RESEARCH ARTICLE

Tourism-induced emission in Sub-Saharan Africa: A Panel Study for Oil-Producing and Non-oil-Producing countries

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Abstract
The tourism industry is undoubtedly among the largest contributors to economic growth and employment generation in most economies of the world, and Africa is not an exception as outlined by World Tourism Organization (UNWTO). Thus, many countries in sub-Saharan Africa (SSA) are paying more attention to tourism development as alternative growth path to boost their economies. However, the tourism-induced growth is not void of its environmental issues. To this end, this study using recent econometrics analysis explored the nexus between tourism arrival GDP growth, urbanization, carbon dioxide emission, and foreign direct investment for oil and non-oil sub-Saharan Africa (SSA) countries, that is, to ascertain the real impacts of tourism and FDI on the environmental performance of the regions. Empirical results show that tourism, GDP growth, and FDI dampen the quality of the environment. For instance, a 1% increase in tourism activities worsens the quality of the environment by 1.09%. Interestingly, renewable energy shows statistical strength to improve environmental quality. The causality analysis resonates with the outcomes of the regression by giving credence to one-way causality between tourism and carbon dioxide emission. A similar trend of causality is seen between FDI and carbon dioxide emission and urbanization and carbon dioxide emission. Thus, as a policy prescription, strict environmental guidelines and regulations are necessary for controlling the unhealthy and undue economic activities that are suspected to impact environment negatively.

Keywords Green Tourism · Sustainable development · Carbon reduction · Panel econometrics · Sub-Saharan Africa

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Introduction

Africa is one of the regions of the world with a steady and fastest tourism growth before the COVID-19 pandemic outbreak. According to World Trade and Tourism Organization (WTTO, 2019) and the United Nations World Tourism Organization (UNWTO, 2020), the continent actually recorded a growth of 4% in 2019 the same as Europe, but even ahead of the USA that recorded just 2% growth in the same period. Moreover, the sector also generated 1 out of every 10 jobs created in the same year across the globe including 19.5milion jobs in sub-Saharan Africa in the same year 2013. Tourism growth also added US$170.7billion to the GDP of the continent in the same year (UNWTO, 2020; Yusuf, 2016). This is also alluded to in the context of the EU by Adedoyin et al. (2021a, 2021b, 2021c) in their investigation of the linkages between economic complexities, a thriving and competitive tourism industry and environmental consequences within the EU. The authors stressed the huge economic benefits of tourism industry to the EU economic growth and development, which includes job

creation, increased foreign exchange earnings, and GDP growth among others.

However, the tourism industry had been repeatedly identified as one of the major contributors of between 5 and 8% to the global carbon emission and by implications to global warming, especially since the tourism industry is known to be highly energy dependent across its value chain and sectors, such as the hotel and accommodation, aviation and airline, food and beverages, and tourism attractions (Adedoyin et al. 2021a, 2021b, 2021c; UNWTO, 2020; WTTC, 2019; Alola & Alola, 2018). Adedoyin et al. (2021a, 2021b, 2021c) argued that many tourist destinations are now known to be highly susceptible to different effects of climate change as a result of tourism activities Hence, the contribution of tourism to economic growth as well as the negative effect on the environment in many countries across the globe is well documented in the literature and has generated the concept of tourist carbon footprint (TCF) due to the escalation in energy consumption with environmental degradation as one negative consequences increase in tourism and tourist activities (Adedoyin et al. (2021a, 2021b, 2021c; Adedoyin, & Bekun, 2020; Adedoyin et al. 2021a, 2021b, 2021c; Gao, & Zhang, 2019; Qureshi et al., 2019; Lasisi et al., 2020; Gyamfi et al., 2021a; Sharif et al., 2020; Baloch et al., 2021). Yet, Adedoyin et al. 2021a, 2021b, 2021c argued that the level of economic complexities vis-à-vis knowledge, skill, and sophistication in methods of production and delivery of goods and services helps in reducing the negative impact on the environment.

Findings, however, reveal that most investigations relating to this study focused mainly on developed economies in Europe, America, and some Asian countries (Adedoyin et al. 2021a, 2021b, 2021c; Adedoyin, & Zakari, 2020; Balsalobre-Lorente, & Leitão, 2020; Ozpolat et al., 2021; Shaheen et al., 2019) with little searchlight on sub-Saharan Africa.

Meanwhile, a number of studies indicated that the general increase in energy consumption and improvement in economic growth on the continent of Africa are often with some levels of environmental consequences (Ssali et al., 2019; Hanif, 2018; Zaidi, & Saidi, 2018). That notwithstanding, the actual connection and implication between tourism-led growth, energy consumption (renewable and nonrenewable), and environmental pollution such as carbon emission are not receiving enough attention in the extant literature. The few pieces of available evidence of such studies are often on the Southern African subregion (Sarpong et al., 2020, and Lee & Brahmasrene, 2016), or on other variables on sub-Saharan Africa in general, while some particularly focus attention on oil-producing countries on the continent and comparison between the oil-based emission and tourism-linked CO_2 emission.

Therefore, this study intends to fill this existing void particularly on the relationship between tourism-led growth,

energy consumption in terms of renewable sources on the one hand, and fossil fuel-based energy usage on the other, and the effect on the environment in a panel of sub-Saharan African context. The focus is on a panel of some identified major tourism destinations in sub-Saharan Africa from 2008 to 2018, with evidence of increased international tourist's arrival in recent decades, increased GDP, as well as a reasonable level of energy mix and consumption in order to probe cointegration among the stated variables and environmental pollution caused particularly by greenhouse gas (GHG) emission. Similar investigations had been carried out on other countries and regions such as the UK, EU, and Asia and from the perspective of the role of research and development in environmental sustainability (Adedoyin et al., 2021; Adedoyin and Bekun, 2020; Adedoyin, & Zakari, 2020; Shittu et al., 2021).

The contribution of this study includes the fact that it further expands our understanding of the actual causality between tourism and energy consumption pattern (renewable and non-renewable energy consumption), and CO_2 emission and global warming as it relates to the continent of Africa. In other words, the novelty of this current study is that it raises and highlights the argument that the type of energy being consumed either fossil fuel or green or renewable energy sources matters in terms of the causality between energy consumption and carbon emission and tourism activities. Empirical findings according to Adedoyin & Zakari (2020) revealed that most investigations on this topic in relation to Africa majorly focus on total energy consumption with positive impact on economic growth in most cases, without accounting for any differences that might occur in CO_2 emission levels where renewable energy consumption is significant in the totality of energy consumed. Most economies across the globe are on a perpetual route for alternative growth path. Among the prominent growth path are Solow growth model which considered capital and labor as key growth determinants. More recently, the tourism-led growth hypothesis (TLGH) emerged in the extant literature which outlined the pivotal role of tourism arrival to economic growth. The current study is built on the intuition that increase or high influx of tourism activities, especially for SSA, is on the high. To this end, we make the assertion that international tourism arrival will induce an increase in energy demand for tourism activities and by extension induce environmental degradation, especially consumption of energy from fossil fuel base. This twin growth catalyst of tourism and energy consumption has its environmental consequences (Ozcan et al., 2021; Katircioglu, 2014). Further backing for the current study stems from the tourism-induced environmental degradation hypothesis which is based on the trade-off between economic growth and tourism on environmental quality. Our study is distinct by the consideration of both non-oil- and oil-dependent countries

