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RESEARCH ARTICLE

Management of green transportation: an evidence-based approach

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Abstract
The objective of the study is to examine the impact of air-railways transportation on environmental degradation in the form of high mass carbon emission, natural resource depletion and forest depletion in the context of Pakistan by using an annual time series data from 1975 to 2016. The results show that railway passengers carried increases carbon emissions while air-railways transportation and travel services degrade environment in the form of natural resource depletion. The study verified "pollution haven hypothesis" where trade liberalization policies increases carbon emissions; however, "population genius" principle is hold where population growth conserve natural resources and environment through affluence and technology. The study concluded that government should take serious action to re-define transportation infrastructure in order to promote environmental sustainability agenda by introducing green vehicles and green transportation system, which is imperative for country's long-term sustainable development.

Keywords Air transportation · Railways transportation · Carbon dioxide emissions · GDP per capita · Trade openness · Forest depletion · Natural resource depletion · Travel services · Pakistan

Introduction

Air pollution—a serious concern the world over

Throughout the world Traffic related problems have become a challenge for the scientists. Every year, some 6.5 million people around the globe die due to air pollution. It is worldwide public health crises. People suffer death due to inhaling sulfur dioxide (SO2), nitrogen oxide (NOx), particulate-matter (PM), and from burning solid fuels indoors (Plumer 2016). New researches discover the fact that long exposure to traffic and air pollutants contribute to 12% of heart attacks worldwide. According to Harvard School of Public Health (HSPH) report, poor air quality is moderate risk to individuals but making the amount of risk intolerable for the entire community (Baccarelli 2011). A study published in Dec 2017, proclaimed that short-term exposure to air pollutants is the cause of premature deaths in elderly community especially low incomes, females, and the Blacks (Dominici 2017).

Air pollution costs USD 5 trillion per year to the world economy, the results can be seen in lower productivity, and degraded quality of life (McCauley 2016). These losses are caused mainly due to air pollution inflicted diseases. One out of ten deaths in the year 2013 was the result of air pollution diseases. The problem is worse in the developing countries. A report says that the economic losses, additionally, due to air pollution, including health costs, agricultural costs, and productivity losses are a lot more than the USD 5 trillion (World Bank 2017a). Man-induced high temperature is examined with regard to earth's general warmth by the scientists. Many epidemiological studies show a deep connection between mortality rate and occupational exposure to transport emissions. These were retrospective and prospective studies (Krzyżanowski et al. 2005). According to one retrospective research, the effects of the occupational exposure to carbon monoxide create heart disease (Stern et al. 1988). A prospective study upon mortality rate of professional drivers in London city, specifically the big lorry drivers, shows

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increased rate of death by stomach cancer and lung cancer (Balarajan and McDowall 1988). The possible relation between the mortality rate and occupational exposure is due to long exposure of diesel fumes (Balarajan and McDowall 1988). Development in air transport has also cast long lasting adverse effects upon earth. These impacts on environment have diverted the attention of debates of environment policy makers. Air transportation has contributed to climatic change, coupled with the environmental and the economic damage by spewing into atmosphere, CO_2, NO_x, noise, and other harmful emissions. A number of western countries have started implementing a "departure tax" in order to cover the environment repair cost (Pels 2008). These, transportation linked, problems have cast deep impact upon supply chain frameworks too.

High-tech commuters are being developed to transport people from one destination to another without wasting much time and hassle, the high speed trains and the high speed air transportation. But the after effect of both cannot be ignored. The fuel emissions are too hazardous to connive at. In any case, most transport examines the air quality issues (Liaquat et al. 2010). Only in the Los Angeles scientists identified harmful air pollutants in the atmosphere. There is evidence of a solid temperature reversal and intense climatic conditions related with the pacific climatic framework; it supports the seriousness of air contamination. Ocean breezes and mountain-actuated streams assume a critical part in controlling toxin transport over the water basin. The circulations of contaminations over it show three-dimensional model examples, including particular raised layers of toxins (Lu and Turco 1995). With the fast financial development in China, the Chinese road transport framework is getting to be one of the biggest and most quickly developing oil shoppers. China's road transportation will steadily turn into the biggest oil buyer in China in the following two decades yet the changes in vehicle efficiency will gain possibly substantial oil-sparing advantages. Specifically, if no control measures are executed, the yearly oil request by China's road vehicles will achieve 363 million tons by 2030. Then again, under the low and high efficiency change situations, 55 and 85 million tons of oil will be spared in 2030, separately (He et al. 2005).

