



Tourism-induced pollution emission amidst energy mix: evidence from Nigeria

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Abstract

In recent years, there is concerted efforts to boost the tourism industry in Nigeria, and regulatory bodies were created for the tourism industry. This study is contributing to the ongoing debate on the tourism-energy-environment literature. Thus, we explore the linkage between tourism development, energy consumption, carbon dioxide (CO₂) emission, and renewable energy consumption in Nigeria for the period of 1995–2016. The present study leverages on Bounds testing to cointegration in a carbon-income function environment while incorporating renewable energy consumption to the econometric framework. Subsequently, autoregressive distributed lag methodology alongside dynamic ordinary least square (DOLS) is utilized for robustness of estimations. Empirical results give credence to the energy-induced emission hypothesis in Nigeria. This outcome is suggestive to policymakers as fossil fuel-based energy consumption deplete the quality of the environment. Similarly, the study also affirms the environmental Kuznets curve (EKC) phenomenon. The emphasis on Nigerian growth trajectory (real income level) relative to her quality of environment via the channel of economic development and energy consumption from fossil-fuel source is indicated. On the other hand, renewable energy consumption in Nigeria shows significant ability to reduce emission level in Nigeria. This result is insightful, which implies that environmental quality is not threatened with an increase in tourist arrivals, hence tourism does not degrade the environment but is sustainable to the environment. Interesting and laudable for stakeholders' international tourism arrival did not deplete the quality of the environment. The plausible explanation is attributed to the scale of tourism in Nigeria which at the moment is still low or much more there is caution/awareness on ecotourism for sustainable environment.

Keywords Sustainable tourism · Carbon-reduction agenda · Green tourism · Ecotourism · CO₂ emission · Environmental sustainability · Nigeria

Introduction

In recent years, in a bid to diversify the economy, successive governments in Nigeria have put in concerted efforts to improve the tourism industry in the country. This is in

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tandem with the global recognition of the sector as the fastest growing industry and major contributor to economic growth, that is, gross domestic product (GDP) and job creation particularly in many developed economies in the world. According to the 2019 publication by the World Travel and Tourism Council (WTTC 2019) in 2018, travel and tourism grows by 3.9% ahead of world economic growth of 3.2%, it contributes 10.4% to the global GDP, and 319 million to jobs globally translating to 1 of every 10 global jobs created. Similarly, the United Nations World Tourism Organization (UNWTO) in its World Tourism Barometer January 2020 edition corroborated the WTTC data, and also confirms international tourism arrival growth of 3.8% for 2019 (UNWTO 2020). International tourism in Nigeria especially the inbound or arrival is still in its developing stage for factors ranging from poor infrastructure to insecurity, terrorism, lack of funding, and government policy inconsistency.

Consequent on the above, tourism is an energy intensive industry, and almost all the sectors within the tourism value-chain consume massive amount of energy to be able to operate effectively, leaving deep holes in their revenue. Meanwhile, due to the perceived, real, and imminent devastating effects of climate change as a proxy of global warming on sustainable development and economy if all measures/protocols to slow down the trend is not vigorously pursued, arrays of robust studies with empirical evidences constantly remind and encourage policy-makers and stakeholders of the need for a shift to sustainable tourism practices (Shehu et al. 2019). Thus, the general consensus is that it is pertinent for individuals, businesses, firms, and corporate bodies to adopt cleaner and efficient energy derivable only from renewable energy sources such as solar photovoltaic (PV), wind, and biomass to meet their energy consumption needs; hence, the sustainable tourism is now a fashionable policy and regulatory trend in the globe (Weaver 2011; Lee et al. 2018; Saint Akadiri et al. 2019).