of SSA countries for the first time in the extant literature by addition of control variables such as FDI and urbanization to explore theme. Thus, our current study augments the EKC framework with tourism and additional macroeconomic variables for more robust inferences for the study area in a linear fashion without consideration for quadratic form. The implication of this is that it will inform policy-makers in both the tourism sector and those in charge of the general economy in various countries in the region to identify the areas they need to focus their policy direction on sustainability, economy, and tourism. This is also germane and contributes to the ongoing debate on combating climate change and global warming using increased renewable energy consumption as against fossil fuel sources across the globe as corroborated to by Adedoyin et al. (2020a). Furthermore, scholars can use the findings from this study to further substantiate appropriately and generalize the impact of tourism-led growth hypothesis and the nexus between it and carbon pollution in the African context.

The remaining segments of this study are organized as follows: The next section is dedicated to the review of existing and relevant literature on the subject matter; section three is on methodology, followed by section four that presents the findings and discussion, while section five is on conclusion, implications, limitations, and suggestions for further studies.

Review of Existing literature

Unarguably, empirical evidence suggests that energy consumption rate is analogous to the rate of economic development in any country from the global North to the global South. Hence, the higher the energy poverty and lower energy consumption rate a country is, the higher the poverty rate and poor economic growth and development in such countries and vis-à-vis. Yet, regulatory environment and economic policy uncertainty are also found to either mitigate or complicate the situation (Adedoyin et al., 2020a; Adedoyin et al. 2021a, 2021b, 2021c; Adedoyin, & Zakari, 2020; Aslan et al., 2021; El Menyari, 2021). In a study involving global top ten tourism destinations, Adedoyin et al. (2021a, 2021b, 2021c) opined that effective implementation of environmental and renewable energy policies plays a huge role in taming the negative impact of energy consumption on environment. While alluding to this narrative, Adedoyin et al. (2021a, 2021b, 2021c) suggested that Japan is capable of achieving her target of cleaner environment and an increase in greener energy consumption in the complex economy if attention is given to policies that dissuade fossil fuel energy consumption while promoting cleaner energy, and economic growth and complexities. This also aligns with findings by Adedoyin et al. (2020a, 2020b) on the BRICS countries

where stringent energy and environmental regulatory framework curb environmental degradation as they opened up for economic growth and development was recommended by the authors.

Similarly, and as earlier noted, the tourism industry is no doubt one of the largest energy-consuming industries and also a huge contributor to national GDP and employment generation in most countries of the world, and Africa is not an exception. Thus, many developing countries including those in sub-Saharan Africa (SSA) are also paying more attention to tourism development to boost their economies. The extant literature substantiates this claim, and especially on the connection between tourism-led economic growth, and other variables including energy consumption, energy mix, foreign direct investment, and environmental pollution and degradation (El Menyari, 2021; Ssali et al., 2019; Alola & Alola, 2019 Hanif, 2018; Zaidi, & Saidi, 2018; Adedoyin, & Bekun, 2020, Gao, & Zhang, 2019; Qureshi et al., 2019; Sarpong et al., 2020; Lee, & Brahmasrene, 2016; Mensah et al., 2019), although a plethora of studies focused mainly on advanced and industrialized economies such as the UK and EU (Adedoyin et al. 2021a, 2021b, 2021c; Lasisi et al 2021; De Vita et al. 2015; Iwata and Okada, 2013; Katircioglu et al., 2014; Nissan et al., 2011).

Unfortunately, there was a dramatic and almost spontaneous downward trend in the growth from Q1, 2020, after the confirmation of the deadly corona virus in many countries of the world, and the non-medical containment measures (border closure, lockdown, shutdowns, flights restrictions, etc.) by March 2020 in many countries, which marked the beginning of a new era not only in tourism, but also in world history, also known as the 'new normal' (BBC News, 2020; UNWTO, 2020; IMF/WEO, 2020; Ozili and Arun, 2020). Nonetheless, despite the above glooming picture of tourism in the year 2020, the projection is that by the middle of 2021, tourism will bounce back, though with the caution that it might take up to 2 ½ to 4 years before we can see tourism returning to the 2019 level (UNWTO, 2020). Conversely, the inadvertent drastic reduction in energy consumption and emission due to lockdowns, restriction of vehicular and human movement, etc., lead to emergence of clearer skylines, cleaner air and environment in many global cities including the hitherto reputed most polluted cities in the world such as Delhi, Beijing, Tokyo, and many European and American cities. Apparently, this signals a positive and new hope for what is possible if the global business community is willing and intentional to tackle environmental pollution, reduce emission, and mitigate climate change by replacing energy consumption from fossil fuel sources and other sustainable practices in the tourism value chain and other energy-intensive industries across the globe.

Thus, with or without this pause occasioned by COVID-19 pandemic, it is imperative to understand probe and

expand the ongoing debate on the causal link between the tourism-led growth hypothesis, energy consumption (renewable and nonrenewable energy use), etc., and the environment, especially the greenhouse gas (GHG) emission as it relates to sub-Saharan Africa which so far is less researched. It is useful to find out if there is any positive correlation and or cointegration between the TLGH, the type of energy use, and environmental pollution in Africa.

In light of the above, as noted by Adedoyin and Bekun (2020) and the World Trade Organization (2018), the tourism industry in the last few decades that accounted for 8% of the global CO_2 emission had overtaken the construction industry to become one of the largest environmental polluters in the world as of 2019. Thus, the causal link between tourism industry, energy use, and GHG emission was established in most of the EU-28 countries between 1995 and 2014 by Balsalobre-Lorente & Leitão (2020), but the increased use of renewable energy in some EU countries reduces the environmental impact. Findings also revealed that economic advancement in production technology, knowledge and skill in highly developed economies, alongside right economic, energy, and environmental policies are useful tools in curbing environmental pollution and climate change while still enjoying the economic benefits of tourism activities (Adedoyin et.al. 2021a, 2021b). Shaheen et al. (2019) also confirmed the correlation between an increase in foreign direct investment (FDI) as a result of tourism, energy use, and CO_2 emission, and Ozpolat et al. (2021) tourism and CO_2 emission, in a panel of top 10 tourism-induced economies. The authors reaffirmed that there is a direct increase in energy consumption as international tourism arrival increases, and consequently, a direct negative impact on the environment. Another investigation by Adedoyin et.al. (2020a, 2020b), in a panel involving the BRICS states, revealed the linkage between coal rent, economic growth, and environmental pollution, while Ozturk (2016) and Aslan et al. (2021) probed the connection among tourism, energy consumption, economic growth, and environment in a panel of 34 developed and developing countries in Europe including Turkey and Russia, and a panel of the Mediterranean countries, respectively.