Of all the transport methods, most harm is conducted by the road transport as far as the air contamination and traffic noise is concerned. Western governments are taking tangible measures to overcome these issues. With the head start, governments take general measures to lower the construction of normal streets. In place, bringing in vogue versatility streets are planned to prompt a concurrent reduction of noise pollution and also air contamination. Secondly, they are taking particular measures for specialized changes in vehicle framework. It is unlikely that the general measures will prompt an outright reduction of street manageability. The primary method for taking care of these natural issues is putting a benchmark liability upon vehicles, regarding air contamination factors (van Gent and Rietveld. 1993). Transport represents 26% of worldwide carbon emission and is one of only mechanical areas where emission is as yet developing. Auto utilization, street cargo, and flying plans are the important supporters of ozone depleting substance outflows from the vehicles. A commendable research is made to look around for the way to deal with the emanations from these three issues. An appraisal of new advancements including elective transport powers to break the reliance on oil is introduced, in spite of the fact that it creates the impression that mechanical development is probably not going to be the sole response to the environmental change issue. To accomplish an adjustment of ozone-harming substance emission from transport, behavioral change realized by strategy will likewise be required. There should be a propensity to center around long-run mechanical arrangements, for some behavioral changes are urgently required, only then the advantages of new innovation are to be completely figured out (Chapman 2007).

Situation in Pakistan

Air pollution has become a serious problem in most of the major cities of Asia. It seems that governments have failed to recognize the issue as one of the most hazardous to nature and human health. The reasons for this dilapidated condition might be the rapid growth of infrastructure in big cities, and the commuting of a large people daily utilizing owned or public transportation. Both these factors have made this region full of pollution emissions (Afroz et al. 2003). The seriousness of the pollution for urban areas has led to the establishment of National Pollution Control Policies (NPC) in developing countries. The commission is working since 1970 and has been successful in implementing (NAAQS) National Ambient Air Quality Standards (Brunner 1985). Among other developing countries, Pakistan is not performing up to the standard in South Asia while it keeps on striving. Currently, of all the factors, the focus is upon vehicular pollutants causing smoke, smog, and hazardous chemicals thrown into the atmosphere. The burnt particles cause high level of particulate matter (PM), i.e., less than 2.5 μm (PM 2.5) in width, which is capable enough to enter into blood stream and ultimately into the lungs, becoming the primary cause of lung cancer (Ali and Athar 2008).

In 1983, Environmental Protection Ordinance presented environmental impact assessment (EIA) in Pakistan, for the first time. The EIA procedure was additionally protected under the Pakistan Environmental Protection Act 1997, which ended up operations under EIA Regulations 2000. Regardless of a sound legitimate premise and exhaustive rules, there is proof that EIA has not yet developed considerably in Pakistan. An assessment of the EIA framework with systematic assessment criteria and in view of meetings with EIA endorsement specialists, counseling firms, and specialists, different weaknesses are uncovered in the EIA framework. Mostly are as follows: deficient limit of EIA endorsement specialists, lacks in screening and checking, poor EIA quality, insufficient open support, and frail observing. By and large, EIA is utilized directly as a task justification tool rather than as project planning tool to add to accomplishing economic improvement. While weaknesses are being tested, focal government has demonstrated a high level of responsibility regarding the environmental insurance by making EIA necessary for all general society that is prone to have unfriendly natural effects (Nadeem and Hameed 2008). Water pollution is also one of the significant dangers to general health in Pakistan. Drinking water quality is inadequately overseen and checked. Among 122 countries, Pakistan is listed at the 80th place, where water pollution severally affected general health mainly due to the cause of large amount of coliforms and lethal metals exist in the groundwater and at surface. The WHO standard for improving water quality is largely ignored due to mismanagement and less resources. Microbial and substance poisons are the fundamental elements capable of different general medical issues (Azizullah et al. 2011).

Throughout the world, urban communities are suffering from air polluted with different poisonous gases injected through autos. The death rate because of car pollution is increasing fast in the metropolitan regions. With the passage of time, individuals recognize that polluted air affects their health severely, atmosphere and economic system of the country too. Climate and atmosphere have affected human activities by maximized particulates of environmental pollution, chlorofluorocarbons, carbon dioxide, methane, nitrogen oxide, lead, and a few other clean and vaporous particles. With the same problem, urban community of Quetta, Pakistan, is crumbling these days. Vehicle exhausts and certain new toxins deliver O3 by photochemical responses, into the atmosphere (Ilyas et al. 2010).

Contribution of the study

The previous studies largely worked on sustainable transportation while they substantially ignored the role of transportation on environment and resource depletion. Further, the study includes the number of control variables, including (a) trade openness to verify pollution haven hypothesis, (b) population growth to verify IPAT hypothesis, and (c) travel emissions, which is imperative for long-term sustainable growth. This study exercise the stated factors in the context of Pakistan where sustainable transportation agenda is largely compromised due to ease of environmental regulations, low transportation infrastructure, and high environmental and resource depletion, which considered the main hurdles to achieved United Nation's environmental sustainability agenda.

