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ORIGINAL PAPER

Measuring the ecological footprint of inbound and outbound tourists: evidence from a panel of 35 countries

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Abstract

The ecological footprint of tourism is imperative to assess for United Nation's environmental sustainable agenda that is provoked for healthy visitation of tourists without damaging natural environment. This would ultimately reap economic and environmental benefits to sustained international tourism. This study examined the relationship between international tourism indicators, air pollutants, and ecological biodiversity underlying the premises of environmental Kuznets curve in the panel of 35 tourists-induced countries for the period of 1995–2016. The study used panel fixed effect and panel two-stage least square regression technique for robust inferences. The results confirmed the following key points, i.e., (1) the U-shaped relationship found between inbound tourists and mono-nitrogen oxide (NO_x), where inbound tourists initially do not emanate the NO_x emissions, while at the later stages, the level of NO_x emissions substantially raises the required strong policy intervention to reduce emissions and provide tourists safe and healthy destinations, (2) inbound tourists linked with the biodiversity loss, and it increases carbon dioxide (CO_2) emissions and greenhouse gas (GHG) emissions in a panel of countries, (3) trade openness affects ecological footprint and potential habitat area, while it decreases NO_x and SO_2 emissions, (4) international tourists' departure exercised the 'rebound effect' on the ecosystem and air pollutants across countries, (5) there is a monotonic increasing relationship between outbound tourists and ecological footprint, while there is a flat/no relationship between outbound tourists, NO_x, CO_2, SO_2, and GHG emissions, and (6) the food management practices supported the ecological diversity, and it reduces the carbon 'foodprint,' while it substantially increases SO_2 emissions in outbound tourists' model. The study emphasized the need for sustainable tourism infrastructure that conserves our natural environment and reduces climatic variability across the globe.

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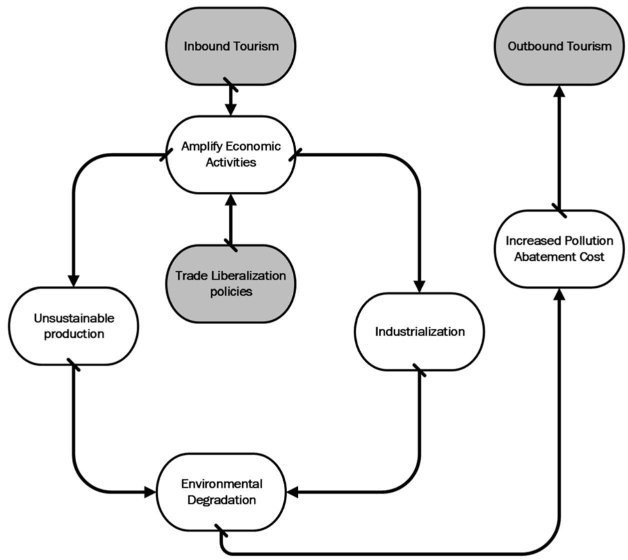
Graphic abstract



Keywords International tourism indicators · Ecological footprint · Mono-nitrogen oxides · Carbon dioxide emissions · Sulfur dioxide emissions · Trade openness

Abbreviations

EKC	Environmental Kuznets curve
EEA	European Environment Agency
CO_2 emissions	Carbon dioxide emissions
SO_2 emissions	Sulphur dioxide emissions
PM_{10}	Particulate matter 10 µm
LCA	Life cycle assessment
EFI	Ecological Footprint Index
EES	Efficient energy saving
LMDI	Logarithmic Mean Divisia Index
EECCB	Energy efficiency in Chinese commercial building
NO_x emissions	Mono-nitrogen oxides
GHG emissions	Greenhouse gas emissions
ECO_FP	Ecological footprint
F_AREA	Forest area
INT_INBOUND	International inbound tourism
INT-OUTBOUND	International outbound tourism
WOOD_FUEL	Wood fuel
TRD_OPEN	Trade openness
PHH	Pollution haven hypothesis
ADF	Augmented Dickey–Fuller
IPS	Im, Pesaran, and Shin
PP test	Philips Perron test
LLC	Levin, Lin, and Chu test
UNEP	United Nations Environment Programme
FE	Fixed effect model
2SLS	Two-stage least squares
SDGs	Sustainable development goals

Introduction

The United Nation Sustainability Development Goals (SDGs) fairly provoked for the transformation of the world with socioeconomic and environmental protection and device 17 SDGs that has to be reached to the countries up to 2030. This study followed the SDGs in heterogeneous panel of countries and focused on three main goals to evaluate country's prosperity over a period of time, i.e., SDG-12 (ensure consumption and production sustainability patterns), SDG-13 (adaptation of climate change policies and its mitigation policies), and SDG-15 (protect forestation, reduced deforestation, manage ecosystem, protect land degradation, and conserve biodiversity). In the given connection, sustainable tourism played a vital role in order to device certain socioeconomic and environmental policies in order to reduce ecological footprints and biodiversity loss. Thus, the relationship between international tourism, air pollutants, and ecological diversity is the complex phenomena, as it is associated with the number of national scale indicators of socioeconomic and environmental sustainability that's influenced by the international inbound tourists and outbound tourists. The European tourism sector is sensitized by air pollutants that affect the biological diversity (EEA

2015). The environmental Kuznets curve (EKC) is vital for the discussion of tourism-induced emissions that required the strong policy vista for conserve the natural environment across the globe (Lee and Brahmasrene 2013).

The EKC hypothesis is imperative to assess country's economic development in environmental protection, and as initial level of economic development, it is expected that higher economic development negatively influenced the country's environment in the form of new toxic air pollutants due to unsustainable industrialization production, while at later stages, it is likelihood that higher economic growth support environmental sustainability agenda by sustainable production and consumption. Thus, EKC hypothesis is deem desirable for evaluating country's environment situation across countries (Stern 2004). This study examined the interlinkages between ecological footprints, different air pollutants, international tourism demand, and growth-specific factors in the panel of 35 heterogonous countries for the period of 1995–2016. The study used nonlinear modeling in order to evaluate different alternative and plausible hypothesis, including, EKC, pollution haven hypothesis (PHH) and food production emissions across countries. This study is unique in many aspects, as previously a very few studies included outbound tourism as a 'rebound effect' on environmental sustainability, while inbound–outbound tourism under EKC hypothesis is fairly unveiled in the previous scholarly work that considered to be filled the existing gap in the literature. The food production emissions assessed with wood fuel hampered the environmental sustainability agenda, which need fair economic and environmental policies to reduce its negative externality to conserve natural flora across countries. The previous studies shed light on the possible linkages between international tourisms, air pollutants, and biodiversity loss, which is compared together in the subsequent section.