Meanwhile, findings on a few investigations directly on sub-Saharan Africa that factored in other variables other than tourism and/or energy use also revealed the causality between GDP and the environmental pollution. Some of the available pieces of evidence that excluded tourism in their variables often focus either on all or on some other variables such as FDI, energy use, and CO_2 emission or environmental pollution in general. Example includes Zaidi & Saidi (2018) on health expenditure, economic growth, and environmental pollution, Bataka (2020) on globalization and environmental pollution, Hanif (2018) on economic development, fossil fuel and clean energy intake, and urban settlement on

carbon emissions. Others that alluded to these findings are Ssali et al. (2019) ecological emission, economic development, energy utilization, and investment from oversees, and Mitchell et al. (2019) pollutant emissions from improved cook stoves of the type used in sub-Saharan Africa. Hanif (2018), for instance, argued that Madagascar, Nigeria, Mauritius, Ghana, Uganda, Cameroon, and particularly South Africa are among the highly ranked developing countries in relation to pollution and CO_2 and GHG emissions in sub-Saharan Africa. Findings further revealed that this increase in environmental pollution is the cause of several devastating biological damages, by implication leading to about half a million death on yearly basis in sub-Saharan Africa according to World Health Organization (2016). Simultaneously, the available evidence, however, suggested both positive and negative correlation and or cointegration between CO_2 and GHG emissions and other environmental pollutions, and energy consumption, GDP, FDI, and TLGH (Bataka, 2020; Ssali et al., 2019; Zaidi, & Saidi, 2018).

Apparently, there is a dearth of panel studies so far with particular attention to SSA on environmental pollution that incorporates the causal link between it and tourism, economic growth, and energy use variables. Among the few available is Lee & Brahmasrene (2016); the authors probed the tourism effects on the environment and economic sustainability of sub-Saharan Africa, yet this does not include urbanization as a variable. That notwithstanding, the authors further analyzed the topic from the perspectives of oil-producing and non-oil-producing nations on the continent. Their findings indicated a highly significant direct impact of tourism and energy use on economic growth, while it concurrently suggested that tourism, energy use, and economic growth have positive and highly significant impact on carbon emissions in countries in the panel. Furthermore, the Lee & Brahmasrene posit that other variables but not tourism have effect on environmental pollution in oil-producing countries in sub-Saharan Africa, whereas in non-oil-producing economies, it is tourism and energy use and not economic growth that is implicated in CO_2. The very recent one is a separate panel of four North African countries of Egypt, Morocco, Tunisia, and Algeria by El Menyari (2021); tourism was discovered to have no negative impact on environmental pollution in the panel countries, whereas electricity consumption does, indicating that the main source of electricity is unclean and nonrenewable sources in the countries are investigated.

Based on the foregoing, there is a need to further probe the cointegration, causality, and correlation between tourism, GDP, energy use, and carbon emission including urbanization, in a panel of tourism-induced economies in sub-Saharan Africa over a period of time. Therefore, to the best of the authors' knowledge, this study is the first one to incorporate GDP, energy use (renewable and fossil fuel sources), oil-producing and non-oil-producing countries, and

urbanization into the investigation of the impact of tourism industry on the environment, especially on carbon dioxide and GHG emissions in a panel study on SSA context. Notably, according to Yusuf, 2016 and UNWTO 2020, the top tourist destinations with the highest tourist receipts in Africa are Egypt, South Africa, and Morocco; the others are Kenya, Gambia, Tunisia, and Namibia. However, for whatever reasons, Egypt and Tunisia are not regarded by the international community as part of SSA; rather, they are referred to as North African countries. Nonetheless, for the purpose of this study, these three countries are not only some of the top tourism destinations in Africa, they are also oil-producing countries; hence, they fit into this panel and are therefore included in this investigation. Other countries with reasonable tourism receipts and available data, either they are oil or non-oil-producing nations including Nigeria, Botswana, Ethiopia, Ghana, Mauritius, Senegal, Cameroon, Mauritania, Tanzania, etc., are also included in this panel study.

Sequel to the above, this study intends to probe the following hypotheses: H1: Does tourism induce environmental pollution in Africa? H2: Does tourism and energy use impact differently on pollution in oil-producing countries and non-oil-producing nations in Africa? H3: Do tourism and renewable energy sources indicate cleaner environment in non-oil-producing SSA countries? The next segment in this paper presents and discourses the methods and econometrics and various tests adopted to probe, analyze, and present this investigation.

Hence, given the overwhelming mix of evidence in the literature, understanding the significant factors that affect environmental degradation in a rapid era of tourism is considered essential. As such, this study provides a clearer empirical analysis of the subject matter within the contest of the sub-Saharan Africa economies. Moreover, this study is divided into three sections, i.e., oil countries, non-oil countries, and combination of both oil and non-oil countries.

Methodology, Model, and Data

Methodology

To identify the right analytical technique(s) to employ, the authors used the cross section dependency (CD) test. The outcome from the CD test helps in either going for the first-generation or second-generation panel data econometric technique. The analysis will be bias, meaningless, and inconsistent if CD test is not carried out (Dong et al. 2018; Nathaniel et al., 2020). To make sure the mentioned problems do not occur, the authors employed three CD tests which are the Pesaran (2007) CD test, the Pesaran (2015) scaled LM test, and Breusch-Pagan (1980) LM test for the

sake of robustness check. More attention was placed on the Pesaran (2007) scaled CD test and Breusch-Pagan (1980) LM because of how our dataset is shown, i.e., the cross sections (N) number figure is larger than that of the time frame (T). The CD test equation is shown in Eq. 1:

$$CD = \left(\frac{TN(N-1)^{\frac{1}{2}-P}}{2} \right) \quad (1)$$

However, from Eq. (3), $P = \left(\frac{2}{N(N-1)} \right) \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} Pij$, where Pij is the pairwise cross-sectional correlation coefficient of the residual from the ADF regression. T and N are the sample and panel scope separately.

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. From the Pesaran (2007), the CIPS stationary test estimation is shown as

$$\Delta Y_{it} = \Delta \varphi_{it} + \beta_i X_{it-1} + \rho_{iT} + \sum_{j=1}^{n} \theta ij \Delta X_{i,t-j} + \varepsilon_{it} \quad (2)$$

Thus, φit, xit, Δ, T, as well as εit denote the intercept, analysis factors, variance operator, time span, as well as disturbance term correspondingly. 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.

Panel cointegration estimation

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

$$\Delta y_{it} = \delta_i d_t + \varphi_i y_{it-1} + \lambda_i x_{it-1} + \sum_{j=1}^{pi} \phi_{ij} \Delta y_{it-j} + \sum_{j=0}^{pi} \gamma_{ij} \Delta x_{it-j} + e_{it} \quad (3)$$

Thus, $\delta t = (\delta i1, \delta i2)'$, $dt = (1, t)'$, and ϕ are the vector of parameters, deterministic mechanisms, and the error correction parameter correspondingly. To identify cointegration existence, four tests were carried out. These four tests were 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

$$G\tau = \frac{1}{N} \sum_{i=1}^{N} = \frac{^\wedge \propto i}{SE(^\wedge \propto i)} \text{ and } G\alpha = \frac{1}{N} \sum_{i=1}^{N} \frac{T^\wedge \propto i}{^\wedge \propto i(1)}$$

Thus, $^\wedge \propto i$ is denoted by $SE(^\wedge \propto i)$ as the standard error. The semiparametric kernel technique of $\propto i(1)$ is $^\wedge \propto i(1)$.