Empirical evidences abound on what is generally referred to as “tourism-led economic growth hypothesis (TLGH)” (Balaguer and Cantavella-Jorda 2002; Ghali 1976; Balsalobre-Lorentes et al. 2020; Brida et al. 2016; Ozturk et al. 2016; Albaladejo et al. 2010; Sharif et al. 2020). The same can be said for its counter argument on economic-led tourism growth by other scholars (Braun et al. 2003; Shan and Wilson 2001). Extant investigations and reports on relationship between tourism, energy consumption, economic growth, and CO₂ emission focusing on the developed regions of the world are also surplus (Katircioglu 2014; Nissan et al. 2011; De Vita et al. 2015; Ozturk 2016). In fact, Balsalobre-Lorentes et al. (2020) in their analysis of effect of globalization on N-shaped TLGH, again, focusing on OECD countries, suggest that renewable energy should be encouraged in the tourism industry to mitigate environmental degradation.

Alola et al. (2019) and Bekun et al. (2019) also alluded to this narrative, but again, their concentration is on EU largest economies.

A similar study on energy consumption and carbon dioxide emission in Nigeria by Oluseyi et al. (2016) was from the building engineering perspectives rather than tourism. Nonetheless, Bekun et al. (2019) took another look at the phenomena with a focus on South Africa. While contributing to the debate, Adesina and Ngozi 2013 reiterated the insensitivity to environmental sustainability in the business plan of most hoteliers in Nigeria.

To the best of our understanding, only a few studies from the energy consumption, economic growth, sustainable development, GHG emission, and tourism nexus point of view have thrown their searchlight on Sub-Saharan Africa (SSA), and Nigeria in particular. Most studies focus on just economics or GDP implications, energy efficiency, building adaptability, and environment to mention but few, but majority concentrates on European countries, small Island countries, Singapore, China etc., and a few African states such as South Africa, Egypt, Kenya, and Tunisia (Bekun and Agboola 2019; Alola et al. 2019; Saint Akadiri et al. 2019; Balsalobre-Lorentes et al. 2020; Yusuf 2016; Muazu et al. 2017; Shehu et al. 2019).

The shortfall therefore remains in studies that consider the relationship between energy consumption, the rate of renewable energy diffusion, energy mix, and the impact of the emission of greenhouse gas (GHG) in Nigeria tourism industry and the impact on the Nigerian economy in particular. Nevertheless, it is pertinent to acknowledge and point out the fact that generally, there is a serious shortage of data on Nigeria, the tourism industry, and on the contribution of tourism to the Nigerian economy in particular.

It is against this backdrop that this study probes the relationship between energy consumption in Nigeria tourism sector, energy mix, renewable energy adoption rate, the emission of GHG, and economic growth in a carbon-income setting. Going by the tourism area life cycle (TALC) theory (Zuo and Huang 2018); as earlier noted, tourism in Nigeria is still in its developmental stage in, with great potentials for involvement, growth and specialization; hence, this study adopts the above theoretical framework for the investigation.

This research contributes to ongoing debates on tourism-induced pollution emission growth in energy consumption and environment by first, focusing on Nigeria in particular, to increase the available resources on the country especially from the tourism-pollution growth perspectives. Second, including the assessment of the rate of renewable energy in Nigeria tourism sector gives additional picture of the readiness by tourism sector to shift to cleaner energy sources, reduces operational cost, and contributes to palliate global warming. Third, the application of multivariate analysis and

mediation model more common in management research is a step further in reflecting the multidisciplinary nature of tourism, energy and environment.

The rest of this study proceed as the following: the “[Literature review](#)” section is for the review of related literature while the “[Methodology and data](#)” section focuses on data and econometrics strategy. The “[Results and discussion](#)” section presents the explanation of the empirical results. The conclusion is presented with policy blueprint accordingly in the “[Conclusion and policy implications](#)” section.

Literature review

Tourism sector is a fast-growing business and a crucial factor in the tourism and hospitality value-chain globally. In fact, tourism generates the highest employment and revenue in the tourism industry world over (UNWTO 2020). At the same time, the sector is energy intensive and as such, 2% out of the 5% emission by the global tourism industry is generated by the tourism sector (UNWTO 2020). Raza et al. (2021) also reiterate the fact that tourism industry contributes enormously to the global GDP to the tune of USD8272.3 billion in 2017, with the projection of growth towards 10.4% to 11.7% by 2028.