International tourism and environmental degradation

The deterioration of environment through ecosystem destruction, natural resource depletion, habitat loss, and new toxic air pollutants led to degrade environment, which need fair policies to adopt sustainable ecosystem policies for conserve natural environment. The relationship between international tourism and environmental degradation is widely discussed in eco-tourism literature. The sustainability agenda is well known for its adaptability and generalizability for environmental protection, while it was largely isolated under the debate of international tourism that considered one of the chief factors to deplete environmental resources through inbound tourism across the globe (Hunter 1997). Hamilton et al. (2005) described the tourists' inflow simulation model by using inbound and outbound tourism data for the year of 1995 for 207 countries. The results show that international tourism will significantly increases in the next coming years; however, the proportion of climatic variability will be less than the percentage changes in the population and economic growth across nations. Kuo and Chen (2009) examined the relationship between tourism and environmental factors by using the 'life cycle assessment (LCA)' model for Penghu Island—Taiwan. The results show that tourists arrival per capita per trip uses 1606 MJ of energy and use water up to 607 L, while it emits around 109,034 g of CO_2, 2660 g of carbon mono NO_x, 597 g of hydrocarbon, and 70 g of mono-nitrogen oxides, respectively. The LCA model will be helpful to reduce excess energy demand and further improve environmental quality, which is helpful for devising sound policy agenda for global sustainable tourism development. Peeters and Dubois (2010) used the simulation technique to evaluate the tourism-induced emissions for the next 30 to 45 years projections and found that global CO_2 emissions will affect by tourists' arrival around 4.4%, while it will further grow till 2035 with the average rate of 3.2% per annum. The policies to reduce air pollution are imperative for the development of sustainable tourism across countries. Taguchi (2012) investigated the EKC curve for SO_2 and CO_2 emissions in Asia and supported the inverted U-shaped relationship for SO_2 emissions, while there is a monotonic increasing function for CO_2 emissions. The results conclude that reduction in the carbon footprint from tourism activities required sound policy vista to devise long-term sustainable policies that should be supportive for balancing the natural ecosystem. Katircioglu (2014) examined the dynamic relationship between tourism, energy demand, and CO_2 emissions in Turkish context and showed that all the variables are connected in the long-run, while in the temporal forecasting modeling, energy demand and tourism both influenced CO_2 emissions. The energy intensification in the tourism industry deteriorates environmental quality in the form of higher carbon emissions that should be reduced by renewable energy sources in a country. Saenz-de-Miera and Rosselló (2014) investigated the relationship between PM_{10} daily concentrations and tourists' arrival in Mallorca, Spain. The results reveal that air pollution is influenced by the daily stock of international tourists, i.e., a 1% increase in the daily stock of international tourists increases the PM_{10} concentration around 0.45 percentage points in a country. The reduction in the pollutant concentration in the air attracts the foreign tourists to increase visitation in the environment-friendly atmosphere, which ultimately gives gains to the country. Tang (2015) examined the relationship between international tourism and environmental degradation in the Heilongjiang Province, China, for the period of 1995–2012. The results show that economic gains and ecological diversity both are the critical factors that required an integrated approach to understand the decoupling relationship between them.

de Vita et al. (2015) examined the long-run relationship between international tourists arrival, per capita income, energy demand, and CO_2 emissions in the context of Turkey and confirmed the carbon-EKC hypothesis in a country. Moreover, international tourists' arrival, per capita income and energy demand significantly increases the CO_2 emissions that should be reduced by sustainable tourism policy agenda at countrywide.

International tourism and biodiversity loss

The impact of tourism activities on biological diversity is the paramount concern for the ecologists and environmentalists to devise a sustainable policy to preserve our natural resources. Ecotourism is the promising solution to reduce biodiversity loss, prevent precious species, natural herbs, rain forests, etc., and for this purpose, it is imperative to limit the tourists' visitation in the sensitive areas, where the natural resources may be exhausted by tourist footprints. Ozturk et al. (2016) investigated the EKC hypothesis for international tourism and ecological footprint in the diversified panel of 144 countries for the period of 1988–2008. The results show that there is an indirect relationship between tourism growth and ecological footprint in the upper-middle and high-income countries, while the prevalence of EKC hypothesis mostly appeared in the panel of upper-middle income countries and high-income countries. Habibullah et al. (2016) considered the large panel of 141 countries to evaluate the possible impacts of tourism activities on biodiversity loss and found that inbound tourism increases the threat to the number of species, including birds, mammals, fishes, and plants, whereas higher per capita income reduces the biodiversity loss. Thus, it is concluded that the gains from international tourism may be used in a more productive way to protect our natural species and ecosystem and promote sustainable tourism across countries. Malik et al. (2016) examined the long-run relationships between international tourism, air pollutants, and biodiversity loss in the context of Austria, while controlling to the other economic factors, including per capita income, population density, food production, and forest area. The results show that international tourists arrival deteriorates the natural environment and potential habitat area, whereas economic growth stimulates international tourism and food production in a country. Thus, it is imperative to conserve biodiversity and improve air quality indicators by sustainable tourism development. Nassani et al. (2017) suggested an integrated economic modeling where international tourism worked as a catalyst to promote socioeconomic considerations and reduces the human costs by involving them through job creation in pleasure destinations to support their livelihoods. This is an implied solution to device a sustained and sustainable tourism policy to reduce human sufferings and promote pro-poor tourism agenda across countries.

There are few more studies that emphasized the need for sustainable environment to reduce negative environmental externality in different economic sectors, i.e., Ma et al. (2017) proposed an efficient energy-saving (EES) technique in the context of China which was previously not measured at national level that account for different psychological and technological factors. The results are calculated on the basis of IPAT and LMDI models and it was found that EES was 165 million tce in the year 2001–2005, 158 million tce in the year 2006–2010, and 127 million tce in the subsequent years, i.e., 2011–2014. The study emphasized the need to calculate EES to aligned with China's EES targets. Ma and Cai (2018) emphasized the need for achievement in energy efficiency in Chinese commercial buildings (EECCB) that account for more than 50% carbon emissions that sabotage the United Nation's sustainability agenda at national level. Thus, the study estimated the EECCB through extended Kaya identity and LMDI technique and found that carbon mitigation up to 625.9 $MtCO_2$ could be achieved by EECCB that is accounted for data quality control and overall energy efficiency achievement in the commercial buildings. Ma et al. (2018) critically reviewed decade analysis of carbon abatement policies for commercial buildings in China and found carbon abatement up to 1596.04 $MtCO_2$ during the year 2001–2015 that is achieved by energy efficiency in the commercial building sector. Ma and Cai (2019) discussed the pathway to reduce carbon emissions through energy conservation mechanism in the Chinese commercial buildings and concluded that the decoupling ordering level is greater in Tianjin, followed by Beijing, Shangai, and Chongqing for the years 2001–2010, while the subsequent years from 2011 to 2015, the decoupling ordering level is greater in Chongqing, followed by Beijing, Tianjin, and Shanghai. Thus, the overall prescribed approach gives fair results in order to carbon mitigation at countrywide. Ma et al. (2019) critically reviewed China civil building Act 2008 that could be achieved with energy efficiency and showed that 183 million tons coal equivalent energy is saved during the year 2011–2015, which needs further revisiting the civil building act with more energy friendly policies. Le et al. (2018) concluded that during roof covering materials in residential building largely encompasses with carbon footprints, which need careful roof design specifications to reduce negative environmental externalities, while Zhang et al. (2019) emphasized the careful need for treating wastewater by the development of an integrated environmental model that could delimit GHG emissions.

Research gap(s)

While reviewing the above-cited literature, the study comes to the conclusion that the previous studies used limited environmental factors and devise on the basis of tourism sustainability agenda, which provoked the need for an integrated environmental modeling for more generalized policy framework. This study takes an initiative to include number of promising environmental factors in an environmental sustainability agenda, including, ecological footprint, biodiversity forest area, mono-nitrous oxides (NO_x), carbon dioxides (CO_2), sulfur dioxides (SO_2), and greenhouse gas (GHG) emissions that are influenced by international tourism development. The previous literature confirmed that ecological footprint is the viable sustainable indicator to assess environmental impacts of tourism across countries (Gössling et al. 2002). The assessment of touristic ecological footprint may be further useful for theoretical underpinning of sustainable tourism agenda to revitalize the global ecotourism process for sustained growth (Hunter 2002). The absence of ecological footprint from the sustainable tourism agenda provides somehow lowest degree of appreciation in the economic development process that influenced the country's resource conservation policies; hence, it is imperative to measure ecological touristic footprint for biological diversification and resource conservation for sustained growth (Hunter and Shaw 2007). The inbound tourism largely puts burden on environment through transportation (see, Martín-Cejas and Sánchez 2010), accommodation, and leisure-based activities; thus, the measurement of ecological footprint of inbound tourists' arrival is substantially imperative for land use management (Peeters and Schouten 2006). The importance of ecological touristic footprint required waste disposal, lowest dependence of fossil fuel, eco-friendly products, and spread general awareness for environmental perseveration; all are prerequisite for global sustainable tourism development. On the basis of significant discussions, the inclusion of ecological footprint in international tourism development provides more policy-oriented debate to conserve natural resources for sustainable economic growth.