Two of the four remaining panel mean estimations proof that the entire panel is cointegrated as shown as follows:

$$\mathbf{P}\tau = \frac{\overset{\wedge}{\propto} i}{SE(\propto i)} \text{ and } P\alpha = \text{T}1\alpha^{\wedge}$$

Ordinary Least Square (OLS) and Quantile Regression (QR)

The analysis uses the technique for 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 statistical tool based on its superior to the OLS for different reasons. 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 socioeconomic measures (De Silva et al. 2016). The QR reinforces this deficit (Salman et al. 2019; Nathaniel et al., 2020). The methodology (QR) does not presume the function of the period (Zhu et al. 2016a, 2016b). In the case of outliers (Bera et al. 2016), forecasts remain robust. No predictions for distribution (Sherwood and Wang, 2016) have been made. The technique for QR is shown as

$$\text{Quant}_\theta(yi/xi) = x\beta_\theta + \mu_\theta, 0b\theta1 \tag{4}$$

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 & Lin (2018), Nathaniel et al. (2020), and other studies.

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.

$$I_t = \vartheta_o P_t^{\xi1} A_t^{\xi2} T_t^{\xi3} \mu_t \tag{5}$$

From Eq. 5, I is a pointer of ecological deprivation, while P, A, and T represent 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 et al. 2020). Based on the analysis of Solarin and Al-Mulali studies (2018) and Nathaniel et al. (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 tourist arrival, respectively. Based on the work of Gyamfi et al. 2021b, 2021c as well as Bamidele et al. 2021, the authors then adopted gross domestic product (GDP), foreign direct investment (FDI), renewable energy (REC), non-renewable energy (NREC), and urbanization (UB) as a proxy T. The extended layout is shown as

$$I_{2t} = \vartheta_o TA_t^{\xi1} FDI_t^{\xi2} GDP_t^{\xi3} REC_t^{\xi4} NREC_t^{\xi5} UB_t^{\xi6} \mu_t \tag{6}$$

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

$$\ln I_t = \vartheta_o \xi_1 TA_t + \xi_2 FDI_t + \xi_3 LnGDP_t + \xi_4 LnREC_t + \xi_5 LnNREC_t + \xi_6 LnUB_t + \mu_t \tag{7}$$

where TA, FDI, GDP, REC, NREC, and UB denote tourist arrival, foreign direct investment, economic growth, renewable energy consumption, non-renewable energy consumption, and urbanization. I, on the other hand, represents

the environmental indicator used in this analysis and, thus, CO_2 emission. To analysis the impact of TA, FDI, GDP, REC, NREC, and UB on I at the selected quantile level, the authors formulated Eq. (8), which is shown as

$$Q_\tau(LnCO_2) = \vartheta_\tau + \xi_{1\tau} TA_{it} + \xi_{2\tau} FDI_{it} + \xi_{3\tau} LnGDP_t + \xi_{4\tau} LnREC_{it} + \xi_{5\tau} LnNREC_{it} + \xi_6 LnUB t + \mu_t \tag{8}$$

whereas the remaining variables maintain their original description, CO_2 represents CO_2 emission. For the explicative variables, the reference point is τ. Qτ corresponds to the **τ**th distributional point regression analysis that can be determined using the formulae in Eq. (9):

$$Q_\tau = \text{argmin} \sum_{k=1}^{q} \sum_{t=1}^{T} \sum_{i=1}^{N} (|y_{it} - \alpha_i - x_{it} Q_\tau|1it) \tag{9}$$

where q, T, N, and Ħ$_{it}$ stand for the number of quantiles, years, cross sections, and weight of the ith country in the ith year, respectively. The sub-Saharan Africa countries were

Table 1 Description of Variables

| Name of Indicator	Abbreviation	Proxy/Scale of Measurement	Source
Carbon dioxide emissions per capita	CO_2	Measured in metric tonnes	WDI
Income	GDP	It is proxied by the gross domestic product per capita (2010 Constant USD)	WDI
Tourist Arrivals	TA	Number of arrivals	WDI
Foreign direct investment	FDI	% of real GDP	WDI
Fossil fuel	NREC	Fossil fuel energy consumption (% of total)	WDI
Renewable energy	REC	Renewable energy consumption (% of total final energy consumption)	WDI
Urbanization	UB	Urban population growth	

Authors compilation

for this analysis and were divided into twofold, i.e., 14 oil-producing and 27 non-oil-producing countries summing up to a total of 41 (list of countries in the Appendix Table 10) from the period of 1995 to 2016. The period of time for this analysis was based on the 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). All variables expect FDI were transformed to logarithm in this analysis. As Table 1 gives a summary of the description of the variables, further discussion on the variables of interest is made. The methodological sequence is appended in Fig. 1

Carbon dioxide emissions per capita (CO_2) This variable is used as the dependent variable in the model as the proxy for the environment. The unit of measurement of carbon dioxide emissions is metric tons per capita. The apriority expectation of this variable can either be positive or negative. A positive change in carbon dioxide emissions would suggest environmental degradation whereas the negative change indicates environmental sustainability. Carbon dioxide is takes the largest percentage among the greenhouse gas emission components at about 70 percent. This justifies the reason of chosen carbon dioxide emissions as environment indicator. Also, for a vivid and insightful study of this particular topic, it is vital to adopt carbon dioxide emission as a measure of environment.

Income (GDP) This variable is used as an explanatory variable to proxy for economic growth across the countries under consideration. The income values are transformed from the local currencies to the dollars of the USA by applying the current exchange rate. A positive change in the income values of the sub-Saharan Africa economies would indicate economic growth. In extension of the instance of GDP as the total value of goods and services produced in a country in a given year, the activities that are involved the totality of GDP impact the environmental performance of any country.
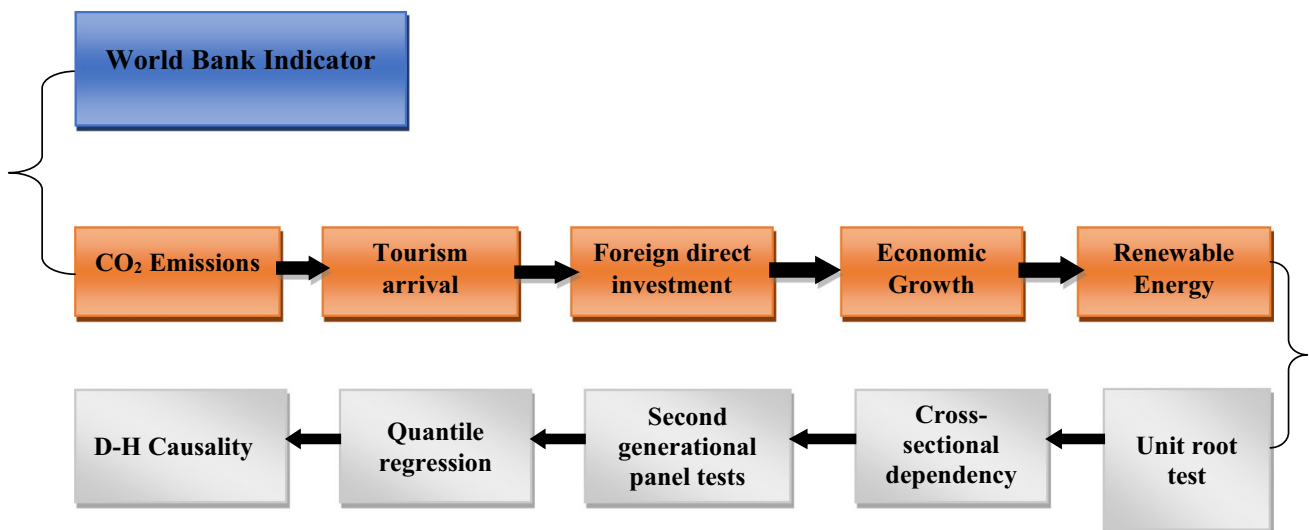
Fig. 1 Analysis Flowchart