Nigeria, despite being the largest economy in Africa, with a growing hospitality sector and enormous endowment to be a vast tourism destination (Ozturk and Acaravci 2009; Ekundayo 2014), thankfully, is one of the least carbon emission oil-producing country in the world. This is partly due to its undesirable status as one of the countries with the least energy consumption per capita among committee of nations (Alao and Awodele 2018; Roy et al. 2020; Yetano Roche et al. 2020), a direct consequence of its poor level of infrastructure particularly electricity, thus creating a huge energy poverty in the country. Whereas, her economic contemporary on the continent, South Africa, accounts for 1% of the world’s carbon dioxide emission, and 42% of the African CO₂ emission, although a non-oil-producing nation but for her vibrant energy as well as tourism sector (Bekun et al. 2019). The scenario in South Africa is similar to the G7 countries according to Gyamfi et al. (2020) where the causality between tourism growth, economic development, and carbon emission has been well established. This is also supported by recent findings by other authors including Khan and Hou (2021), Liu et al. (2019), and Usman et al. (2021) with significant impact of energy consumption, tourism, financial development, and trade openness on environmental degradation in both developing and developed countries over a period of time, although with some differences relative to the level economic growth and technological development between the groups of developing and developed nations which the later groups leverage on to mitigate some of the

negative impacts to a certain extent. Alluding to this fact, Yusuf (2016) reveals that in 2013, tourism alone generated 19.5million jobs in Africa, while contributing US\$170.7 billion to the continent’s GDP. Egypt, South Africa, and Morocco are the top three tourist destinations and with the highest tourist receipts in Africa, others are Kenya, Gambia, Tunisia, and Namibia (Yusuff 2016). It is sad to note that Nigeria is lagging behind these smaller countries in this humongous industry despite being a supposed “tourist paradise in Africa” with great potentials for foreign exchange and economic growth through tourism (Ekundayo 2014, Matthew et al. 2021; Nathaniel and Olaife 2021), although the cultural-based tourism is gaining momentum and the country is performing better in this aspect (Amalu et al. 2021). Yet, the relationship and impact of the energy consumption in the hotel sector on environment and economic growth in the country cannot be ignored.

According to Muazu et al. (2017), despite international tourism still somewhere between involvement and development stages in Nigeria, the tourism sector accounts for 40% of services sector in the country, 1.6% of employment, and 1.7% of GDP in 2015, although the above figures for tourism contribution to Nigeria’s GDP in 2015 is as high as 6.11% and to employment in the same year is up to 2.8% (Matthew et al. 2021). Apparently, and particularly for the study area, this is not unconnected to the fact that Abuja in Nigeria is the seat of the Federal government of Nigeria, and home to regional or country head office of most international organizations, diplomatic missions and the likes. All these institutions draw visitors and participants to the city from all around the world for government-related businesses including meetings, conferences, and workshops with the needs for accommodation in high-end hotels with huge energy demand and consumption. Findings by Salehi et al. (2021) substantiate this assertion with regard to heavy energy consumption of large hotels from the perspective of Iran, a developing country like Nigeria.

Similarly, current empirical studies also indicate that most energy use in Nigeria is in form of electricity, mostly from captive generation using diesel-powered generators, as well as liquefied gas for cooking (Shehu et al. 2019). Some increasing energy demands in tourism and hotel industry are often needed to meet customers’ satisfaction in the area of energy consuming services such as heating and cooling, lighting, laundry, cooking, sport and recreation, information, and communication including the Internet and television. Different factors such as the physical and operational size and structure, star ratings of the hotel, and energy sources available, determine the amount of energy consumed (Salehi et al. 2021). In fact, Muazu’s (2017) findings indicate that about 12–13 million liters of diesel is used to run fossil fuel electricity generators to augment the shortage of grid electricity supply. Definitely, the above figures by Muazu

must have double if the latest data is obtainable, and findings reveal this is the common practice in all sectors i.e., public, private, and businesses, in Nigeria with its attending negative implications on the environment. However, findings from this study reveal that despite the high energy consumption in the study area mostly from nonrenewable sources, the GHG emission is negligible since the hospitality sector is concentrated within and around Abuja metropolis that enjoys better electricity supply from the grid than any other parts of the country. This further confirms findings by Muazu (2012) and Shehu et al. (2019) on this topic.