The above discussion confirmed the strong correlation between international tourism demand, air pollutants and ecological factors in a panel of countries. This study is different from the previous studies in many aspects, i.e.,

1. The study used international tourism indicators as a proxy for economic growth. The previous studies confirmed that international tourism indicators provide healthy opportunity to the tourists in the pleasure destinations and generating sufficient income, job opportunities, and pro-poor tourism across countries (Mahadevan et al. 2017), while on the other hand, international tourism affected country's economic growth in the form of environmental degradation and provoked the need for global sustainable tourism development (Fairer-Wessels 2017).
2. The current study used international tourists arrivals and international tourists departures in tourism demand modeling that affected resource depletion in the form of ecological footprints and biodiversity loss in a panel of countries.
3. The current study used six diverse environmental factors including ecological footprint, forest area, mono-nitrogen oxides, CO_2 emissions, greenhouse gas emission, and sulfur dioxide emission that is influenced by international tourism indicators.
4. Forest area served as a proxy for 'potential habitat area' and/or 'forest biodiversity'. The basis for this setting is that forests are biologically diverse systems that represents naturally richest biological areas of our globe and offered a wide variety of plant, microorganisms, and animals that exist/habitat in the forest (Convention on Biological Diversity 2016; Ozturk 2016, etc.).
5. The study used first lagged of the tourism indicators, i.e., initial level of international inbound tourists, and initial level of outbound tourists, which facilitate to find out the previous tourism reforms been held across countries.
6. International tourists' departures used for measuring the 'rebound' effect on ecological biodiversity and air pollutants in a panel of countries.
7. The square of the tourism indicators is used to estimate the environmental Kuznets curve (EKC) across countries.
8. The study used trade openness for reviewing the trade liberalization policies, which have a considerable impact on the environment and ecosystems across the globe.
9. The study used wood fuel data to capture the food management policies in the tourists' destinations. The basis for this setting is that wood fuel is used for cooking and heating, especially in the rural areas, where gas and electricity was not here, while the tourists infrastructure mostly built in our rural areas where the scenic beauty attracts the foreign visitors to increase their visitation in smoke free areas; therefore, the wood is the only source to cook food for the tourists in the forest.
10. The study used two distinct models for international tourism coupled with the trade openness and wood fuel that simultaneously impact on ecological biodiversity and air pollutants across countries.

These 10 point distinctions distinguished this study different from the other available studies, which analyzed by the sophisticated panel econometric techniques for robust

Table 1 List of variables

Variables	Measurement	Symbol	Theoretical expectations	Data source
Dependent variables				
Ecological footprints	Hectares	ECO_FP		UNEP (2016)
Forest Area	1000 Hectares	F_AREA		UNEP (2016)
Mono-nitrous oxides	Gigagrams CO_2 equivalent	NO_x		UNEP (2016) and Liu et al. (2016)
Carbon dioxide emissions		CO_2		UNEP (2016)
Greenhouse gas emission		GHG		UNEP (2016)
Sulfur dioxide emission		SO_2		UNEP (2016) and Klimont et al. (2013)
Independent variables				
International inbound tourists	Number of tourist arrivals	INT_INBOUND	Positive	World Bank (2017)
International outbound tourists	Number of tourist departures	INT_OUTBOUND	Positive	World Bank (2017)
Wood fuel	Cubic meters	WOOD_FUEL	Positive	UNEP (2016)
Trade openness	% of GDP	TRD_OPEN	Positive	World Bank (2017)
Miscellaneous variables for testing tourism-induced environmental Kuznets curve				
Square of international inbound tourists	Double the number of tourist arrivals	$(INT\_INBOUND)^2$	Negative	
Square of international outbound tourists	Double the number of tourist departures	$(INT\_OUTBOUND)^2$	Negative	

inferences. The objective of the study is to examine the impact of international tourists' arrivals (and international tourists' departure) on ecological biodiversity and air pollutants under the EKC framework. The more specific objectives are:

- To examine the impact of international tourists' arrival on ecological footprint, forest area, CO_2 emissions, GHG emissions, NO_x and SO_2 emissions under the EKC framework, in the panel of selected tourism-induced countries.
- To analyzed the 'rebound effect' of international tourists' departure on ecological footprint, forest area, CO_2 emissions, GHG emission, NO_x and SO_2 emissions under the premises of EKC framework.
- To what extent trade liberalization policies influenced the ecological footprint, forest area, CO_2 emissions, GHG emissions, NO_x and SO_2 emissions.
- How much changes have been observed in the ecological footprint, forest area, CO_2 emissions, GHG emissions, NO_x and SO_2 emissions due to the usage of wood fuel in the tourists' destinations.

These objectives empirically measured by the panel fixed effect regression and panel two-stage least square regression techniques for conclusive findings are helpful to draw the sustainable tourism policy framework in a panel of selected countries.

Data source and methodological framework

The study focused on the antecedents of international tourism, ecosystems, and air pollutants which is measured by the number of key socioeconomic and environmental factors including international inbound tourists (international tourists' arrival)—people in numbers, international outbound tourists (international tourists' departure)—people in numbers, ecological footprint in hectares, forest area in 1000 hectares (served as a proxy for 'potential habitat area' and/or 'forest biological diversity'), wood fuel in cubic meters (served as a proxy for food management practices in the tourists' destinations), trade openness as percentage of GDP, NO_x, GHG emissions, CO_2 emissions, and SO_2 emissions used in the gigagrams CO_2 equivalent, respectively. Table 7 shows the list of sample countries in appendix for ready reference. The interpolation technique is used to fill the missing gaps between the time series of the studied variables. The data set of the variables is taken from 1995 to 2016 and has been obtained from the UNEP (2016) and World Bank (2017) databases. Table 1 shows the list of the studied variables and their expected relationships between them.

Table 1 shows the following hypothetical relationships between the variables, i.e., tourism indicators include both the international inbound tourists and international outbound tourists with their square terms helpful to validate the EKC hypothesis, i.e., inverted U-shaped relationship between the environmental factors and tourism indicators in the panel of countries. The tourism-induced EKC hypothesis would be evaluated on the basis of nominal terms of inbound–outbound tourism and its second-order coefficient values, i.e., at initial level, we expect that inbound–outbound tourism increases the concentration of air pollutants due to unsustainable production, while the second-order coefficient of tourism factors would be negative due to sustainable reforms across countries. Thus, we would be substantiating tourism-induced EKC that is estimated by panel FE and panel 2SLS models. Moreover, the study hypothesizes that wood fuel and trade openness both damage the natural environment in the form of ecological footprints, potential habitat loss, and raising the tropospheric ozone, carbon emissions and sulfur dioxide emissions. The basis for this setting is that wood fuel damages the natural environment in the form of forest depletion (Sulaiman et al. 2017), while traditional cooking stove led to serve different health-related diseases to the humans and made an influential factor for climatic change (Miah et al.2009). In this study, we used trade openness to assess the impact of technological advancement on environmental deterioration, as higher the technological advancement in a country, greater will be the trade that may affect the natural environment to support 'pollution haven hypothesis.' The larger number of studies confirmed the damaging effects of trade openness on environment through the mechanism of 'pollution haven hypothesis' where dirty polluting industries made an investment in the developing countries to enjoy ease of environmental less regulations for their production, which deteriorate natural environment across the globe (see, Zaman and Abd-el Moemen 2017; Ahmed et al. 2017, etc.).

The study has some novel contributions that makes it distinct from other previous studies related to sustainable tourism; at first ecological footprint of tourism is assessed by different air pollutants, forest area, food production, trade openness and inbound and outbound tourism; further the measurement of ecological footprints of tourism is evaluated under curvilinear relationship between tourism factors and ecological factors that are mainly ignored in the previous studies (Zaman et al. 2016). The previous studies majorly worked on EKC with respect to ecological footprint and per capita income, which does not truly represent the gist of sustainable tourism under ecological footprints made by international tourists (Ozturk et al. 2016; Bella 2018, etc.), while this study used inbound and outbound tourism as a proxy for country's economic growth and validated the EKC hypothesis with respect to ecological footprint and international tourism factor that gives robust inferences in the field of sustainable tourism. The study assessed 'pollution haven hypothesis' with respect to trade openness and ecological factors, while food production and ecological footprint nexus also evaluated to check the 'foodprint' across countries that we believe filled the gap of literature in the existing work of sustainable tourism.