The current study has a unique novelty in terms of its evaluating environmental and resource depletion, which is imperative for sustained growth that could be achieved by green transportation, cleaner production techniques, ISO certification, environmental regulations, and sustainable consumption and production. The study used air transportation and railway transportation in their prescribed models that largely covered transportation system in a given country context. Sustainable transportation is the prime agenda, which need interactive environmental modeling to mitigate high mass carbon emissions and conserve natural resource capital in a country.

Literature review

According to the report released by the World Bank (2014), up to 35% of the urban community is at high risk due to air pollution. More than 22,600 adult deaths in 2005 are reported with one or another reason of air pollution. Around 80,000 people were hospitalized, some 8000 cases are reported of Chronic Bronchitis and more than five mio cases are registered of lower respiratory disease in children under 5 years. Further, rise in mortality rate is due to road accidents. The data covering all concerns of air pollution is quite alarming in big cities especially Rawalpindi, Islamabad, Lahore, Faisalabad, Karachi, Peshawar, Quetta. The air pollution is mostly due to heavy road transportation and poor infrastructure. Faster growing population in urban areas due to workers' migration from rural areas to urban areas in search of good income has put a huge toll upon environment. Ozone, nitrogen, sulfur dioxide, and particulate matters are typical indicators of air quality, but unfortunately, poor or no monitoring is being done to maintain the healthy level of these indicators (WHO 2003). Ahmad et al. (2011) showed that average level of NO_2 from 42 sites of sampling was found to be $27.46 \pm 0.\ 32$ ppb, in Rawalpindi alone. The study also shows that the sampling exceeded the annual allowed limit of NO_2 in most of the sampling places of Pakistan. Jalil and Mahmud (2009) investigated the relationship among carbon outflows, energy utilization, income, and foreign exchange of product of China by utilizing time series information of 1975–2005. The aim of the study was to estimate environmental Kuznets curve relationship between the carbon outflow and GDP per capita. The study found that income and energy utilization effected by the carbon discharges by the income and energy used while the trade had positive relation with carbon emission but its impact on carbon outflows was statistically insignificant. The study proves significant for the polluted environment of Pakistan. Frankel and Rose (2005) examined the impact of trade on the environment of the countries. The study used the specific reason for trade and used exogenous geographic determinants of trade as variables. The study also used to verify environment Kuznets curve for estimation. It suggested that the trade reduces three measurements of air pollution, high significance for concentration of sulfur dioxide, sufficient for nitrogen dioxide and reducing different metals. The study also found that trade had harmful effects upon the environment. Demirel et al. (2008) studied the relationship between road transportation and environment. The potential negative effects of transportation on environment could be recorded as deterioration of air quality, ozone-reducing substance outflows, extended risk of worldwide environmental change, corruption of water assets, and disorder and natural surrounding misfortune and discontinuity. Inside this report, specific significance was the linkage between urban structure and transport outflows, since it was the urban structure that in a general sense decides transportation request. The study composed the model including four particular segments. That was geometry, topology, air quality, being non-spatial data, and metadata. The metadata, object requirement, land utilize recognition, and advancement of transportation frameworks were used in model. Then an exchange log approach was established. As a consequence of arrangement, urban, water, roadway, forest, and desolate land classes were observed and their fleeting changes in the area of 1987 and 2001 were resolved. Transportation frameworks, for example, streets, harbor, and air terminal, were digitized from satellite pictures so as to obviously recognize these structures and their progressions inside the 15-year time frame. The study found that air quality in the examination region has been declined from 1990 to 2000 since carbon emission, hydrocarbons, nitrogen dioxide, particulates, and sulfur dioxide demonstrate a positive pattern in this period. The study also found that improvement of transportation foundations made an appeal in this locale and urban zones extended swiftly; in parallel, the aggregate air quality for the district decline pointedly. Cariou (2011) investigated on slow streaming leading to reduced carbon emission from container shipping. The study measured the rate at which carbon emission had been decreased for different holder exchanges and examined the initial investment cost at which this system was practical over the long haul. The study discovered that such decreases must be managed given a shelter cost of, in any event, \$350–\$400 for the primary compartment exchanges. The study also found that the slow streaming had reduced carbon emission 11% in last 2 years, near the objective of a 15% decrease by 2018 that was proposed by the International Maritime Organization. Besides, the carbon emission was reduced without the reception of any new innovation in the short run; however, stayed delicate over the long haul. The study reveals that if bunker costs fall while cargo rates and stock costs rise, the benefit intentions in working a vessel at full speed were probably going to rise. Since this was probably going to cause cargo rates to rise, moderate steaming could, as it stays sustainable, if bunker costs stayed high or if capable market-based arrangements, for example, impose taxes as well as trade frameworks, were executed to support shelter costs. In any case, an assortment of specialized components was not considered.