Theories (such as EKC) have revealed the pattern of relationship that exists between economic growth (GDP) and the environment. The patterns could be U-shape. Inverted U-shape or even N-shape points toward what happens to environmental performance at any given stage of economic growth. This justifies why we chose economic growth (GDP) as among the explanatory variables.

Tourist Arrivals (TA) This is another independent variable that is proxied for tourism. This tourism variable measures the number of international tourists who visit and stay within the confines of tourist establishments. A positive change in tourist arrivals signifies gains from tourism, while a negative change indicates that tourism has no significant benefit. The tourism sector and its management involves utilization of energy to run the industry both in transportation of the tourists and in entertainment of the tourists through hotels and holidays management. These activities involve high utilization of energy which impact the environment (mostly negative due to fossil fuels). This is why the tourism arrival is considered essential to this study.

Fossil Fuel (NREC) This is one of the explanatory variables in the model that is proxied for a non-renewable source of energy as well as a control variable in the model. Fossil fuel of energy consumption is a composition of the following products: natural gas, oil, coal, and petroleum. A positive change in the fossil fuel value with regards to a priori expectation would imply a detrimental effect on the environmental sustainability of the panel countries. The economic activities of sub-Saharan countries are highly dependent on fossil fuels energy utilization which has serious environmental implication.

Renewable energy (REC) This is one of the explanatory variables in the model that is proxied for a renewable source of energy as well as a control variable in the model. Renewable energy consumption is a composition of all the renewables, namely solar, wind, hydro, tidal, geothermal, and biomass energies. A shift from fossil fuels to alternative source of energy (renewable) tends to reduce the negative implication of fossil fuels to the environmental performance. Utilizing renewable energy source as one of the explanatory exposes the effect of renewable energy on economic and environmental performance of the region.

Foreign Direct Investment (FDI) This variable is used as an explanatory variable to proxy for investment from oversees into the countries under consideration. Foreign direct investment is the net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor. A positive change in the FDI values of the

sub-Saharan Africa economies would indicate economic pollutant Hallo, while a negative will indicate pollutant heaven hypothesis (PHH). Due to less rigid laws and regulations of the region against the foreign investors, the foreign investors tend to engage on some economics practices (such as engaging carbon-intensive mechanism through adopting fossil fuel energy source) that are unfriendly to the environmental performance of the region. It is vital to capture the impact of the activities of foreign investors through FDI.

Urbanization (UB) This variable is used as an explanatory variable to proxy movement from rural areas to the urban areas within the countries under consideration. Most economic activities (industrial and manufacturing, social gathering, and other functions) take place in the cities with higher population than rural areas, hence the reason for choosing the urbanization as among the explanatory variables.

Empirical results and discussion

This section presents the interpretation of result and discussion of empirical findings. We set off with preliminary analysis of basic summary statistics and correlation analysis. Table 2 provides both oil and non-oil blocs. The results show that most series under investigation for combined blocs are negatively skewed and all series show heavy tail as reported by Kurtosis with magnitude more than 2. Subsequently, the pairwise correlation analysis shows more glimpse into the series a nature of relationship as reported in Table 3. The pairwise correlation shows strong statistical relationship between GDP growth and tourism, which gives credence to the tourism-induced GDP growth. However, we also observed FDI–growth relationship. Interestingly, we can see a positive statistical relationship between tourism and economic growth. Similar statistical relationship is observed between FDI and CO_2 emission. These relationships between macroeconomic indicators and CO_2 emissions are instructive for the government officials in the investigated blocs. It is worthy to note that pairwise analysis is not sufficient to substantiate any claim given the weakness in the test. Thus, this study proceeds to explore more econometrics analysis to explore the relationship between the outlined variables.

Subsequently, this study investigates the effect of common shows among the investigated countries under review as presented in Table 4. The cross-sectional dependency test is necessary to avoid pitfall of spurious regression and policy guidance by extension. Furthermore, the cross-sectional test support models either first- or second-generational estimators. In our case given, we reject the null hypothesis of no-cross-sectional dependency. We advance with second-generational estimator. Table 5 shows both first- and second-generational unit root for the investigated variables. In

Table 2 Descriptive statistics

		LnCO$_2$	LnTA	FDI	LnGDP	LnNREC	LnREC	LnUB
		NON-OIL COUNTRIES						
	Mean	-1.7257	10.947	0.1128	6.4913	1.0165	4.2812	3.28729
	Median	-1.7369	11.904	0.4957	6.4180	0.0000	4.4045	3.3961
	Maximum	0.4575	14.734	4.6379	8.1696	4.0103	4.5823	4.1710
	Minimum	-3.8674	0.566	-13.183	0.0000	0.0000	0.0000	1.6893
	Std. Dev	0.9144	3.519	1.9893	0.6679	1.3907	0.3669	0.4783
	Skewness	0.3222	-1.825	-2.2817	-2.1278	0.8300	-4.8498	-0.6584
	Kurtosis	2.3873a	5.386a	13.656a	24.537a	2.0201a	49.571a	2.8821a
		OIL COUNTRIES						
	Mean	-0.1553	13.138	0.7224	7.7872	3.2440	3.2444	15.667
	Median	-0.3198	12.953	0.7331	7.7206	3.4687	4.1701	15.816
	Maximum	2.4162	16.458	5.0865	9.9297	4.6049	4.5880	18.321
	Minimum	-4.7725	9.104	-13.121	6.1361	0.0000	-2.8309	11.888
	Std. Dev	1.3697	1.845	1.8733	0.8577	1.4262	1.6486	1.2894
	Skewness	-0.0736	0.091	-3.2383	0.4961	-1.3223	-1.4882	-0.5869
	Kurtosis	2.3945b	1.845a	24.388a	2.6416a	3.8206a	4.4491a	3.1476a
		COMBINATION OF OIL AND NON-OIL COUNTRIES						
	Mean	-1.1903	11.690	0.3346	6.9331	1.7759	3.9278	7.5079
	Median	-1.4179	12.284	0.6778	6.8012	1.8821	4.3634	3.6523
	Maximum	2.4162	16.458	5.0865	9.9297	4.6049	4.5880	18.321
	Minimum	-4.7725	0.566	-13.183	0.0000	0.0000	-2.8309	1.6893
	Std. Dev	1.3206	3.217	1.9748	0.9602	1.7556	1.1205	5.9318
	Skewness	0.6397	-1.942	-2.5185	0.1092	0.2039	-3.0626	0.7058
	Kurtosis	2.9099a	6.993	16.047a	7.5915a	1.4097a	12.994a	1.5796a

a = 0.01, b = 0.05, c = 0.10

Table 6, we present the Westerlund cointegration test. The results show long-run equilibrium (cointegration) relationship between our study variables over the sampled period for both oil and non-oil countries in sub-Saharan countries.