It is evident that human actions largely affected the environment in the form of natural resource depletion, increase in air pollutants, water pollution, loss of biodiversity, etc. (Zaman 2017). Therefore, it is imperative to devise policies to support sustainable tourism for economic and healthier gains. The Solow model is considered the good reference point to start any growth model, which is simple and abstract representation for the complex economy, besides that it represents the 'dynamic general equilibrium model.' The 'Green Solow' model is used by environmentalists to interlink 'Environmental Kuznets Curve (EKC)' with 'macroeconomics' modeling, as it is by-product to converge technological progress into sustainable growth path (Brock and Taylor 2010). On the basis of its significance, this study used Solow growth model to decompose the functional relationship between air pollutants and international tourism with some controlled variables. The Solow growth model focused on country's output, country's factors of production, and the amount of technology used by the country to perform their economic functions for healthier gains. The famous Solow's identity in the form of production function is as follows:

$$Y_t = f(K_t, A_t \times L_t) \tag{1}$$

where 'Y,' 'K,' 'A' and 'L' shows country's economic output, capital, technology, and labor, respectively. The multiplicative form of '$A \times L$' shows the 'effective labor' that provoked the effectiveness of technology to boost labor productivity under the country's given technological knowledge, which augment the output accordingly. The subscript 't' shows that the production or economic output obtained from given country's factor of production rises over time.

It is evident that natural and land resources does not incorporated by Solow in the growth accounting matrix due to the reason that the amount of land and natural resources remains fixed over a period of time, so ever-increasing efforts to increase country's production or economic output deplete the country's existing environmental resources. Hence, it is imperative to conserve our resources by sustainable growth policies. We extend our analysis to add up different environmental factors in the growth account matrix to observe the impact of different growth-related factors that influenced the air quality indicators, i.e.,

$$E_t = A I_t^{\alpha} W_t^{\beta} T_t^{\gamma} \varepsilon_t \tag{2}$$

The study further decomposed Eq. (2) into the nonlinear regression equation, i.e.,

$$\ln E_{it} = \ln A_{it} + \alpha \ln I_{it} + \beta \ln W_{it} + \gamma \ln T_{it} + \ln \varepsilon_{it} \tag{3}$$

Differentiating Eq. (3) with 't,' we have the growth rate of the following equation, i.e.,

$$\frac{1}{E_{it}}\frac{\mathrm{d}E_{it}}{\mathrm{d}t} = \frac{1}{A}\frac{\mathrm{d}A_{it}}{\mathrm{d}t} + \alpha\frac{1}{I}\frac{\mathrm{d}I_{it}}{\mathrm{d}t} + \beta\frac{1}{W}\frac{\mathrm{d}W_{it}}{\mathrm{d}t} + \gamma\frac{1}{T}\frac{\mathrm{d}T_{it}}{\mathrm{d}t} + \frac{1}{\varepsilon}\frac{\mathrm{d}\varepsilon_{it}}{\mathrm{d}t} \tag{4}$$

where 'E' shows different air pollutants, 'A' indicates technology that assume constant over a period of time, 'I' shows international tourism indicators including both the inbound tourism and outbound tourism, 'T' indicates trade openness, 'ln' indicates natural logarithm, 'i' shows panel of countries, i.e., 'i' = 1…35; 't' indicates time period, i.e., 't' = 1995–2016, and ε indicates error term.

Equation (4) is further decomposed into more specific form by estimating the nonlinear relationship between tourism indicators and selected environmental factors under the applications of EKC hypothesis, which specified two distinct tourism models, i.e.,

Model 1: Relationship between International Inbound Tourists and Environmental Pollutants

$$\begin{aligned}\ln(\text{ECO\_FP})_{i,t} = \beta_0 + \beta_1 \ln(\text{INT\_INBOND})_{i,t-1} \\ + \beta_2 \ln(\text{INT\_INBOND})^2_{i,t} \\ + \beta_3 \ln(\text{WOOD\_FUEL})_{i,t} \\ + \beta_4 \ln(\text{TRD\_OPEN})_{i,t} + \varepsilon_{i,t}\end{aligned} \tag{5}$$

$$\begin{aligned}\ln(\text{F\_AREA})_{i,t} = \beta_0 + \beta_1 \ln(\text{INT\_INBOND})_{i,t-1} \\ + \beta_2 \ln(\text{INT\_INBOND})^2_{i,t} \\ + \beta_3 \ln(\text{WOOD\_FUEL})_{i,t} \\ + \beta_4 \ln(\text{TRD\_OPEN})_{i,t} + \varepsilon_{i,t}\end{aligned} \tag{6}$$

$$\begin{aligned}\ln(\text{NO}_x)_{i,t} = \beta_0 + \beta_1 \ln(\text{INT\_INBOND})_{i,t-1} \\ + \beta_2 \ln(\text{INT\_INBOND})^2_{i,t} \\ + \beta_3 \ln(\text{WOOD\_FUEL})_{i,t} \\ + \beta_4 \ln(\text{TRD\_OPEN})_{i,t} + \varepsilon_{i,t}\end{aligned} \tag{7}$$

$$\begin{aligned}\ln(\text{CO}_2)_{i,t} = \beta_0 + \beta_1 \ln(\text{INT\_INBOND})_{i,t-1} \\ + \beta_2 \ln(\text{INT\_INBOND})^2_{i,t} \\ + \beta_3 \ln(\text{WOOD\_FUEL})_{i,t} \\ + \beta_4 \ln(\text{TRD\_OPEN})_{i,t} + \varepsilon_{i,t}\end{aligned} \tag{8}$$

$$\begin{aligned}\ln(\text{GHG})_{i,t} = \beta_0 + \beta_1 \ln(\text{INT\_INBOND})_{i,t-1} \\ + \beta_2 \ln(\text{INT\_INBOND})^2_{i,t} \\ + \beta_3 \ln(\text{WOOD\_FUEL})_{i,t} \\ + \beta_4 \ln(\text{TRD\_OPEN})_{i,t} + \varepsilon_{i,t}\end{aligned} \tag{9}$$

$$\begin{aligned}\ln(\text{SO}_2)_{i,t} = \beta_0 + \beta_1 \ln(\text{INT\_INBOND})_{i,t-1} \\ + \beta_2 \ln(\text{INT\_INBOND})^2_{i,t} \\ + \beta_3 \ln(\text{WOOD\_FUEL})_{i,t} \\ + \beta_4 \ln(\text{TRD\_OPEN})_{i,t} + \varepsilon_{i,t}\end{aligned} \tag{10}$$

Model 11: Relationship between International Outbound Tourists and Environmental Pollutants

$$\begin{aligned}\ln(\text{ECO\_FP})_{i,t} = \beta_0 + \beta_1 \ln(\text{INT\_OUTBOND})_{i,t-1} \\ + \beta_2 \ln(\text{INT\_OUTBOND})^2_{i,t} \\ + \beta_3 \ln(\text{WOOD\_FUEL})_{i,t} \\ + \beta_4 \ln(\text{TRD\_OPEN})_{i,t} + \varepsilon_{i,t}\end{aligned} \tag{11}$$

$$\begin{aligned}\ln(\text{F\_AREA})_{i,t} = \beta_0 + \beta_1 \ln(\text{INT\_OUTBOND})_{i,t-1} \\ + \beta_2 \ln(\text{INT\_OUTBOND})^2_{i,t} \\ + \beta_3 \ln(\text{WOOD\_FUEL})_{i,t} \\ + \beta_4 \ln(\text{TRD\_OPEN})_{i,t} + \varepsilon_{i,t}\end{aligned} \tag{12}$$

$$\begin{aligned}\ln(\text{NO}_x)_{i,t} = \beta_0 + \beta_1 \ln(\text{INT\_OUTBOND})_{i,t-1} \\ + \beta_2 \ln(\text{INT\_OUTBOND})^2_{i,t} \\ + \beta_3 \ln(\text{WOOD\_FUEL})_{i,t} \\ + \beta_4 \ln(\text{TRD\_OPEN})_{i,t} + \varepsilon_{i,t}\end{aligned} \tag{13}$$