Hassan et al. (2013) researched that air pollution is due to industrialization as well as transportation in metropolitan regions of Pakistan. In that specific research, Rawalpindi in addition to Islamabad, the identical twin cities of Pakistan were measured. The sample observations of the most important air pollutants were taken on, according to their typical methods at Air Quality Monitoring Station. Five key air pollutants were measured, i.e., nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon dioxide (CO_2), ozone (O_3), and particular matters (PM2.5). The standard mean values of all the pollutants were measured on monthly as well as quarterly bases. The concentration of NO_2 and PM2.5 was measured by Environmental Protection Agency of Pakistan. Supplementary pollutants concentrations were taken up by the usual procedures. Geographic Information System was used as means for demonstration plus investigation of Environmental Impact of air pollution. Passquill as well as Smith dispersion model was used to calculate the buffer zones. Some moderation measures were also suggested to evaluate the ecological and fitness Impacts of PM2.5 as well as of NO_2. The researchers found that the toxic waste altitude because of NO_2 and PM2.5 upon IJP road Rawalpindi up till Industrial Estate Islamabad was maximum. They concluded that the air toxic waste, due to the Industrial Estate Islamabad, was reaching at shocking intensity. On the basis of observational statistics, it was also concluded, according to the concentration of NO_2, at sampling sites of IJP road up till manufacturing Estate I-10 that it had reached at the aggressive altitude. The buffer sector estimates signify that inhabitants in the environment of these localities were at danger of losing fitness characteristics. McKinnon (2007) concluded that Governments have targeted the resolution of CO_2 problem. For the reason, all the greenhouse gas emission has to be measured accurately. The study analyses that 33.7 million tons of CO_2 emissions from transport amount to 6% of the total emissions in the atmosphere. This data is related to UK only and calculated in 2004. According to him, for overall change in the system, there should be widespread acceptance of the basic science of climate change and the recognition of the potential threat it poses to the ecosystem and the way of life of should be changed accordingly for the reduction of these emissions. So, 80% lies on the general public awareness about threats of air pollution. Masood et al. (2011) identifying and then presenting a solution to the transportation pollution problem is one of the main tasks that governments have to attend to in the developing countries. Though a large sum is reserved for improved transport system, the current condition of the system is in ruin still. The reason behind it is bad planning, poor governance, and seeping corruption. Thus, in countries like Pakistan, main cities are under crises. These problems can be solved by building better infrastructure. But still it is not the only solution. Road projects should be included in the overall plan of improvement. There should be traffic management too. There should be low cost transport available for people in densely populated areas so that high level of mobility is provided and environmental sustainability is achieved. Shah et al. (1997) argued that severe air pollution is a threat to human health and for healthy economic growth in big cities of Asia. Remarkable growth in human population and increased number of vehicles have led to significant damaging to air quality. There is intense pollutant concentration in industrial areas mainly. It is estimated that only in Jakarta, the total suspended particle emission are 96,733 tons/year. Particulate matter emission, i.e., less than 10 μm is 41,396 tons/year, and NO_x, i.e., nitrogen oxide emissions are 43,031 tons/year. The yearly TSP average in most polluted areas is five to six times the standard of air quality. It is crucial, technically, that big polluters be identified and punished for this crime against humanity. Quality of fuel, like diesel should be enhanced and low lead and unleaded gasolines should be made cheaper so that it can be used in place of leaded gasolines. Until and unless clean-vehicle emission standards are not introduced for all vehicle classes, there would not be any encouraging effects upon atmosphere. There should be awareness on all level about deteriorating air quality and strict compliance to the rules should be made. Senarath (2003) confirmed the overview that air pollution and respiratory illness in Sri Lanka are inter-related. In Sri Lanka, the impact of air pollution on human beings has crossed all the limits. Thus, it is imperative now to indicate effect and the controlling steps should be taken. Through this research, she illustrates the major air pollutants and their main sources. She interlinks the health effects of air pollution with the meager steps been taken. In Sri Lanka, over 69% of the household sector and nearly 17% of the industrial region is causing air pollution. Some stationary sources are open burning of domestic and industrial refuse. Transport sector is causing 12.5% air pollution. So basically, air pollution in Sri Lanka is due to the combustion of commercial energy. Though transport sector is the primary sector for the contribution of air pollution. Emissions from other sources are comparatively low except for sulfur dioxide. Carbon monoxide is the biggest chunk in the pollutants to the environment. Industrial sector is contributing nearly half of SO in the environment. Thus the country suffers most. If total figures are analyzed, the number of hospitalization and the death in hospitals in 1995–2001, there is a marked rise of asthma. According to Annual Health Bulletin, 2001, surge in respiratory diseases is the cause of deaths in all age groups. Yeh (2007) examined the situation and stressed upon normal vehicle replacement and management system. One of the most important strategies to tackle the issues of energy dependence, air quality, and the climatic change can be the adoption of alternative fuel vehicles (AFVs). Despite awareness of the issue, AFVs are still not the first choice of the people around the globe. There is need of empirical analysis to understand this technology Adoption Process with new market structures, the effectiveness of rules and regulations and with it the incentives, and the proper infrastructure needed to acquire its application commercially. Natural gas vehicles (NGVs) are adopted and are in the process of being popular in eight countries, these are as follows: Argentina, Brazil, China, India, Italy, New Zealand, Pakistan, and the USA. These countries have effectively maintained policies to promoting NGVs targeting the market segments, stakeholders for the purpose. Zhou et al. (2010) examined the impact of air pollution in China. Urban traffic emissions are major challenges faced by the Chinese Government. The reason could be “rapid private motorization” process, which has brought more vehicles on the road than the past decades. Researchers have found out that on-road traffic has increased the ultra-fine particles in Beijing. But China through traffic control measurement have reduced the emissions to 51% from 2008 onwards. A big achievement on their part.