Discussions

After the confirmation of the existence of cointegration in all the groups, which points toward a long-run relationship among the selected variables, we proceed with the explanation of the findings from the regressions as shown in Table 7. The explanation is based on both ordinary least square and quantile regression for a robust check, but our emphasis is on the outcome of quantile regression. From the non-oil countries group, a positive and statistically significant relationship is found between tourism arrival and carbon emission (environmental degradation) both in OLS and all the quantiles except the median (50th quantile) that shows insignificant positive (negative relationship) influence of tourism arrival on environment quality which may be the increasing number of tourists within these countries that affect transportation which is the biggest component that increases tourism–emission mix. Tourism arrival exerts a

stronger negative influence on the environment quality in the 75th–90th quantile with the largest coefficient (0.0923). This shows that a 1 percent point increase in tourism arrival will cause a 0.0923 percent point increase in carbon emission (decrease in environment quality) across the non-oil countries. This suggests that the presence of the tourists and their activities in the non-oil sub-Saharan Africa is unfriendly to the environment performance in the region. An insight is given toward the possibility of reversing this trend from the finding from the median (50th quantile). This shows that an increase in tourism arrival has the possibility of remedying the environmental degradation. This could be possible with strict implementing and monitoring of environmental regulations void of corruption by the government officials in the affected region. This supports the finding by Udemba (2019); Sarpong et al. (2020); Gyamfi et al. (2021a, 2021b, 2021c, 2021d, 2021e), and Bamidele et al. (2021). A statistically significant positive relationship is found between FDI and carbon emission both in OLS and across the entire quantiles except the 90th quantile that shows a negative relationship with emission. This depicts a negative impact of foreign investors on the environment management of the non-oil region of sub-Saharan Africa. Basing on the quantile (5th) with the highest influence of carbon emission with regards

Table 3 Correlation matrix

	$LnCO_2$	LnTA	FDI	LnGDP	LnNREC	LnREC	LnUB
	NON-OIL COUNTRIES						
$LnCO_2$	1.0000						
LnTA	0.401a	1.0000					
LnFDI	0.1390a	-0.154a	1.0000				
LnGDP	0.6477a	0.149a	0.1456a	1.0000			
LnNREC	0.2841a	0.535a	-0.0131	0.1226a	1.0000		
LnREC	-0.6057a	-0.372a	-0.0839b	-0.2385a	0.0499	1.0000	
LnUB	0.4598a	0.570a	0.3203a	0.3939a	0.1345a	-0.3210a	1.0000
	OIL COUNTRIES						
$LnCO_2$	1.0000						
LnTA	0.101b	1.0000					
LnFDI	0.0442	-0.023	1.0000				
LnGDP	0.8924a	-0.009	0.1239b	1.0000			
LnNREC	0.4783a	0.408a	-0.1553a	0.2450a	1.0000		
LnREC	-0.6918a	0.233a	0.1513a	-0.4968a	-0.4574a	1.0000	
LnUB	0.0100	0.006a	-0.2390a	-0.2514a	0.6114a	-0.2249a	1.0000
	COMBINATION OF OIL AND NON-OIL COUNTRIES						
$LnCO_2$	1.0000						
LnTA	0.093a	1.0000					
LnFDI	0.1647a	0.054	1.0000				
LnGDP	0.8478a	0.100a	0.2064a	1.0000			
LnNREC	0.5791a	0.201a	0.0410	0.4900a	1.0000		
LnREC	-0.6972a	-0.140a	-0.0077	-0.5388a	-0.4415a	1.0000	
LnUB	0.5758a	0.101a	0.1528a	0.6313a	0.6379a	-0.4643a	1.0000

a = 0.01, b = 0.05, c = 0.10

Table 4 Cross-sectional dependency test results for combined countries

	Pesaran(2007) CD Test	Pesaran(2015) LM Test	Breusch-Pagan LM
$LnCO_2 = f(LnTA, LnGDP, FDI, LnREC, LnNREC, LnUB)$	-1.765c	0.671a	6597.70a

a = 0.01, b = 0.05, c = 0.10

to its coefficient, a percent point increase in FDI will lead to 0.058 percent increase in degradation of non-oil sub-Saharan African countries' environments except quantile (90th) which shows a negative significant relationship at 0.0510 percent which might result in that at this level, the policymakers have taken note of the harm FDI that is causing to the environment, resulting in implementing strong regulations and policy to control. The other outcomes indicate that foreign investors are flaunting the environmental regulations in the various countries of their economic activities base. FDI can either be positive or negative in sustainable development as it concerns environmental effects. The controlling and determinant force behind its environmental and economic impact is the effectiveness of government officials to implement and monitor the adherence to environmental laws. It is a well-known fact that advanced countries are keen and strict with environmental regulations and this does not augur

well with some of the indigenous investors who will now consider developing economies as a substitute in performing their economic activities under the auspices of globalization and economic integration Most developing countries including sub-Saharan African countries are known with laxity in implementing sustainable policies, and this has resulted in foreign investors exploring the loopholes in the laws to the detriment of the environmental quality. This supports the findings by Gyamfi et al. 2021d, Udemba, 2019, Sarkodie and Strezov, 2019, Zhang and Zhang 2018, and Balsalobre-Lorente et al., 2018. A positive relationship is found between economic growth, non-renewable energy consumption, urbanization, and carbon emission. Economic growth exerts intense negative influence on the environment of the non-oil region in the 75th–90th quantiles at 0.77 and 0.92 percent point, respectively, while fossil fuels and urbanization exert negative stronger influence on the environment