$$\begin{aligned}\ln(\text{CO}_2)_{i,t} = \beta_0 + \beta_1 \ln(\text{INT\_OUTBOND})_{i,t-1} \\ + \beta_2 \ln(\text{INT\_OUTBOND})^2_{i,t} \\ + \beta_3 \ln(\text{WOOD\_FUEL})_{i,t} \\ + \beta_4 \ln(\text{TRD\_OPEN})_{i,t} + \varepsilon_{i,t}\end{aligned} \tag{14}$$

$$\begin{aligned}\ln(\text{GHG})_{i,t} = \beta_0 + \beta_1 \ln(\text{INT\_OUTBOND})_{i,t-1} \\ + \beta_2 \ln(\text{INT\_OUTBOND})^2_{i,t} \\ + \beta_3 \ln(\text{WOOD\_FUEL})_{i,t} \\ + \beta_4 \ln(\text{TRD\_OPEN})_{i,t} + \varepsilon_{i,t}\end{aligned} \tag{15}$$

$$\begin{aligned}\ln(\text{SO}_2)_{i,t} = \beta_0 + \beta_1 \ln(\text{INT\_OUTBOND})_{i,t-1} \\ + \beta_2 \ln(\text{INT\_OUTBOND})^2_{i,t} \\ + \beta_3 \ln(\text{WOOD\_FUEL})_{i,t} \\ + \beta_4 \ln(\text{TRD\_OPEN})_{i,t} + \varepsilon_{i,t}\end{aligned} \tag{16}$$

where ECO_FP indicates ecological footprints, F_AREA indicates forest area, NO_x indicates mono-nitrogen oxides, CO_2 indicates carbon dioxide emissions, GHG indicates greenhouse gas emissions, SO_2 indicates sulfur dioxide emissions, INT_INBOUND indicates international inbound tourists, INT_OUTBOUND indicates international outbound tourists, WOOD_FUEL indicates wood fuel, TRD_OPEN indicates trade openness, 'i' indicates cross section identifiers, i.e., 35 countries, 't' indicates time period from 1995 to 2016, '$t-1$' indicates first lag of the respective variables, 'ln' indicates natural logarithm, and ε indicates white noise error term.

Equations (5) to (16) estimated curvilinear relationship between ecological factors (CO_2, SO_2, GHG, NO_x, and forest area) and inbound–outbound tourism and may derive one of the policy result, i.e., whether ecological footprint confirmed the inverted U-shaped relationship between them (when $\beta_1 < 0$ and $\beta_2 > 0$) or U-shaped relationship between ecological footprint (CO_2, SO_2, GHG, NO_x, and forest area) and inbound–outbound tourism (when $\beta_1 > 0$ and $\beta_2 < 0$) or flat relationship between them (when $\beta_1 = 0$ and $\beta_2 = 0$). Further, the positive expected relationship between wood fuel and ecological footprints substantiates the 'foodprint' (when $\beta_3 > 0$). The positive relationship between the trade openness and ecological footprint (CO_2, SO_2, GHG, NO_x, and forest area) confirmed the 'pollution haven hypothesis' (when $\beta_4 > 0$) across countries.

These variables selected because of the widely used indicators in terms of evaluating the impact of international tourism indicators on environmental factors in the previous studies, i.e., Peeters and Schouten (2006) analyzed the influence of inbound tourists on ecological footprints and argued that the total ecological footprint of inbound tourists was 1.42 million hectares in Amsterdam. Kitzes et al. (2009) emphasized the need to develop a sound 'National Ecological Footprint accounting method' that identifies the possible improvement in the ecological footprints statistics across the globe. Dwyer et al. (2010) examined the tourism-induced emissions frequency that contributed around 3.9–5.3% of total industry's GHG emissions in Australia. Perch-Nielsen et al. (2010) concluded that air transport among all the tourisms' sub-sectors exerts more than 80% of GHG gas emissions in Switzerland. Gössling et al. (2011) emphasized the need to refine the tourisms' food management policies for substantial reducing the global carbon 'foodprints.' These cited studies confirmed the strong linkages between tourism activities, ecosystems and air pollutants across the globe. On the basis of significant discussions, the present study hypothesized the following research questions, i.e.,

H1 Is EKC hypothesis valid for international tourists' arrival (inbound tourism) in the panel of selected countries?

H2 Does EKC hypothesis supported international tourists' departure?

H3 Whether trade liberalization policies are harmful to the global environment and ecosystem? and

H4 Does wood fuel (used for food production and consumption) entail the higher global GHG emissions?

These research questions are evaluated by the sophisticated econometric techniques to infer the robust parameter estimates for policy implications.

Results and discussion

Summary of panel unit root estimates

Table 2 shows the summary of the different panel unit root tests for the ready reference, while Table 8 shows the descriptive statistics in appendix. The results show that CO_2 emission is differenced stationary in all the prescribed panel unit root tests, excluding PP Fisher Chi-square test, where this relationship is level stationary. In case of GHG emissions, both the IPS and ADF Fisher Chi-square test confirm that the given variables are differenced stationary; however, the remaining two panel unit root tests including PP Fisher unit root test and LLC test signify that the GHG emissions are level stationary. Therefore, there is mixed order of integration found for GHG emissions in the different panel unit root tests.

Table 2 further shows that NO_x is differenced stationary in the entire prescribed panel unit root testing procedures. The SO_2 emission is stationary at level, as all the panel unit root tests confirmed the significance of this variable at 1% level. Therefore, the order of integration for NO_x is I(1) and SO_2 is I(0) variables. The ecological footprint and forest area both exhibit the differenced stationary series, except PP Fisher Chi-square test; similarly trade openness shows differenced stationary series, except in the LLC panel unit root test. The data for wood fuel is stationary at level in ADF and PP Fisher Chi-square tests, while LLC and IPS tests confirmed the different stationary series. The inbound tourists and outbound tourists are highly volatile in nature, and it becomes stationary at their first difference. The overall result of the panel unit root tests confirmed the differential results in diverse panel unit root testing procedures, which is quite visible to follow the long-run cointegration process by Johansen Fisher panel cointegration test. Figure 1 shows the data trend for the studied variables for the ready reference.

Panel cointegration estimates

Tables 3 and 4 show the Johansen Fisher panel unit root tests for international inbound tourists and international outbound tourists, coupled with the explanatory variables. The results of Table 3 show the four cointegration equations with the 'response' variables. The results confirmed that all the six series/equations in the Model-1 exhibit the cointegration relationship between the variables that indicate the

Table 2 Summary of panel unit root tests

Methods	CO_2 (gigagrams CO_2 equivalent)	GHG (gigagrams CO_2 equivalent)	NO_x (gigagrams CO_2 equivalent)	SO_2 (gigagrams CO_2 equivalent)	ECO_FP (hectares)	F_AREA (thousand hectares)	TRD_OPEN (% of GDP)	WOOD_FUEL (cubic meters)	INT_INBOUND (number of tourist arrivals)	INT_OUTBOUND (number of tourist departures)
Level										
Levin, Lin & Chu t*	−0.853	−1.457***	−.0518	−11.249*	2.840	−1.085	−3.102*	−5.043*	−1.107	2.815
Im, Pesaran and Shin W-stat	0.084	0.493	4.507	−4.370*	2.849	2.724	0.186	0.697	2.432	12.240
ADF—Fisher Chi-square	85.908	83.594	38.836	225.843*	53.062	52.241	67.579	87.382***	54.347	61.949
PP—Fisher Chi-square	95.055**	111.363*	43.866	198.362*	112.411*	199.362*	49.355	407.924*	53.443	64.756
First difference										
Levin, Lin & Chu t*	−5.144*	−5.671*	−7.731*	−6.937*	−11.927*	−3.315*	−15.235*	−5.131*	−10.045*	1.796
Im, Pesaran and Shin W-stat	−7.823*	−8.145*	−9.227*	−7.730*	−13.893*	−0.390	−11.290*	−7.612*	−9.060*	−0.533
ADF—Fisher Chi-square	186.757*	192.774*	220.513*	185.671*	311.104*	54.863	254.874*	183.680*	208.894*	179.398*
PP—Fisher Chi-square	412.106*	456.689*	482.913*	567.048*	1292.77*	53.198	487.627*	368.388*	374.043*	360.204*