Other than road and water pollution factor, Feitelson et al. (1996) surveyed the effect of aircraft noise pollution. People are willing to pay for residence around the airport area, taking contingent valuation approach. The study also examined that the current compensation program was not suitable for house owners or renters for high noise disturbance. It implied that current policy which was made for compensation, not fully accommodated the residents, as this policy was not covering full area of residents. The study argued that such valuation should analyze noise from multiple aspects rather than single measured aspect. The study showed that the household or renters were unwilling to pay for residence. And that different households had different thresholds. The study suggested that airport authorities should provide additional compensation for household or rentals, in case they buy the residence. As they would be living in increased noise pollution which was above the level considered as socially acceptable. van Gent and Rietveld (1993) examined the road transport and its impact on environment in Europe. The two most imperative parts of the ecological harms created by street transport were air contamination and movement disorder. European governments took after two directions to take care of these issues. To start with, governments took general measures to lower the portability of streets that were planned to lower the disturbance as well as air pollution. Secondly, they took steps to implement the enhancements of specialized vehicles. The study divulged that it was impossible to ultimately change the streets design. But through some basic methods, they could take care of ecological issue, i.e., to set a yard stick for the vehicle owners. That would apply some rules and regulation and a strict compliance of them too. Martín-Cejas and Sánchez (2010) investigated the impact of transport on tourism related to ecological foot print analysis. The study tried to assess street transport used in Lanzarote Island and it suggests manageable tourism improvements. The ecological foot print indicator was used as methodology. (EF) The Ecological Footprint is a methodology to evaluate the environmental implications of alternative development models. This indicator allows to estimate the equivalent land/sea, or biosphere, productive activities. Its marvelous attribute is that it accounts for the demand of natural resources. It facilitates the understanding of environmental impacts. Vaishnav et al. (2016) argued that international civil aviation organization should have to emphasize those policies that support to carbon neutral growth, which would helpful for sustainable global growth. Aldakhil et al. (2018) considered the case study of BRICS nation by using a time series data from 1995 to 2015 and found that logistics activities improve country's economic growth on the cost of high mass carbon emissions, which need fair sustainable policies for green growth. Awan et al. (2018) emphasized the need of social sustainability in supply chain business process that would improve international business through collaboration and corporate governance. Table 1 shows the recent literature on transport-emissions nexus across the globe.

The above studies confirmed the strong contaminated effect of vehicular pollution to human health and environment. This negative impact gives sound basis of drew to this study to analyzing it in given country context, i.e., Pakistan. The more specific objectives are as follows:

i) To analyze the impact of air-railways transportation on carbon emissions, natural resource depletion, and net forest depletion in Pakistan.
ii) To examine the role of trade openness in environmental and resource degradation to verify "pollution haven hypothesis" in a country.
iii) To investigate the IPAT hypothesis, where emissions level are responsible to appreciable rise by high mass population growth, affluence and technology.

These studied objectives are imperative to device sound policy inferences to reduce vehicular pollution, trade associated emissions, and population based emissions in a given country context.

Data and methodology

List of variables

Table 2 shows the list of variables, symbol and its measurement for ready reference.

Data source

The data is taken by World Development Indicators (WDI) published by World Bank (2017b).

Research framework

Figure 1 shows the research framework of the study.