The foregoing notwithstanding, there is increasing awareness of the abundance of renewable energy sources in Nigeria among scholars, policy-makers, and stakeholders in the sector. Evidences also suggest the evolving and vibrant renewable energy market in Nigeria providing the technical support needed to those who are ready to make a shift and contribute to greener environment. Despite this, the diffusion of renewable energy in Nigeria in general and the tourism sector in particular is still a source of concern.

Consequently, findings from this study reveal and identify the followings as the energy mix within tourism sector in Nigeria; giving the source/type, mean, standard deviation coefficient, and the ranking of each, electricity (grid) mean of 4.8662 standard deviation of 0.45426 is ranking number 1 among the sources of energy use in the research area. This is followed by diesel with the mean of 4.2293, standard deviation of 0.71497, ranking number 2. The next commonly use energy source is gas having a mean of 3.7197, standard deviation of 0.96632, and ranks 3; followed by petrol the mean is 1.9299, standard deviation is 0.95484, and the rank is 4; and lastly is renewable sources with the mean of 1.2803, standard deviation of 0.79125, and ranking the least 5 (Shehu et al. 2019).

Obviously, the energy source with the highest GHG emission in the mix is diesel, while the cleanest but with the lowest ranking in terms of negligible use by the tourism is the renewable.

Therefore, the hypotheses this study seeks to address are as follows:

- H₁: Does tourism sector in Nigeria drive pollution?
- H₂: Does renewable energy adoption mitigate emission in Nigeria?
- H₃: Is there a chance for Sustainable development and tourism in Nigeria?

Methodology and data

Data and model specification

This section presents the methodological sequence to explore the relationship between the hypotheses previously highlighted. Our analysis utilized data from yearly frequency time series from 1995 to 2016. The data span is limited due to availability of international tourism arrival data from the World Bank Development Indicators (WDI database). The variables involve per capita CO₂ (metric tons), tourist arrivals (number of arrivals), actual income (constant US\$ 2010), square of income (it measures the square of GDP per capita), renewable energy usage (percentage of total final energy consumption), and fossil fuel (percentage of total final energy consumption). All data were collected from the World Bank’s World Development Indicators (World Development Index, 2020). The choice of the period for the study is restricted to the availability of data. As Table 1 gives a summary of the description of the variables, further discussion of the variables of interest is as follows.

Variable definition

Carbon dioxide emissions per capita (CO₂) 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 in 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.

Table 1 Description of variables

Name of indicator	Abbreviation	Proxy/scale of measurement	Source
Carbon di oxide emissions per capita	CO ₂	Measured in metric tons	WDI
Income	<i>Y</i>	It is proxied by the gross domestic product per capita (2010 Constant USD)	WDI
Tourist arrivals	TA	Number of arrivals	WDI
Square of income	<i>Y</i> ²	It measures the square of GDP per capita	WDI
Fossil fuel	<i>F</i>	Fossil fuel energy consumption (% of total)	WDI
Renewable energy	<i>R</i>	Renewable energy consumption (% of total final energy consumption)	WDI

Source: authors’ compilation

Income (Y) 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 Nigeria economy would indicate economic growth.

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.

Fossil fuel (F) 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, namely natural gas, oil, coal, and petroleum. A positive change in the fossil fuel value with regard to a priori expectation would imply a detrimental effect on the environmental sustainability of the panel countries.

Renewable energy (R) 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.

The aim is to investigate the influence of tourism, economic growth, clean energy usage, and fossil-fuel on Nigeria's CO₂ emission level. Thus in line with extant literature, we fitted a carbon-income function as:

$$CO_{2t} = f(TA_t, Y_t, Y_t^2, R_t, F_t) \quad (1)$$

From Eq. 1, CO₂ is denoted as carbon dioxide pollution, TA denotes tourist arrival, Y denotes as income, Y² denotes as square of income, R denotes as renewable energy intake, F denotes as fossil fuel, and t denote the time frame for the estimation.