*, **, and *** indicates significance at 1%, 5%, and 10% level, respectively

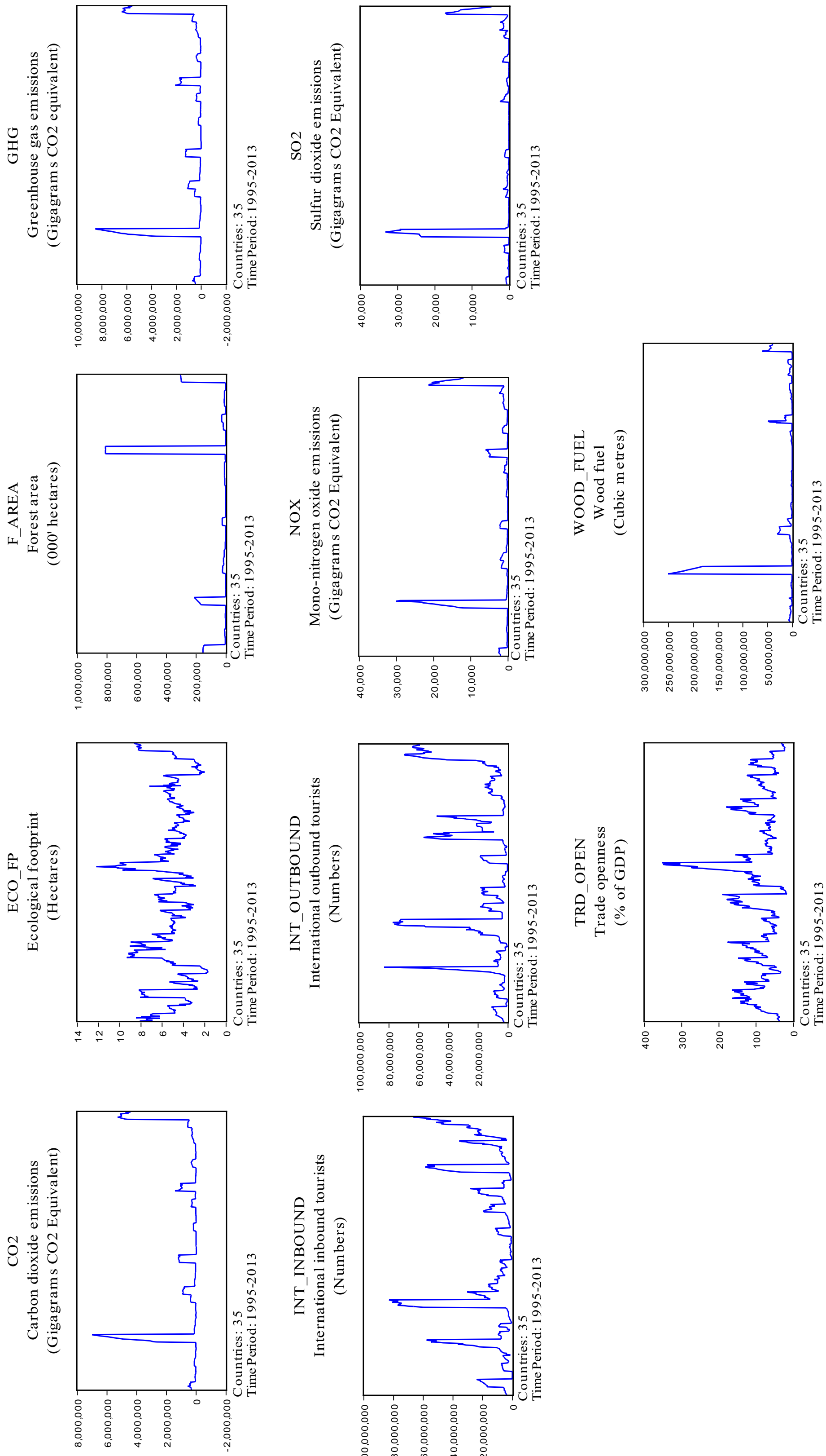


Fig. 1 Level plots of the variables. *Source:* UNEP (2016) and World Bank (2017)

Table 3 Johansen fisher panel cointegration test for Model-1

Number of cointegrating equations	Equation (5) Trace test	Equation (6) Trace test	Equation (7) Trace test	Equation (8) Trace test	Equation (9) Trace test	Equation (10) Trace test
None	576.1*	619.6*	535.6*	556.3*	526.4*	600.2*
At most 1	211.3*	301.0*	243.5*	234.8*	227.9*	285.4*
At most 2	110.3*	163.7*	125.4*	124.9*	110.7*	175.1*
At most 3	97.20**	111.5*	129.5*	112.5*	127.5*	143.7*

* and ** indicates 1% and 5% significance level, respectively

Table 4 Johansen fisher panel cointegration test for Model-11

Number of cointegrating equations	Equation (11) Trace test	Equation (12) Trace test	Equation (13) Trace test	Equation (14) Trace test	Equation (15) Trace test	Equation (16) Trace test
None	575.9*	596.9*	572.7*	585.8*	592.0*	717.5*
At most 1	224.3*	257.7*	228.3*	247.5*	243.0*	287.9*
At most 2	115.2*	147.0*	129.8*	131.7*	127.9*	167.9*
At most 3	104.8*	108.4*	120.6*	113.3*	123.3*	138.3*

* indicate 1% significance level

importance of these variables connected in the long-run process to deduce the policy formulation for the given region.

Table 4 shows the Johansen Fisher panel cointegration test for Model-11 and found that all the six series of the given model confirmed the cointegration relationship between the variables, having 4 cointegration equations between them. The results specify that trace statistics signify their relationship in the given model that is failure to accept the null hypothesis of ‘no cointegration’ against the alternative ones. The overall results show that the selected variables are connected over the long-run process; therefore, it is required to estimate their parameter values in order to find the conclusive policy formulation across the globe.

Estimates of panel fixed effect and panel 2SLS models

Table 5 shows the results of panel fixed effect regression and panel 2SLS regression for addressing the country specific shocks and possible endogeneity from the Model-1. The result does not support the inverted U-shaped relationship between ecological footprint and international inbound tourists, as the coefficient value of inbound tourists does not signify their impact on ecological footprint; however, doubling the international tourist’s arrival has a direct and significant impact on ecological footprint in a panel of countries. It is evident that if the international tourists exhaust the economic resources in a way of depleting natural resources, then the ‘United Nation convention of biological diversity’ and ‘Kyoto protocol’ could not be achieved and/or implemented in an ineffective way; then, it would damage the global environment. The results imply that international inbound tourists associated with the disturbance of ecosystem, as it puts the burden on the natural ecological system. Similarly, the trade openness increases the ecological footprint across countries. The results argued that trade liberalization policies seems to be dangerous for conservation of natural resources and if the trade policies would not be devised in a way for sustainable production and consumption, then the environmental consideration will always be on stake and the ‘dirty polluting industries’ may emerge that affect the sustainability agenda across countries. Lin et al. (2018) concluded that tourist ecological footprints in the city largely created traffic intensity, shopping frequency, overburden on cultivated land, and ecosystem footprint that create severe problem of country’s sustainability agenda. Tang et al. (2018) emphasized the need for ecological-based tourism infrastructure for conserving ecosystem diversity that is imperative for green development. Katircioglu et al. (2018) confirmed that sustainable tourism infrastructure improves environmental quality that is helpful to reduce ecological footprint globally.

