.3391c	−2.6562	−4.4946a	−1.868	−3.968a	−1.535	−3.278a
OIL COUNTRIES								
$LnCO_2$	−1.8559	−6.5903a	−2.7802	−6.6145a	−2.747	−5.650a	−2.870	−5.835a
FDI	−3.1065a	−6.9291a	−3.6644a	−6.9105a	−3.378a	−5.443a	−3.580a	−5.521a
LnGDP	−0.5901	−4.1620a	−2.0336c	−4.3376a	−2.508	−3.591a	−2.234	−3.886a
LnREC	−0.9674	−5.1113a	−0.5798	−5.1895a	−2.492a	−4.923a	−2.737b	−4.799a
LnNREC	−1.820	−3.5123a	−1.900	−3.4931a	−1.544	−4.309a	−2.238	−4.655a
LnUB	−4.9888a	−2.4248a	−0.6076	−3.9434a	−2.067	−2.104c	−0.989	−2.565b
COMBINATION OF OIL AND NON-OIL COUNTRIES								
$LnCO_2$	−1.1783	−5.5427a	−2.2486	−5.6210a	−1.978	−5.082a	−2.695	−5.259a
FDI	−3.0816a	−7.0562a	−3.7605a	−7.0482a	−3.618a	−5.582a	−3.749a	−5.815a
LnGDP	−2.2245	−4.7629a	−0.7819	−4.5169a	−2.047	−4.100a	−2.190	−4.258a
LnREC	−1.1192	−4.9890a	−2.5148	−4.9887a	−2.064c	−4.765a	−2.566	−4.697a
LnNREC	−1.690	−3.4629a	−1.730	−2.2565b	−0.185	−1.679c	−0.755	−2.120b
LnUB	−3.7498b	−2.3683a	−3.0950	−3.5497a	−2.284	−2.238a	−1.638	−2.393b

NOTE: a, b, c represents 1%, 5% and 10% significant levels.

Table 5
Westerlund cointegration test.

NON-OIL COUNTRIES				
	Group Statistics		Panel Statistics	
Dependent/models	Gτ	Gα	Pτ	Pα
$LnCO_2$=f (FDI, LnGDP, LnREC, LnNREC, LnUB)	−2.067c	−2.020c	−6.109a	−1.797b
OIL COUNTRIES				
$LnCO_2$=f (FDI, LnGDP, LnREC, LnNREC, LnUB)	−2.332a	−1.336b	−3.144a	−0.449b
COMBINATION OF OIL AND NON-OIL COUNTRIES				
$LnCO_2$=f (FDI, LnGDP, LnREC, LnNREC, LnUB)	−2.186a	−2.077a	−7.471a	−1.171b

NOTE: a, b, c represents 1%, 5% and 10% significant levels.

utilize the first generation or second generation estimational techniques and to avoid spurious inferences.

The study proceeds to identify if there is cross-section evidence among the variable. The Pesaran (2007) CD test, Pesaran (2015) LM test and the Breusch and Pagan (1979) LM test were employed. Table 3 indicates the CD in the frameworks. This proof allows the analysis to continue with rigorous estimating techniques for CD to avoid spurious inferences.

The stationarity results are shown in Table 4. The findings reported by Im et al., (2003) indicated that all factors were stationary at first difference. Identical outcome was found in the second generation CIPS unit root test which is vigorous to sequential association as well as CD test.

Table 5 displays the co-integration procedure for Westerlund (2007). The outcome proves that the variables of the two models are cointegrated. After establishing the presence of co-integration, we advanced with the two regression analysis. Our review will, however, be focused on the QR evaluation with little comparison with OLS.

Table 5 displays the outcome of test of cointegration with

Table 6
Ordinal least square (OLS) and Quantile Regression (QR).

$LnCO_2$=f (FDI, LnGDP, LnREC, LnNREC, LnUB, Dummy, FDI*Dummy)						
	OLS	Q.05	Q.25	Q.50	Q.75	Q.90
FDI	0.0034c	−0.0091a	−0.0016	0.0083a	0.0061a	0.0088b
LnGDP	0.4454a	1.0263a	0.9889a	1.0506a	1.0239a	1.0307a
LnREC	−0.8131a	−0.2294a	−0.2000a	−0.2585a	−0.2793a	−0.2922a
LnNREC	0.1395a	0.1359a	0.2070a	0.1910a	0.1794a	0.2182a
LnUB	0.0940a	0.0504a	0.0493a	0.0187a	0.0281b	0.0160c
Dum	−1.3319a	−0.8423a	−0.9028a	−0.5575a	−0.7517a	−0.8648a
FDI*Dum	−0.0038b	−0.0008	−0.0048	−0.0110a	−0.0107a	−0.0132c
Constant	−0.0038a	−8.4701a	−8.0456a	−7.7933a	−7.2318a	−6.9702a
F-Statistic	785.96a					
R2/Pesudo R2	0.8267	0.5462	0.6195	0.6531	0.6819	0.6488
Adj R-square	0.8257					
Observation	1,161	1,161	1,161	1,161	1,161	1,161