Table 5 Panel IPS and CIPS unit root test

Variables	IPS (Im et al,. 2003)				CIPS (Pesaran 2007)			
	Intercept		Intercept and trend		Intercept		Intercept and trend	
	Levels	1st Diff	Levels	1st Diff	Levels	1st Diff	Levels	1st Diff
NON-OIL COUNTRIES								
LnCO$_2$	-0.8278	-5.0009a	-1.9736	-5.1071a	-1.559	-5.054a	-2.598	-5.029a
LnTA	-0.9811	-5.9257a	-2.5611	-6.5712a	-2.549	-4.979a	-1.3442	-5.904a
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
LnTA	-1.520	-4.5123a	-2.910	-4.5931a	-2.564	-5.329a	-1.138	-5.755a
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
LnTA	-1.291	-4.4529a	-2.710	-3.2561b	-1.185	-3.679b	-1.655	-4.134a
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

a = 0.01, b = 0.05, c = 0.10

Table 6 Westerlund Cointegration Test

Dependent/models	Group Statistics		Panel Statistics	
	Gτ	Gα	Pτ	Pα
NON-OIL COUNTRIES				
LnCO$_2$ = f(LnTA, FDI, LnGDP, LnREC, LnNREC, LnUB)	-1.267c	-3.020c	-3.109a	-2.797b
OIL COUNTRIES				
LnCO$_2$ = f(LnTA, FDI, LnGDP, LnREC, LnNREC, LnUB)	-4.332a	-2.336b	-4.144a	-2.449b
COMBINATION OF OIL AND NON-OIL COUNTRIES				
LnCO$_2$ = f(LnTA, FDI, LnGDP, LnREC, LnNREC, LnUB)	-3.186a	-3.077a	-6.471a	-4.171b

a = 0.01, b = 0.05, c = 0.10

of the non-oil region in the 50th–75th (0.1685 and 0.1588) and 25th–50th (0.4469 and 0.5642) quantiles, respectively. It is important to mention here that urbanization displays a significantly negative relationship with carbon emission in the 90th quantile which is a good story for the non-oil region. This is a good sign that urbanization will impact favorably to the environmental performance. These findings reflect the characteristics of developing economies that depict maximum efforts put in pursuit of economic growth at the expense of environment performance, and massive rural–urban migration that most times leave the urban areas in environmental mess if necessary environmental measures are not taken. These findings support the findings of Bekun et al. 2021a, 2021b, 2021c; Onifade et al. 2021; Udemba, 2019; Bekun et al., 2019; Shahbaz et al., 2010; Shahbaz et al., 2013; and Guangyue and Deyong, 2011. A statistically significant negative relationship is found between renewable energy consumption and carbon emission. This

Table 7 Ordinal least square (OLS) and Quantile Regression (QR) Result for long-run relationship

	OLS	Q.05	Q.25	Q.50	Q.75	Q.90
NON-OIL COUNTRIES						
LnTA	0.0217a	0.0263a	0.0116b	-0.0353	0.0157	0.0923a
FDI	0.0343b	0.0580b	0.0548c	0.0140c	0.0294c	-0.0510c
LnGDP	0.7637a	0.6567a	0.5142a	0.5993a	0.7727a	0.9215a
LnREC	-0.8327a	-0.7762a	-0.7970a	-0.7351c	-0.4669a	-1.7212a
LnNREC	0.1355a	0.1129a	0.1267a	0.1685a	0.1588a	0.0690a
LnUB	0.2588a	0.4469a	0.5642a	0.3975c	0.4126a	-0.3187a
Constant	-4.4192a	-5.1899a	-4.1611a	-4.0300a	-6.1753a	0.3324
F-Statistic	289.88a					
R2/Pseudo-R2	0.7477	0.5809	0.5657	0.5601	0.5319	0.5173
Adj R-square	0.7451					
Observation	594	594	594	594	594	594
OIL COUNTRIES						
	OLS	Q.05	Q.25	Q.50	Q.75	Q.90
LnTA	0.0660a	0.0899c	0.0864a	0.0638a	0.0481a	0.0363b
FDI	0.0288c	0.06504	0.0196c	0.0120b	0.0429b	0.0353c
LnGDP	1.1320a	1.0199a	1.2148a	1.1221a	1.0613a	1.0014a
LnREC	-0.1373a	-0.1816a	-0.0826a	-0.1319a	-0.1809a	-0.1740a
LnNREC	0.2321a	0.1226c	0.2538a	0.2689a	0.2415a	0.2949a
LnUB	0.0629b	0.2646a	0.0414	0.0133c	0.0186a	0.0195c
Constant	-11.2051a	-12.930a	-12.168a	-10.4262a	-9.3735a	-8.8635a
F-Statistic	820.23a					
R^2/Pseudo-R^2	0.9424	0.7268	0.7514	0.7872	0.7867	0.7970
Adj R-square	0.9412					
Observation	308	308	308	308	308	308
COMBINATION OF OIL AND NON-OIL COUNTRIES						
	OLS	Q.05	Q.25	Q.50	Q.75	Q.90
LnTA	-0.0243b	-0.0555a	-0.0279a	-0.0147b	0.0879	0.0154b
FDI	0.0057c	0.0093c	-0.0030c	0.0903b	0.0130c	0.0695b
LnGDP	1.0975a	1.1009a	1.0550a	1.0960a	1.0749a	1.1133a
LnREC	-0.2359a	-0.0238a	-0.1656a	-0.0146a	-0.0137a	-0.0129a
LnNREC	0.1620a	0.0388c	0.0441b	0.0422b	0.0500a	0.0667a
LnUB	-0.0310a	-0.0350a	-0.0203a	-0.0360a	-0.0285a	-0.0477a
Constant	-7.9453a	-9.0270a	-8.7837a	-8.8031a	-8.6149a	-8.6986a
F-Statistic	1071.01a					
R2/Pseudo-R2	0.8777	0.6233	0.6637	0.6801	0.6987	0.6830
Adj R-square	0.8769					
Observation	902	902	902	902	902	902

a = 0.01, b = 0.05, c = 0.10

depicts a positive impact of renewable energy consumption on the environmental quality of the non-oil region. This is in line with the theory and authors expectation. This finding supports the findings by Bekun et al. (2019), Gyamfi et al (2021e), Steve et al (2021), and Aseidu et al. (2021). The findings according to the OLS-cum-quantile regression on oil countries are similar to those of the non-oil countries except in few cases with varying coefficients. The coefficients of the economic growth and FDI in all the quantiles of oil countries show that economic growth and FDI exert

stronger negative influence on environment than those of non-oil countries. This is expected of the analysis because the oil countries have high tendencies of attracting greater percentage of foreign investors both in the form of transnational corporations and on individual basis who are players in oil businesses. The economic activities in the oil countries are equally expected to be greater than those of the non-oil countries considering the influx of foreign investors due to the availability of oil resources. Considering the development history of the region, most of the oil-dependent

countries in the African region tend toward an increase in economic growth because of resource revenue which does not necessarily mean good livelihood of the masses.