The study used ‘forest area’ in a next regression apparatus, which served as a proxy for the ‘forest biological diversity’ or in a simple manner, we called it the ‘potential habitat area.’ The result does not support the inverted U-shaped relationship between forest area and international inbound tourists, as the coefficient of inbound tourist is statistically insignificant; however, doubling the inbound tourists has a significant and positive impact on forest area. Moreover, trade openness and wood fuel both directly influenced the

Table 5 Panel fixed effect and panel 2SLS regression for Model-1

Variables	Log(ECO_FP)		Log(F_AREA)		Log(NO_x)		Log(CO_2)		Log(GHG)		Log(SO_2)	
	Fixed Effect	2SLS	Fixed Effect	2SLS	Fixed Effect	2SLS	Fixed Effect	2SLS	Fixed Effect	2SLS	Fixed Effect	2SLS
Constant	−0.993*	−1.089*	7.860*	7.856*	10.073*	10.387*	11.515*	11.169*	8.876*	10.112*	18.366*	18.971*
Log(INT_INBOUND)$_{t-1}$	0.047	0.049	0.009	0.009	−0.126*	−0.129*	−0.028	−0.032	−0.017	−0.018	−0.220	−0.229
Log(INT_INBOUND)^2	0.003*	0.003**	0.001*	0.001*	0.005*	0.005*	0.004**	0.004*	0.011*	0.034*	−0.002	0.0001
Log(TRD_OPEN)	0.174*	0.222*	0.047*	0.066*	−0.448*	−0.550*	−0.003	−0.007	−0.006	−0.010	−1.256*	−1.613*
Log(WOOD_FUEL)	0.013	0.010	0.007*	0.003	−0.112*	−0.115*	−0.021*	−0.024*	−0.012*	−0.015*	−0.255*	−0.223*
Statistical tests												
R-squared	0.939	0.939	0.99984	0.99984	0.9948	0.9947	0.986	0.987	0.999	0.9948	0.968	0.967
Adjusted R-squared	0.935	0.935	0.99983	0.99982	0.9945	0.9943	0.985	0.986	0.995	0.9946	0.965	0.965
F-statistics	229.024*	228.894*	92,477.50*	92,072.94*	3830.542*	2703.094*	1265.981*	1032.342*	2012.343*	1756.545*	444.748*	434.957*

'Log' indicates natural logarithm. *, **, and *** indicates significance at 1%, 5%, and 10% level, respectively

'potential habitat area' in the panel fixed effect regression; however, the coefficient value of wood fuel does not signify their relationship in the panel 2SLS regression. The impact shows that trade and wood fuel both damage the forest biodiversity and if trade factor and wood fuel dependency would not offset then the biodiversity richness will be at risk and it may destroy the species and new herbs. The policies should be made for preservation of our natural ecological base that has been affected by the excessive number of international tourists' arrival across countries (Gössling et al. 2002). Brandt and Buckley (2018) confirmed the negative externality of ecotourism on forest biodiversity loss and confined the need for sustainable tourism policies in order to conserve natural environment through research and development, information technologies, and knowledge sharing system globally. Ali et al. (2018) concluded that macroeconomic shocks contemporaneous have a negative impact on tourism development that need fair economic and environmental policies to delimit the negative shocks and give positive impact on country's tourism development agenda.

The study used tropospheric ozone emissions, i.e., mono-nitrogen oxides (NO_x) in the next regression apparatus. The results confirmed the U-shaped relationship between NO_x and international inbound tourists, i.e., initially inbound tourism reduces the NO_x emissions while at the later stages it escalates NO_x emissions. The results convey that inbound tourism increases NO_x emissions at the later stages of economic development that required the environment-friendly policies to reduce air emissions to support sustainable development in a country. Trade and wood fuel, both the variables significantly decreases the amount of NO_x emissions from the atmosphere. The results imply that trade liberalization policies and food management (or wood fuel management) in the tourists destinations support to reduce the NO_x emissions across countries (World Health Organization 2006). Zhou et al. (2018) concluded that inbound tourism affiliated with high mass emissions of air pollutants that required strict environmental regulations to conserve the natural heritage. Ahmad et al. (2018) confirmed the direct relationship between tourism development and environmental degradation that need green tourism policies to respond United Nation global sustainability development agenda.

Table 5 further shows the influence of international inbound tourists on CO_2 emissions, and it does not confirm the inverted U-shaped relationship between carbon emissions and international tourists' arrival, i.e., initial level of inbound tourism does not have significant relationship with the carbon emissions, while at later stages of tourism development, CO_2 emissions significantly rise, over the period of time. The impact of inbound tourism on carbon emissions at later economic stages emphasized the need for carbon-free policies that attract the tourists to increase visitation at safe and healthy environment, which ultimately support the country's developmental projects. The wood fuel management, however, significantly decreases the carbon emissions. The policies should be formulated in order to lessen the carbon emissions from the tourism development across the globe (Lee and Brahmasrene 2013). In the next regression apparatus, the results do not validate the inverted U-shaped relationship between GHG emissions and inbound tourists, as initial level of tourism development does not have a significant impact on the GHG emissions, while at the later stages of tourism development, GHG emissions significantly escalate, over the period of time. Thus, if climatic variability in the form of massive GHG emissions could not mitigate, then the problem of massive emissions, health issues, food challenges, and water resources will be cumbersome to the country's sustainability agenda, which will damage the country's natural resources and green tourism agenda globally. The results show that food management in the tourists' destinations reduces the GHG emissions that indicate the importance of food trajectory in the global climate footprints to mitigate environmental issues (Gössling et al. 2011). Finally, the study does not confirm the EKC hypothesis for SO_2 emissions and inbound tourists in a panel of countries. Besides that, trade openness and wood fuel both significantly decrease the concentration of SO_2 emissions from the atmosphere. The wood fuel management is desirable for mitigating SO_2 emissions in the tourist destination (Skog and Rosen 1997). Jovicic (2019) emphasized the need to change the conventional understanding of tourism with new emerging perceptive of smart tourism destination, which would fully interact with e-tourism, knowledge-based tourism, public–private collaboration, etc. Kiráľová (2019) argued that sustainable tourism marketing is the viable policy instrument in order to conserve natural fauna and flora of the country. Cooper et al. (2019) concluded that tourism governance is imperative to intact with the stakeholders in order to design tourism-based policies related to innovation and financing for long-term growth. The remaining statistical results verify the goodness -of -fit for the models, and stability of the models.

Table 6 shows the panel fixed effect and panel 2SLS regression for Model-11. The results show that there is a monotonic increasing function between ecological footprint and initial level of international outbound tourists which implies that the previous reforms being held for managing the outbound tourists were not appreciated that exhausted the natural ecosystem in the panel of selected countries. In addition, trade liberalization policies subsequently damage the natural ecosystem that required an urgent wakeup call to the policy makers for devising the sound policy vista to preserve the natural ecological base. In the next regression, forest area is influenced by the outbound tourists, which verify the positive association between the two variables at initial and later stages

Table 6 Panel fixed effect and panel 2SLS for Model-11

Variables	Log(ECO_FP)		Log(F_AREA)		Log(NO_x)		Log(CO_2)		Log(GHG)		Log(SO_2)	
	Fixed Effect	2SLS	Fixed Effect	2SLS	Fixed Effect	2SLS	Fixed Effect	2SLS	Fixed Effect	2SLS	Fixed Effect	2SLS
Constant	−0.814*	−0.968*	7.625*	7.607*	9.181*	9.479*	12.121*	12.887*	11.121*	12.990*	6.523**	6.701**
Log(INT_OUTBOUND)$_{t-1}$	0.051***	0.049***	0.029*	0.029*	−0.026	−0.023	−0.031	−0.034	−0.019	−0.021	−0.090	−0.091
Log(INT_OUTBOUND)^2	−0.0002	−0.0001	0.0004**	0.0004***	0.001	0.002	0.004	0.007	−0.002	−0.004	0.014	0.014
Log(TRD_OPEN)	0.295*	0.349*	0.076*	0.091*	−0.431*	−0.528*	0.027	0.033	0.029	0.032	−1.886*	−1.912*
Log(WOOD_FUEL)	0.017	0.015	0.008*	0.005	−0.110*	−0.108*	−0.047*	−0.038*	−0.049*	−0.038**	0.327*	0.327*
Statistical Tests												
R-squared	0.930	0.930	0.99984	0.99984	0.9947	0.9946	0.984	0.985	0.996	0.9944	0.613	0.613
Adjusted R-squared	0.925	0.925	0.99983	0.99983	0.9943	0.9943	0.983	0.984	0.994	0.9940	0.610	0.610
F-statistics	196.171*	194.431*	94,439.89*	92,285.92*	2751.7483*	2701.285	1123.4344*	1098.9878*	22,121.12*	19,909.223*	234.179*	233.435*

'Log' indicates natural logarithm. *, **, and *** indicates significance at 1%, 5%, and 10% level, respectively of economic development. The results imply that forest biological diversity is affected by the previous reforms that were proposed to reduce the after-effects of outbound tourists across countries. The impact of tourism development on forest biodiversity and ecological footprint could be serious when the human-made actions destroy the natural habitat that intensify the air pollution and food securities issues across the globe. The trade liberalization policies should be flexible for balancing the potential habitat areas for the growth of species. The relationship between NO_x and outbound tourists confirmed the flat/no relationship between them, while this relationship is supported by the trade policies and food management, as both significantly reduces the tropospheric concentration across countries. The policies to strengthen the tourism reforms for outbound tourists required the sustainable tourism agenda across countries. The results are linked with the previous studies of Hall (2019) that emphasized the need for sustainable tourism infrastructure in order to comply with United Nation sustainable development goals of poverty reduction, while Asmelash and Kumar (2019) indicated the need for stakeholders participation in sustainable tourism policies for proposing good indicators for sustainable tourists' movement across countries. Pulido-Fernández et al. (2019) discussed the risk dimension of environmental degradation in order to expand tourism infrastructure, which would be controlled by regulatory measures.