NOTE: a, b, c represents 1%, 5% and 10% significant levels, Dum=Dummy.

Westerlund (2007) approach. The result shows that the variables in all the classifications of the countries (oil countries, non-oil countries and combination of the two groups) are cointegrated. Having established the presence of cointegration, authors proceed with regression analysis. We further run a unified regression for the entire groups in one sample both in our quantile and OLS regressions, and the outcome is shown in Table 6. The explanation of both quantile regression and OLS outputs are as follows: Mixed (positive and negative) relationship is found between foreign direct investment and environment degradation in the Sub-Sahara African countries with varying degrees in their coefficients and level of significant. The result shows negative relationships between FDI and environment degradation at the initial stage (0.05th and 0.25th quantiles). This denotes FDI is impacting the regions environment favourably at the initial stage. The output of OLS and other quantiles (0.50th, 0.75th and 0.90th) show a positive relationship between foreign direct investment and environmental degradation. This suppose to be the dominant finding of FDI considering the fact that both median (0.50th) and OLS depicts the same finding. This negates the facts that oil resources could be a deciding factor for the movement of foreign direct investments. Hence, the same trend is witnessed acrose the region irrespective of where oil rent is domiciled. Most probably, there are other factors that sees to the attraction of FDI such as, access to cheap labor, closeness to market and less rigid policies in curtailing the excesses of the foreign investors. This is a pointer that Sub-Saharan region of African countries are still progressing in their economic activities and growth with neglect to the quality of their environment. This justified the view of some advocates against the positive impact of FDI especially on the sustainability of developing countries. This finding is in supports of pollution haven hypothesis (PHH). This is supports the findings Pao and Tsai (2011); Ren et al., (2014); Shahbaz et al., (2015); Solarin et al., (2017); Salahuddin et al. . 2018; Gorus and Aslan (2019); Sarkodie and Strezov (2019) Udemba (2020b), c for India and Turkey). A positive relationship between economic growth and environmental degradation across the quantiles for the entire Sub-Saharan regions in Africa in different levels of significant and coefficients. The impact is massive from median to 0.90th quantile with higher coefficients than others. This finding supports our assertion that the economic handlers of the selected countries in Sub-Sahara are focusing on achieving their economic goals without much emphasis on the environments. Most developing countries including the selected African countries in our study are after increasing and achieving their economic goals at the expense of their environment quality. This finding is in consonance with the findings of Wang et al. (2018); Al-Mulali (2011). A negative with significant at 1 percent level relationship is established between renewable and environment. It has been found that transition to more conservative (renewable) sources of energy guarantees better of environment irrespective of the location of the economy. This aligns with the findings of Dong et al. (2017): Sebri and Ben-Salha, 2014. However, the outcomes of non-renewable energy consumption and urbanization show positive relationships between environmental degradation and non-renewable energy use and urbanization in the regions. Positive relationship is registered between fossil fuel energy consumption and environment degradation with major impact recorded in 0.25th and 0.90th quantiles. Likewise, urbanization and environment, major impact is recorded in the initial stage (0.05th and 0.25th) in Sub-sahara African countries. This shows that economic growth of Sub-Sahara African countries are energy led growth anchored on fossil fuel energy use which has a high propensity of dilapidating the environment of countries involved. Also, the finding depicts non-regulation of city activities towards maintaining a clean city and environment. This reveals that most countries in African region are still behind the technological innovations that pave ways for clean production and economic performance. This supports the findings of Al-Mulali et al. (2013): Jia et al. (2019): Udemba and Agha (2020). Also, the likelihood of companies in the cities to exploit laxity in environment laws may contribute to the degradation of the regions environment. Moreover, the location dummy (where Dummy =1 for oil region) is found to have a negative and significant intercept-shifting relationship with carbon emission. Since, the dummy is coded 1 for oil countries, the finding could be read as less negative impact of the selected variables on the environment of the oil countries than the non-oil countries in varying degrees according to the coefficients of OLS and quantiles (0.05th →0.9th). The less negative impact of the selected variables on oil countries environment with the negative relationship found between Dummy variable and carbon emission (where dummy =1 for oil countries) is backed with the impact of FDI on environment (FDI*Dum is negatively related to the carbon emission). This exposition has the same trend with the initial negative interaction found between FDI and cabon emission where mixed (positive and negative) results are found. This suggests that FDI may likely be a good policy to mitigate emission in these countries if persistence is kept in implementing and monitoring the activities of foreign investors in the regions.