However, the findings from both OLS and quantile regression of the combined data of both regions (oil and non-oil countries in sub-Saharan Africa) attest to the findings from the individual regions. The findings are really interesting with some levels of similarities with individual regions but on a varying degree in the coefficients and the amount of negative relationship that exists among the selected variables. A mixture of negative and positive relationships existed between tourism arrival, urbanization, and FDI and carbon emission for the case of non-oil countries. Specifically, a negative relationship is found between tourism arrivals, urbanization, and FDI and carbon emission in 50th quantile of tourism arrival, 90th quantile of urbanization, and 90th quantile of FDI, respectively. The same scenarios occurred in the combined regression in the case of tourism arrival, FDI, and urbanization in greater dimension. Thus, a negative relationship occurred between tourism arrival, urbanization, and FDI and carbon emission in the 5th, 25th, 50th for the case of tourism arrival and across all the quantiles for the case urbanization, and in the 25th quantile for the case of FDI. The OLS findings for the both variables show a negative relationship between tourism arrival, urbanization, and carbon emission. The findings that hinge on tourism arrival, FDI, and urbanization are a good story for the regions, especially the non-oil region. This is a pointer toward maintaining a good environment with good policies framed around the tourism arrival, urbanization, and FDI.

Robustness Result

For robustness purposes, the fully modified lease square (FMOLS) proposed by Pesaran et al. (1999) was utilized and the outcomes affirm that of the quantile regress utilized for the study. For both non-oil and oil countries, it was observed

that tourism, economic growth, FDI, energy use, and urbanization all increase emission within these countries, while renewable energy intake decreases pollution. However, in the combined countries, tourism, economic growth, FDI, and energy use increase pollution, while renewable energy intake and urbanization decrease pollution for the countries as highlighted in Table 8.

Granger causality estimation and analysis were equally performed for forecasting and robust check on the results from the both OLS and quantile regression. Most times after the confirmation of cointegration and long-run relationship, granger causality is advised to be estimated in support of the findings of the regression. Granger causality estimate was done for the three groups (oil, non-oil, and combined), and the results are shown in Table 9 as follows: Unidirectional transmission is found passing into carbon emission from tourism arrival for oil countries, from FDI to carbon emission for non-oil countries and combined group, from economic growth to carbon emission for non-oil countries and combined group, from renewable energy use to carbon emission for non-oil countries, from carbon emission to renewable energy use for the combined group, from urbanization to carbon emission for non-oil countries, and from carbon emission to urbanization for the combined group. Furthermore, bidirectional transmission is found between renewable energy use and carbon emission for the oil countries, and between urbanization and carbon emission for the oil countries. The findings from the granger causality attest to and support the regression results, hence unidirectional causal transmission from both tourism arrival and FDI to carbon emission, bidirectional causal transmission between renewable energy use and carbon emission, and between urbanization and carbon emission. This shows the tendency of tourism arrival, FDI, urbanization, and renewable energy consumption impacting favorably on the environment of the regions in this study.

Table 8 Fully modified least square (FMOLS)

	NON-OIL COUNTRIES	OIL COUNTRIES	COMBINATION OF OIL AND NON-OIL COUNTRIES
LnTA	0.016b	0.036b	0.056b
FDI	0.008b	0.025c	0.025c
LnGDP	0.709a	0.737a	0.728a
LnREC	-0.402c	-0.002c	-0.031c
LnNREC	0.530a	0.291a	0.512a
LnUB	0.076c	0.012b	-0.104c
R-squared	0.972	0.979	0.984
Adjusted R-squared	0.968	0.977	0.982

a = 0.01, b = 0.05, c = 0.10

Table 9 The DH Granger causality evidence

	NON-OIL COUNTRIES	OIL COUNTRIES	COMBINATION OF OIL AND NON-OIL COUNTRIES
Null Hypothesis	W-Stat	W-Stat	W-Stat
$LnTA \nearrow LnCO_2$	0.528	3.640b	0.239
$LnCO_2 \nearrow LnTA$	0.098	0.016	1.325
$FDI \nearrow LnCO_2$	7.787a	1.625	5.948a
$LnCO_2 \nearrow FDI$	0.696	2.079	2.028
$LnGDP \nearrow LnCO_2$	7.805a	0.257	3.203b
$LnCO_2 \nearrow LnGDP$	0.729	1.394	0.804
$LnNREC \nearrow LnCO_2$	1.040	0.988	1.181
$LnCO_2 \nearrow LnNREC$	1.452	0.123	0.499
$LnREC \nearrow LnCO_2$	0.004c	3.730b	0.718
$LnCO_2 \nearrow LnREC$	3.001	5.101a	6.323a
$LnUB \nearrow LnCO_2$	3.055b	2.529c	0.773
$LnCO_2 \nearrow LnUB$	2.281	3.482b	8.971a

a = 0.01, b = 0.05, c = 0.10

Concluding remark and policy implications

This is an inclusive panel studies of the sub-Saharan African countries' environmental performance under tourism growth and FDI growth policies. Emphasis is laid on tourism and FDI because sub-Saharan African countries are considered new tourism and FDI routs with regards to her richness in both cultural heritage and resources endowments. We apply different scientific approaches such as OLS, quantile analysis, and Granger causality in this study to ascertain the real impacts of tourism and FDI on the environmental performance of the regions. Our findings and justifications are based on the outcomes of the three mentioned approaches. Findings from OLS and quantile regressions revealed a mixed impact of both policies (tourism and FDI) on the environmental performance of the studied region. Hence, a negative and positive influence is recorded, but drawing from the findings in the combined regression, we conclude that tourism and FDI policies have tendency of impacting favorably on the environment of the regions in our studies if regulations are implemented and monitored without biasedness from the government officials.

Following the findings from our study, the following policies are recommended for the countries of the sub-Saharan Africa. Strict environmental guidelines and regulations are necessary for controlling the unhealthy and undue economic activities that are suspected to impact negatively on the environment. Emission target is worth implementing in the industrial areas to reduce the emission from the urban areas. The defaulters will be made to pay a bit extra tax. Financing and decentralizing the energy system to a more renewable energy source will be a great advancement into decarburizing and achieving some level of green economy in the region. Countries of the region are encouraged to embark on massive sensitization of the masses on the importance of healthy environment so as to reduce some activities with high tendencies of affecting environment negatively. Public transport system should be introduced and maintained to discourage the excessive usage of automobile that run on fossil fuels which will reduce excessive emission from the automobiles.

Furthermore, our findings on the breakdown of foreign production have no substantial ramifications for the countries of sub-Saharan Africa, as previously stated. State governments in sub-Saharan Africa should strive to match the criteria of the global market in order to avoid being considered pollution hot spots. For example, increasing the entry barrier to dirty industry, regulating the export of pollution-producing items, and stimulating the development of new export competitive advantages are all possible. In addition, the countries of sub-Saharan Africa must gradually and efficiently adjust the economic growth trend in order to achieve balanced and stable progress through supply-side reform.

Additionally, decision-makers in sub-Saharan Africa's countries should promote sustainable and cleaner energy sources for economies in order to reduce the continent's dependency on fossil fuel emissions. This can be accomplished through the effective use of renewable energy's environmental attributes (such as solar, wind power, and hydraulic energy, among others).

Conclusively, this study has implication to other developing countries, especially the ones close to the sub-Saharan regions. Also, the topic can still be investigated with other variables such as institutional quality to have insight into the effectiveness of government regulation on the environmental performance of the region.

Appendix

Table 10 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

Declarations

Ethical approval The 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 Not Applicable.

Consent to publish Applicable.

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

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