Secondly, the above equation in its natural logarithm form is expressed to ensure homoscedasticity of the coefficients representing the elasticities of the relationships under investigation:

$$\ln CO_{2t} = \beta_0 + \beta_1 \ln TA_t + \beta_2 \ln Y_{,t} + \beta_3 \ln Y_{,t}^2 + \beta_4 \ln R_t + \beta_5 \ln F_{,t} + \varepsilon_t \quad (2)$$

Given that t signifies the time span which is 1995–2016 as mentioned earlier, ε captures the stochastic term.

Empirical sequence

To better understand the hypothesized claim over the outlined variable, this section presents the methodological series of sequence to operationalize the claims.

Stationarity check

The initial step is to explore the parameter stationarity because virtually time series variables are considered to be non-stationary (Nelson and Plosser 1982), which can end in spurious findings that are inaccurate for assumptions. We administered traditional stationarity checks like ADF and PP techniques. The ADF and PP experiments investigate serial association below the stationarity null assumption of the first differences sequence. The main benefit of the PP estimation above the ADF estimation is that the expectation of homoscedasticity is not a basic precondition in PP estimations.

Cointegration estimation

After examining the stationarity of the parameters as well as finding if none of the parameter was incorporated of I(2) or higher, the ARDL bound estimation method introduced by Pesaran et al. (2001) is used to analyze if cointegration association existed among the parameters. Not like many cointegration experiments (like Engle and Granger 1987), the ARDL method tackles possible endogeneity problems by believing all variables are endogenous. It also has much benefit compare to Johansen's (1988) cointegration analysis, to be relevant to time series that are incorporated at level, first difference or both and again was identify much efficient for few scale samples.

The ARDL cointegration procedure has essential econometric assets comparative to orthodox panel/time-series data techniques. It could solute endogeneity issues in econometric techniques while at the matching period grip either short-or long-term coefficients. The ARDL cointegration techniques are again competent of taking into consideration coefficients in a joint integration order, such as I(0) or/and I(1) but not I(2). Pesaran et al. (1999) however suggested that the ARDL technique is precise, strong, and extraordinary to lag orders and outliers.

Results and discussion

This section presents the discussion of the empirical results in a stylized manner. This analysis starts with certain preliminary empirical analysis, capturing the variables used and reporting them as normally distributed in Table 2. According to the summary statistics, data shows there is a notable change between the lowest and highest values for the

Table 2 Descriptive statistics of underlined variables

	LnCO ₂	LnTA	LnY	LnY ²	LnR	LnF
Mean	0.473	14.847	7.447	5.707	4.397	2.936
Median	0.350	14.885	7.399	5.966	4.443	2.951
Maximum	0.015	15.625	7.844	1.980	4.486	3.128
Minimum	1.164	13.846	7.183	4.551	4.124	2.337
Std. dev	0.329	0.5031	0.224	5.027	0.101	0.150
Skewness	-0.867	-0.197	0.342	0.481	-1.393	-2.022
Kurtosis	2.446	1.956	1.639	2.257	3.648	8.283
Jarque–Bera	5.801**	2.179*	4.059*	9.477***	14.324***	77.466***

Triple, double, and single asterisks depict 1%, 5%, and 10% statistical rejection levels respectively

Table 3 Correlation analysis

	LnCO ₂	LnTA	LnY	LnR	LnF
LnCO ₂	1				
<i>p</i> -value	–				
LnTA	0.157	1			
<i>p</i> -value	(0.3196)	–			
LnY	0.432***	0.428***	1		
<i>p</i> -value	(0.0042)	(0.0046)	–		
LnR	-0.393***	0.012	0.406***	1	
<i>p</i> -value	(0.0099)	(0.9358)	(0.0075)	–	
LnF	-0.053	0.351**	-0.281*	-0.189	1
<i>P</i> -value	(0.7370)	(0.0224)	(0.0714)	(0.2282)	–

Triple, double, and single asterisks denote 1%, 5%, and 10% indicate statistical rejection levels

time under consideration. Tourist arrivals are observed to have the highest average and maximum value followed by income, while carbon dioxide has the lowest average within the period of investigation.