4.2. The DH granger causality evidence

Granger causality test was applied in our study for a robust check and validation of findings from other analyses such as quantile regression and OLS estimations. The granger causality estimation will help us to drive home our augment on pollution haven hypothesis in the selected countries. The analysis helps in forecasting insight into the subject of the study among the chosen variables. It goes beyond inferring the level and direction of relationship that existed among the variable, and establishes the movement and origin of the effect (i.e. which among the variables is causing other). The output of the granger causality is displayed in Table 7. From the output, we found uni-direction of causal relationship transmitting from FDI to environment for the case of oil countries and the combined category and a bi-directional transmission between FDI and environment for non-oil countries respectively. Also, bi-directional causal transmission is found between economic growth and environment for non-oil countries and the combined category respectively, while uni-directional causal relationship transmitting from environment to economic growth is found for oil countries. An uni-directional causal relationship is recorded transmitting from environment to non-renewable energy consumption for the case of oil countries, and neutral causal relationship is witnessed between non-renewable energy consumption and environment for non-renewable countries and combined categories. Uni-directional causal relationship is found passing from environment to renewable energy consumption for non-oil countries, from renewable energy consumption to environment for oil countries, and from environment to renewable energy consumption for the combined category respectively. Bi-directional causal relationship is found between urbanization and environment for both oil countries and the combined countries respectively, neutral causal relationship is witnessed between urbanization and environment for the case of non-oil countries. In summary, a nexus is established among the variables of

Table 7
The DH Granger causality evidence

	NON-OIL COUNTRIES	OILCOUNTRIES	COMBINATION OF OIL AND NON-OIL COUNTRIES
NULL HYPOTHESIS	W-Stat.	W-Stat.	W-Stat.
FDI ↗ $LnCO_2$	17.814a	2.5777c	15.222a
$LnCO_2$ ↗ FDI	4.1858b	0.7834	1.1635
LnGDP ↗ $LnCO_2$	7.9006a	9.2227a	20.676a
$LnCO_2$ ↗ LnGDP	132.68a	0.6927	128.00a
LnNREC ↗ $LnCO_2$	0.1207	0.1576	0.4761
$LnCO_2$ ↗ LnNREC	0.4369	2.6777c	0.0931
LnREC ↗ $LnCO_2$	1.9555	3.8408b	2.0354
$LnCO_2$ ↗ LnREC	45.270a	1.6622	5.6740a
LnUB ↗ $LnCO_2$	2.1659	2.4606c	7.0696a
$LnCO_2$ ↗ LnUB	1.0724	4.5418b	2.8536c

NOTE: a, b, c represents 1%, 5% and 10% significant levels.

interest in this study, thus, FDI, economic growth, environment, urbanization, renewable and non-renewable energies. The causal interactions of FDI to all the variables proves that foreign direct investment is inducing the environment of the Sub-Sahara countries negatively, hence, bi-directional between FDI and environment, and between economic growth and environment.

5. Conclusion remark and policy suggestion

Sub-Saharan African countries are known for rich natural and human resources capable of attracting prospective investors from across the globe. With the current concern over the increasing climate change which are associated with different factors, divided views have emerged with regards to the impact of foreign direct investment on climate change through direct impact on environment. Some scholars support positive impact of foreign direct investment, while others are averse about the positive impact. These two strong oppositions have paved way for the emergency of two hypothesis supporting negative impact (Pollution haven hypothesis) and positive impact (Pollution halo hypothesis) respectively. Bearing in mind the likelihood of finding negative impact of FDI on the environment of the selected countries, we opined that pollution haven hypothesis is expected to be revealed in the case of the countries.