Figure 1 clearly exhibits the mechanism through which air-railways transportation, economic growth, trade liberalization policies, and population growth deteriorate environment, i.e., air-railways transportation cause high mass carbon emissions and resource depletion via route of economic activities in the form of passengers carried and goods transported. Economic growth may harmful for the environment, if and only if, the countries may not acquire cleaner production technologies. Trade liberalization policies seldom address dirty polluting industries, which comes up with trade negotiations and then enjoying tax liberty to operate in developing countries. This phenomenon is called "pollution haven hypothesis." Finally, IPAT hypothesis would be checked by population growth, i.e., high mass population growth may increases environmental and resource damages, which need to overcome by "population genius" principle.

Hypothesis development

The following are the hypothesis of the study, i.e.,

H1: Air-railways transportation degrade environment in the form of high mass carbon emission and resource depletion.
H2: Economic growth increases CO_2 emissions and natural resource depletion, if an only if, a country not used sustainable instruments.
H3: Trade activities degrade environment, which support pollution haven hypothesis, and
H4: High population growth exhausts economics resources to verify IPAT hypothesis while reverse is true for "population genius\principle."

Econometric modeling

The study followed the framework of Saleem et al. (2018), Zaman et al. (2017a,b), Qureshi et al. (2017), etc. These studies largely were worked on transportation infrastructure and environmental degradation across different economic settings, which considered as a base line studies and formulated the following empirical equations for Pakistan's economy to assess sustainable transportation infrastructure in a country, i.e.,

$$\ln(CO_2) = \beta_0 + \beta_1 \ln(ATPC) + \beta_2 \ln(RPC) + \beta_3 \ln(TS) + \beta_4 \ln(GDPPC) + \beta_5 \ln(TOP) + \varepsilon \qquad (1)$$

Table 1 Literature on transport-emissions nexus

Authors	Country	Time period	Results
Saleem et al. (2018)	NEXT-11 countries	1975–2015	APC ∩CO2 GDPpc ∩ CO2 RPC CO2 RGT, ED, PD↑ CO2 ED, PD↑GHG
Khan et al. (2018)	40 countries	1990–2015	ART↑ED AF, RPC↑CD CT↑GDPpc
Zaman et al. (2017a)	11 transition economies	1995–2013	GDPpc↑CO2 IT↑CO2, GDPpc ED → CO2 IT→GDPpc
Alshehry and Belloumi (2017)	Saudi Arabia	1971–2011	TE↔ROEC GDPpc→TE GDPpc→ROEC
Lin and Benjamin (2017)	China	1980–2010	GDPpc↑CO2 EI↑CO2 CI↑CO2
Xie et al. (2017)	China's 283 cities	2003–2013	TINF↑CO2 GDPpc↑CO2 TINV↑CO2
Wang et al. (2017)	China's megacities	1990–2010	GDPpc↑CO2 URB↑CO2 IND↑CO2 URD, TCF↓CO2
Li and Chen (2017)	Shenzhen, China	n/a	HRB&V↑CO2
Nassani et al. (2017)	BRICS nation	1990–2015	TS↑FFUEL IND↑FFUEL RGT↑N2O RGT↑GHG TS↑GHG M2∩N2O GDPpc GHG
Fukui and Miyoshi (2017)	United States	1995–2013	AFT↓CO2
Vaishnav et al. (2016)	United States	2012	ICAO Ж CO2↓

APC shows air passenger carried, CO2 shows carbon dioxide emissions, GDPpc shows per capita GDP, RPC shows railways passenger carried, RGT shows railways goods transported, ED shows energy demand, PD shows population density, GHG shows greenhouse gas emissions, ↑ shows increases, ∩ shows inverted U-shaped relationship, shows U-shaped relationship, ART shows air-railways transportation, AF shows air freight, CD shows custom duty, CT container traffic, IT shows international tourism, → unidirectional causality, TE shows transport emissions, ROEC shows road energy consumption, ↔ shows bidirectional causality, EI shows energy intensity, CI shows carbon intensity, TINF shows transport infrastructure, TINV shows technological innovations, URB shows urbanization, IND shows industrialization, URD shows urban road density, TCF shows traffic coupling factor, HRB&V shows high-rise building and villas, TS shows travel services, FFUEL shows fossil fuel emissions, N2O shows nitrous oxide emissions, M2 shows broad money supply, and AFT shows aviation fuel tax

$$\ln(\mathrm{NRD}) = \beta_0 + \beta_1 \ln(\mathrm{ATPC}) + \beta_2 \ln(\mathrm{RPC}) + \beta_3 \ln(\mathrm{TS}) + \beta_4 \ln(\mathrm{GDPPC}) + \beta_5 \ln(\mathrm{PG}) + \beta_6 \ln(\mathrm{TOP}) + \varepsilon \quad (2)$$

$$\ln(\mathrm{FEDP}) = \beta_0 + \beta_1 \ln(\mathrm{ATPC}) + \beta_2 \ln(\mathrm{RPC}) + \beta_3 \ln(\mathrm{TS}) + \beta_4 \ln(\mathrm{GDPPC}) + \beta_5 \ln(\mathrm{PG}) + \varepsilon \quad (3)$$

where CO_2 shows carbon dioxide emissions, NRD shows natural resource depletion, FDEP shows net forest depletion, ATPC shows air transport passenger carried, ATFC shows air transport freight charges, RPC shows railways passengers carried, RGT shows railways goods transported, TS shows travel services, GDPPC shows per capita GDP, PG shows population growth, TOP shows trade openness, "ln" shows natural logarithm, and shows error term.