Table 3 reports the correlation matrix of the variables over the period. We observed from the table positive and negative statistically significant relationships among the variables under review. From the estimation it was observed that carbon dioxide is positively significant related to

economic growth but negatively related to renewable energy. Moreover, there is a positive and significant relationship between tourist arrival, economic growth, and fossil fuel. This implies that an increase in the number of international tourists who visit and stay within tourist establishments will lead to an increase in economic growth and the use of fossil fuel in the country under review. Similarly, there is a positive significant relationship between economic growth and renewable and a negative relationship with fossil fuel, which implied that renewable energy usage increases economic growth while fossil fuel decreases it.

Stationarity check

Subsequently, the ADF and the PP unit root test were employed to examine if the variables were stationary or otherwise. From the analysis of Table 4, it was indicated that at the level of both estimations, none of the variables were stationary at level form. But at first difference of both estimations, all the variables were stationary at 1% significant level. The analysis proceeds to check for cointegration among the underlined variables.

The outcome from the ARDL cointegration analysis from Table 5 indicates that the *F*-stat. (5.645) is greater than the upper bound critical values at 1% significant level

Table 4 Stationary results

Indicators	Augmented Dicky Fuller Stat				Philips Perron Stat			
	At level		At 1st level		At level		At 1st level	
	$\pi\tau$	$\pi\theta$	$\pi\tau$	$\pi\theta$	$\pi\tau$	$\pi\theta$	$\pi\tau$	$\pi\theta$
LnCO ₂	-1.876	-1.822	-6.724***	-6.680***	-1.862	-1.807	-6.723***	-6.680***
LnTA	-1.876	-2.063	-6.648***	-6.560***	-1.919	-2.140	-6.648***	-6.560***
LnY	-0.097	-1.228	-2.732***	-3.437***	-0.744	-1.339	-4.073***	-4.598***
LnY ²	-0.816	-0.068	-3.482***	-2.571***	1.323	0.159	-3.896***	-3.193***
LnR	-1.787	-2.585	-6.556***	-6.512***	-1.800	-2.606	-6.558***	-6.513***
LnF	-5.092	-4.650	-5.363***	-5.408***	-4.934	-4.711	-5.341***	-5.379***

Triple, double, and single asterisks are 1%, 5%, and 10% means statistical rejection level respectively. Significant level respectively; thus, $\pi\tau$ is with constant, $\pi\theta$ is with constant and trend

Table 5 ARDL Bounds test to cointegration analysis

Model	F-statistic	Lag length	Conclusion
$\text{LnCO}_{2t} = f(\text{LnTA}, \text{LnY}, \text{LnY}^2, \text{LnR}, \text{LnF})$	5.645***	1, 1, 1, 1, 0	Cointegration
Significant level	I(0) bound	I(1) bound	
1%	4.35	5.38	
5%	3.68	4.12	
10%	2.54	4.01	

Triple, double, and single asterisks are 1%, 5%, and 10% significant levels respectively

(5.38). However, it establishes a proof of long-run association among the study outlined variables. Nevertheless, there was a confirmation from the Johansen (1988) estimation, which again proof that the variables are cointegrated which is shown in Table 6. The trace statistics and the Max-Eigen statistics reveal three cointegrating equations of 5% and 10% significant levels, thus, affirming the presence of cointegration vector and long-run bond among the variables under review.

Estimation of EKC by autoregressive distributed lag Since we identified a cointegration connection among parameters, we also extracted long-term projections of tourist arrival, economic growth, square of economic growth, clean energy usage, and fossil fuel. The methodologies employed are unique and capable of ensuring robust results. Table 7 offers long-run outcomes of this analysis.