The results of Table 6 further specify the relationship between CO_2 emissions and outbound tourist and conclude that there is no/flat relationship between them. Trade factor also does not hold the significant relationship with the CO_2 emissions; however, wood fuel significantly decreases the carbon emissions in a panel of countries. The study highlighted the need for ecotourism that absorb the after-effects of international tourism across the globe (Stolton et al. 2015). The similar results have been obtained in relationship with the GHG emissions and outbound tourism, as both the variables does not show any significant relationship between them. Wood fuel significantly associated with the decreasing GHG emissions, while trade doesn't exhibit the significant relationship with the GHG emissions across countries. The policies should be made to reduce climate change variability due to the after-effects of international tourists' departures in the panel of countries (see, Aryal 2008). Finally, the study shows the flat/no relationship between SO_2 emissions and international outbound tourists, coupled with the trade liberalization policies that support to lessen sulfur dioxide emissions, while wood fuel substantially increases SO_2 emissions in a panel of countries. The dependency of wood fuel puts a strain on the economy, as it escalates the global air pollutants; hence, it is imperative to devise sustainable policy instruments to reduce air emissions by using biofuel as energy source for household and commercial usage. The other statistical tests indicate the goodness of fit for the models and stability for the models accordingly.

Conclusions

This study measured the dynamic impact of international tourism indicators on ecosystem and air pollutants in the panel of 35 tourism-induced countries, over the period of 1995–2016. The study used two broad tourism indicators, i.e., international tourists arrival and international tourists departure; two ecological indicators, i.e., ecological footprint and forest area; and four diverse air pollutants, i.e., NO_x, GHG emissions, CO_2 emissions, and SO_2 emissions for robust inferences. The study used all these variables in the premises of environmental Kuznets curve (EKC) by taking an initial level of tourism indicators (i.e., first lagged of the indicators) for assessing the previous tourism reforms that were held across countries, while the square of the tourism indicators is used for evaluating the EKC hypothesis in a panel of countries. The study employed panel fixed effect regression technique in order to absorb the countries-specific shocks, while panel two-stage least square regression is being used to address the possible endogeneity from the given studied models. The following results have been drawn from this exercise, i.e.,

1. The results of panel regression confirmed the existence of U-shaped EKC hypothesis in relationship between tourists' arrival and NO_x, while this relationship disappeared in the international outbound tourists' model.
2. There is a monotonic increasing relationship between outbound tourists and ecological footprint, while there is a flat/no relationship between outbound tourists and (1) NO_x and (2) SO_2, respectively.
3. Trade liberalization policies act as a catalyst that substantially decreases NO_x and SO_2 emissions, while trade policies should be aligned with the ecological diversity, as it damages the natural environment and ecological base across countries.
4. The adequate food management practices in the tourists destinations are helpful to reduce the carbon 'foodprint' from the foodstuff.

The overall results come to the policy conclusion of sustainable tourism/ecotourism in a panel of countries. International tourism required strong policy instruments to conserve ecological base with the effective trade liberalization reforms and food management practices that would sustain the natural flora across the globe. The U-shaped relationship between international tourists' arrival and NO_x indicate the need for sustainable tourism policies that may lessen the concentrations of air pollutants from the atmosphere. International inbound tourists damage the ecological biodiversity by increasing the carbon emissions and GHG emissions that required national legislation reforms for the sustainable tourism across countries.

Eco-tourism policies may speed up the process of income generation by devising healthier policies both for the foreign tourists and for the local residents of the country, which reduces out-of-pocket health expenditures and different viral health diseases to augment economic growth. There is a need to replace traditional gas stoves with the modernized gas stoves to reduce health concerns and mitigate GHG emissions from the atmosphere. Trade policies should be competitive enough and environmentally regulated that provide safe and healthy environment to the foreign tourists and local residents, which ultimately would increase international tourists' arrival; thus, an effective strategic tourism approach is required for carbon-free environment.

The involvement of stakeholders in tourism planning, operations and management would be helpful to support sustainability agenda across countries. The appropriate measures/planning for food–water–energy resources in the pleasure destinations would be helpful to attract foreign visitors to increase their visitation and get a sufficient income from them, which may spend on environmental protection. The promotion of technical knowledge for sustainable production and consumption will be devoted for the successful tourism policies to improve air quality indicators. The resources devoted for research and development for promotion of ecotourism will be one of the sustainable initiatives to reduce environmental impacts of tourism across countries.

It is imperative to adopt cleaner production techniques for low carbon emissions and to develop rural sector by providing education, employment, and health facilities for maintaining the natural heritage sites and attract the foreign tourists' accordingly. There is a need to use low carbon vehicles and promote green transportation business, which ultimately gives larger tourism revenues in the form of air–railways freight, passengers carried, and goods transportation. Trade liberalization policy should be supported and aligned with the conservation of ecological diversity that reduced the concentrations of air pollutants and maintained the natural flora. These policies should be made under the binding agreement of United Nations Kyoto protocol for global environmental sustainability.

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Appendix

See Tables 7 and 8.

Table 7 Sample countries. *Source*: World Bank (2017)

S. no.	Countries	S. no.	Countries
1	Austria	19	Lithuania
2	Australia	20	Luxembourg
3	Belarus	21	Netherlands
4	Belgium	22	New Zealand
5	Bulgaria	23	Norway
6	China	24	Poland
7	Croatia	25	Portugal
8	Czech Republic	26	Russian Federation
9	Denmark	27	Slovakia
10	Estonia	28	Slovenia
11	Finland	29	Spain
12	France	30	Sweden
13	Germany	31	Switzerland
14	Greece	32	Turkey
15	Hungary	33	UK
16	Ireland	34	Ukraine
17	Japan	35	USA
18	Latvia		

Table 8 Descriptive statistics. *Source*: UNEP (2016) and World Bank (2017)

Methods	CO_2 (gigagrams CO_2 equivalent)	ECO_FP (gigagrams CO_2 equivalent)	F_AREA (000 hectares)	GHG (gigagrams CO_2 equivalent)	INT_INBOUND (number of tourist arrivals)	INT_OUTBOUND (number of tourist departures)	NO_x (gigagrams CO_2 equivalent)	SO_2 (gigagrams CO_2 equivalent)	TRD_OPEN (% of GDP)	WOOD_FUEL (cubic meters)
Mean	467,137	5.18133	47,559.9	600,436	13,492,525	14,134,029	1705.55	1541.79	90.34866	10,610,195
Maximum	6,998,789	12.1952	809,269	8,545,654	83,051,000	83,183,000	30,000	33,262	352.9	2.51E+08
Minimum	−10,333	1.65,018	86.75	−6668.9	60,000	261,000	0.44	0.16	16.75	12,122
Std. Dev.	1,166,316	1.79,017	144,403	1,472,307	16,935,936	18,234,162	4427.37	5028.01	49.64735	36,323,161
Skewness	3.71826	0.71064	4.37293	3.62176	2.149576	1.978128	3.9266	4.654	1.944805	5.230972
Kurtosis	16.3405	3.50036	22.4839	15.4614	7.281044	5.958393	18.3499	24.5576	9.468268	30.18233

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