It is expected that air-railways transportation and travel services largely involved in escalating high mass carbon emissions and resource depletion to support aviation-based

Table 2 List of Variables

Variables	Symbol	Measurement
Dependent variables		
Carbon dioxide	CO_2	Metric ton per capita
Natural resource depletion	NRD	% of GNI
Forest depletion	FDEP	% of GNI
Independent variables		
Air transport passenger carried	ATPC	Air transport, passenger carried
Railway passenger carried	RPC	Million passenger-km
Gross domestic product per capita	GDPPC	Constant 2010 US$
Population growth	PG	Annual %
Trade openness	TOP	% of GDP
Travel service	TS	% of commercial service

emissions and vehicle emissions, while per capita GDP and trade policies may either decrease environmental resource and carbon emissions by adopting sustainable instruments and rigid environmental policies, or it may deplete natural resources and increase carbon emissions due to unsustainable production and consumption, and unregulated environmental policies, which may further support "pollution haven hypothesis" in a country. Population growth may have a dual impact on environmental and resource depletion, on one hand, it may exhausts economic and environmental resources, while on other hand, it may support to economic growth through generating new ideas and innovation, which support "genius principle."

The study used conventional cointegration techniques, including ADF unit root test (see Dickey and Fuller 1979; Dickey, Bell, and Miller 1986) to assess the unit root among the studied variables. The Johansen cointegration test is further used, after the identification of unit root among the variables, to assess long-run and cointegrated equations in the given model. The trace statistics and maximum eigenvalue test allow to assess the number of cointegrating equations exhibit in the given model. The confirmation of long-run cointegration in the given model, the study proceed for autoregressive distributed lag (ARDL) model, often called bounds testing approach to cointegration. The ARDL-bounds testing approach worked well under mall sample size and mixed order of integration of the studied variables that distinguished it with other available cointegration techniques, including error correction model, fully modified OLS, dynamic OLS, etc. (see Pesaran, Shin, and Smith 2001).

The following empirical equations are used in ARDL-bounds testing specification for estimation, i.e.,

$$\Delta(CO_2)_t = \alpha_0 + \sum_{i=1}^{p}\phi_i\Delta(CO_2)_{t-i} + \sum_{i=0}^{q}\theta_i\Delta(ATPC)_{t-i} + \sum_{i=0}^{r}\lambda_i\Delta(RPC)_{t-i} + \sum_{i=0}^{s}\varphi_i\Delta(TS)_{t-i} + \sum_{i=0}^{s}\varphi_i\Delta(GDPPC)_{t-i} + \sum_{i=0}^{s}\varphi_i\Delta(TOP)_{t-i} + \delta_1(ATPC)_{t-1} + \delta_2(RPC)_{t-1} + \delta_3(TS)_{t-1} + \delta_4(GDPPC)_{t-1} + \delta_5(TOP)_{t-1} + \upsilon_t \quad (1.1)$$

$$\Delta(NRD)_t = \alpha_0 + \sum_{i=1}^{p}\phi_i\Delta(NRD)_{t-i} + \sum_{i=0}^{q}\theta_i\Delta(ATPC)_{t-i} + \sum_{i=0}^{r}\lambda_i\Delta(RPC)_{t-i} + \sum_{i=0}^{s}\varphi_i\Delta(TS)_{t-i} + \sum_{i=0}^{s}\varphi_i\Delta(GDPPC)_{t-i} + \sum_{i=0}^{s}\varphi_i\Delta(PG)_{t-i} + \sum_{i=0}^{s}\varphi_i\Delta(TOP)_{t-i} + \delta_1(ATPC)_{t-1} + \delta_2(RPC)_{t-1} + \delta_3(TS)_{t-1} + \delta_4(GDPPC)_{t-1} + \delta_5(PG)_{t-1} + \delta_6(TOP)_{t-1} + \upsilon_t \quad (2.1)$$