From our empirical results in Table 7, we observe a positive and negative sign for income per capita and the square of income per capita along with statistical significance at 1% and 5% accordingly based on the ARDL techniques employed. This indicates an inverse U-shaped connection among the *variables under consideration*. The outcome of positively significant of income on pollution and negatively significant of income square on pollution confirms the EKC

Table 6 Johansen Fisher cointegration test results

Hypothesis no. of CE(S)	Fisher stat (from trace)	p-value	Fisher stat (from max-eight)	p-value
$r \leq 0$	42.91**	(0.0408)	0.86*	(0.0784)
≤ 1	23.73*	(0.0546)	0.47*	(0.0825)
$r \leq 2$	11.43*	(0.0749)	0.52**	(0.0425)
$r \leq 3$	3.565	(0.9639)	0.19	(0.9718)
$r \leq 4$	1.50	(0.4757)	1.12	(0.4757)
$r \leq 5$	0.98	(0.4562)	0.75	(0.5671)

Triple, double, and single asterisks are 1%, 5%, and 10% significant levels respectively

Table 7 ARDL long-run estimation outcome (1, 1, 1, 1, 0)

Long-run			
Variables	Coefficient	Std. error	t-statistic
LnTA	-0.488*	0.317	-1.538
LnY	1.591***	0.574	2.772
LnY ²	-0.750**	0.427	-1.335
LnR	-1.953*	1.018	-1.918
LnF	1.126*	0.965	1.166
Constant	0.177*	5.371	0.03
F-statistic	17.922***		
Diagnostic estimations	Chi-square	p-value	
Serial correlation LM	3.21	(0.2483)	
Heteroskedastic ARCH	2.642	(0.2041)	
Jarque–Bera	2.534	(0.4531)	
Ramsey reset	1.315	(0.6210)	

Triple, double, and single asterisks are 1%, 5%, and 10% means statistical level rejection levels respectively. All the diagnostics estimation are satisfactory

theory. However, the analysis confirms the study of Chen et al. (2019) for China, Ghana (Solarin et al. 2017), Indonesia (Kurniawan and Managi 2018), and Pakistan (Rahman et al. 2019) but in contrary to that of Lin et al. (2016) for China. It is interesting to observe that tourist arrival has a significant and negative effect on carbon dioxide in Nigeria. This implies that environmental quality is not threatened with an increase in tourist arrivals, hence tourism does not degrade the environment but is sustainable to the environment. This outcome is contrary to the outcome of Sarpong et al. (2020) for southern Africa region but similar to that of Katircioglu and Taspinar (2017) for Turkey as well as Heidari et al. (2015) for ASEAN countries. Renewable energy on the other hand is observed to be significant and negatively related to carbon dioxide. This implies that the use of renewables is better for controlling environmental degradation in Nigeria and affirms the finding of Gyamfi et al. (2020) for E7 economics. Fossil fuel energy consumption is reported to have a positive and significant effect on carbon dioxide emissions. This suggests that fossil fuel increases environmental degradation in Nigeria. The outcome confirms the findings of Gyamfi et al. (2020), Wang and Tao (2013), and Qi et al. (2014). In general, we can observe the effects of the results for Nigeria economy revealing the existence of an inverted U-shaped relationship between Y , Y^2 , TA , R , and F , hence validating the EKC hypothesis for Nigeria economy.

Table 8 shows the outcomes of the short-run analysis. From the analysis, tourist arrival has a negative significant relationship with carbon dioxide at 5% level which implies that even in the short run, tourism is not causing pollution in Nigeria. However, economic growth has a positive significant relationship with carbon dioxide at

Table 8 ARDL short-run estimation outcome

Short run			
Variables	Coefficient	Std. error	<i>t</i> -statistic
ECM(−1)	−0.323*	0.160	−2.013
D(LnTA)	−0.157**	0.074	−2.114
D(LnY)	1.216**	0.589	2.061
D(LnY ²)	0.021	0.024	0.011
D(LnR)	−0.632	0.524	−1.205
D(LnF)	0.364	0.293	1.242
Constant	0.057*	1.742	0.032
<i>R</i> ²	0.759		
Adjusted <i>R</i> ²	0.717		

Triple, double, and single asterisks are 1%, 5%, and 10% means statistical rejection level respectively

5% level. The remaining variables did not show significant relationship with the dependent variable. Moreover, error correction term (ECT) that reveals the pace of adjustment is significant as well as negative coefficient (−0.323) demonstrates the long-run association among parameters.