Scientific approaches such as Pesaran (2015) LM test, Pesaran (2007) CD and Breusch and Pagan (1979) LM test to evaluate for cross-sectional dependence as well as Pesaran (2007) and Im et al. (2003) panel root unit test to evaluate the integration features of variables were utilized. We then utilize Westerlund (2007) test to analyze the long-run equilibrium among variables. To evaluate the long-run coefficients of the variables, the ordinal least square (OLS) and the Quantile Regression (QR) tests are also applied. In all, we found mixed results (with emphasis on Dummy and interactive variable, FDI*DUM) which depicts the pollution have hypothesis and likelihood of pollution halo hypothesis for the regions. Both positive and negative relationships between FDI and environment degradation are found with quantile regression and OLS. Also, a positive relationship is found between economic growth and environment dilapidation, between non-renewable energy use and environment. Interestingly, a negative relationship is deduced between renewable energy use and environmental degradation. A robust check was done with granger causality and the findings as mentioned under empirical discussion section give credence to the findings from quantil regression especially with interative variable, hence, FDI Granger causing environment in one way for oil countries, and feedback transmission between FDI and environment degradation for non-oil countries.

Having confirmed the mixed impacts of FDI and negative impacts economic growth, urbanization, and non-renewable energy consumption on the environmental performance of the selected countries in Sub-Sahara African, the policy suggestion will be for framing of environment regulation policies that will checkmate the excesses of the foreign investors in those countries. Such policies could be introducing carbon emission tax and emission ceiling where a fine option will be given to any firm that defaults with the ceiling policy or such firm will face strict measures such as outright closure or revoking of operational license from government. Setting up an environmental regulatory agency with head office all over the entire countries involved that will see to maintenance of environmental quality is another good policy. From the side of authorities of the selected countries, there is a need to frame a strong long term strategy for sustainable development goal up to 2030. This will give the successive government sense of commitment in assuring good quality of environment.

Conclusively, this study is not limited to only Sub-Saharan African countries for policy modelling, but all other developing countries with similar attributes of the researched countries can benefit from this research.

Availability of data and materials

The data for this present study are sourced from the World Bank Data Index. The current data specific data can be made available upon request but all available and downloadable at the earlier mentioned database and weblink.

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Authors' contributions

The first authors (Dr. Bright Akwasi Gyamfi) was responsible for the conceptual construction of the study's idea. Second author (Dr. Festus Vector Bekun) handled the literature section while third authors (Prof. Edmund Ntom Udemba) managed the data gathering, preliminary analysis and Prof. Dr. Murad A. Bein was responsible for proofreading and manuscript editing.

Ethical approval

Authors mentioned in the manuscript have agreed for authorship read and approved the manuscript, and given consent for submission and subsequent publication of the manuscript.

Consent to participate

Note Applicable.

Consent to publish

Applicable.

CRediT authorship contribution statement

Bright Akwasi Gyamfi: Conceptualization, Formal analysis, Methodology. **Murad A. Bein:** Validation, Visualization, Data curation, Writing – original draft, Investigation. **Edmund Ntom Udemba:** Writing – original draft, Writing, Validation. **Festus Victor Bekun:** Visualization, proofreading and manuscript editing, Supervision, Corresponding.

Declaration of competing interest

I wish to disclose here that there are no potential conflicts of interest at any level of this study.

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Appendix Table 1. Description of variables

VARIABLES	MEASUREMENT	SOURCES	SYMBOLS
CO_2 Emissions	Metric tons per capita	World Development Indicators (WDI, 2020)	CO_2
GDP per Capita	In constant 2010 USD	World Development Indicators (WDI, 2020)	GDP
Foreign Direct Investment	% of real GDP	World Development Indicators (WDI, 2020)	FDI
Renewable Energy Consumption	% of total final energy consumption	World Development Indicators (WDI, 2020)	REC
Non-renewable energy consumption	% of total	World Development Indicators (WDI, 2020)	NREC
Urbanization	Urban population growth	World Development Indicators (WDI, 2020)	UB

Sources: author's compilation, 2020.

List of Countries

OIL COUNTRIES	NON-OIL COUNTRIES
Algeria	Benin
Angola	Burkina Faso
Cameroon	Burundi
Chad	Cabo Verde
Congo, Rep.	Central African Republic
Cote d'Ivoire	Comoros
Egypt	Eritrea
Gabon	Ethiopia
Ghana	Gambia, The
Libya	Guinea
Morocco	Guinea-Bissau
Nigeria	Kenya
Sudan	Lesotho
Tunisia	Madagascar
	Malawi
	Mali
	Mauritania
	Mozambique
	Niger
	Rwanda
	Senegal
	Sierra Leone
	Tanzania
	Togo
	Uganda
	Zambia
	Zimbabwe

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