Diagnostic evaluations demonstrate that the model is safe of heteroskedasticity as well as serial correlation. The Jarque–Bera normality test shows that errors are normally spread. The Ramsey check indicates that the model has no issues with mis-specification. These diagnostic tests reveal the fitted model is robust and suitable for policy direction.

Sensitivity check: dynamic ordinal least square technique For purposes of reliability verification, Saikkonen's (1992) and Stock and Watson's (1993) technique which is dynamic ordinary least squares (DOLS) is utilized to test the long-term association among variables. The DOLS estimate protocol helps with the inherent simultaneity bias and works best for small samples by using lags and results inside the explanatory variables, relative to other similar estimating approaches.

It was observed from the outcomes that tourist arrival has a negative statistically significant relationship with pollution in the Nigeria economic (Table 9). It implies that the arrival of tourist to Nigeria does not increase pollution. Moreover, there is a positive significant and negative significant relationship for income and square of income with pollution. This confirms the EKC presence in Nigeria's economy. However, renewable energy decreases pollution while fossil fuel which is non-renewable energy increases pollution in the Nigeria's economy.

Table 9 Dynamic least squares (DOLS)

Variables	Coefficient	Std. error	<i>t</i> -statistic
LnTA	−0.161**	0.128	−1.261
LnY	1.270***	0.299	4.240
LnY ²	−0.073**	0.205	0.355
LnR	−2.289***	0.490	−4.667
LnF	1.213**	0.433	2.798
<i>C</i>	−1.063*	2.489	−0.427
<i>R</i> ²	0.862		
Adjusted <i>R</i> ²	0.762		

Triple, double, and single asterisks are 1%, 5%, and 10% means statistical rejection levels respectively

Conclusion and policy implications

The impact of tourism as a driver of economic and environmental degradation has intensified in developing blocs. To this end, using annual frequency data for the case of Nigeria with ARDL methodology, we explore the nexus between international tourism arrival, economic growth, and non-renewable and renewable energy mix using a multivariate constructed econometric strategy to rationalize the relationship of the outlined variables.

Empirical findings from this study reveal high energy consumption in the study area mostly from nonrenewable (fossil-fuel base) sources, but the GHG emission is negligible the tourism sector is concentrated within and around less pollutant cities in Nigeria that enjoys better electricity (energy) supply from the grid than any other parts of the country for obvious reasons. In addition, there exists very low rate of renewable energy diffusion, poor energy mix, and positive connections between the aforementioned and higher CO₂ emission and economic growth. Thus, suggestion is given to operators, policymakers, and regulatory bodies in the tourism and hospitality industry in Nigeria's energy and environment to properly implement measures that will encourage rapid diffusion of the available clean sources of energy by operators in the hospitality industry to improve the tourism environment in Nigeria and for positive impact on the economy of the country.

In terms of the present study limitations, the conclusions are drawn from single country case, although it is one of the most populous nation in African continent. Thus, inferences and generalization can be made on the theme under consideration. In this study, the tourism-induced pollution nexus while accounting for the pertinent role of energy mix (renewables and non-renewable energy) for the case of Nigeria has a huge tourism potential. However, further study can be conducted for the entire Sub-Saharan African blocs which has received less documentation in the extant literature by applying disaggregated dataset.

Author contribution Ruth Bamidele: contributed to idea conceptualization of the study. Ilhan Ozturk: supervising and manuscript editing. Bright Akwasi Gyamfi: design, analysis, and conclusion. Festus Victor Bekun: literature search.

Declarations

Ethical approval Not applicable.

Consent to participate Not applicable.

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