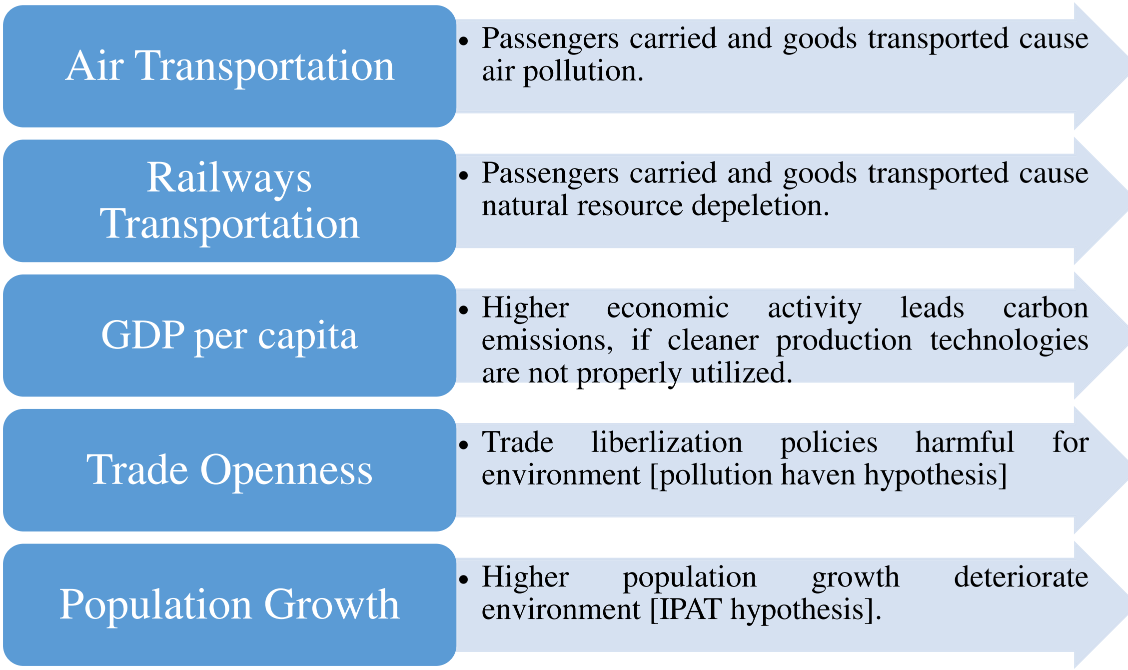

Fig. 1 Research framework

$$\Delta(\mathrm{FDEP})_t = \alpha_0 + \sum_{i=1}^{p} \phi_i \Delta(\mathrm{FDEP})_{t-i} + \sum_{i=0}^{q} \theta_i \Delta(\mathrm{ATPC})_{t-i} + \sum_{i=0}^{r} \lambda_i \Delta(\mathrm{RPC})_{t-i} + \sum_{i=0}^{s} \varphi_i \Delta(\mathrm{TS})_{t-i} + \sum_{i=0}^{s} \varphi_i \Delta(\mathrm{GDPPC})_{t-i} + \sum_{i=0}^{s} \varphi_i \Delta(\mathrm{PG})_{t-i} + \delta_1(\mathrm{ATPC})_{t-1} + \delta_2(\mathrm{RPC})_{t-1} + \delta_3(\mathrm{TS})_{t-1} + \delta_4(\mathrm{GDPPC})_{t-1} + \delta_5(\mathrm{PG})_{t-1} + \upsilon_t \quad (3.1)$$

where Δ is the first difference operator and p shows lag length size.

The Wald F statistics are further used to assess the null hypothesis against the alternative hypothesis regarding the possibility of cointegrating equations. The hypothesis formulation for three desirable equations are listed below, i.e.,

For CO_2 equation:

$$H_0: \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$$
$$H_1: \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq 0$$

For NRD equation:

$$H_0: \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = 0$$
$$H_1: \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq \delta_6 \neq 0$$

For FDEP equation:

$$H_0: \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$$
$$H_1: \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq 0$$

The null hypothesis is evaluated under Narayan (2004) critical values. The value falls between upper bounds value accepted confirmed the alternative hypothesis, while values fall under lower bounds value rejected the alternative hypothesis. Thus, this process gives sound inferences for robust empirical exercise for conclusive remarks.

The error correction model is used further for short-run dynamics in the given model, i.e.,

$$\Delta(\mathrm{CO_2})_t = \alpha_0 + \sum_{i=1}^{p} \phi_i \Delta(\mathrm{CO_2})_{t-i} + \sum_{i=0}^{q} \theta_i \Delta(\mathrm{ATPC})_{t-i} + \sum_{i=0}^{r} \lambda_i \Delta(\mathrm{RPC})_{t-i} + \sum_{i=0}^{s} \varphi_i \Delta(\mathrm{TS})_{t-i} + \sum_{i=0}^{s} \varphi_i \Delta(\mathrm{GDPPC})_{t-i} + \sum_{i=0}^{s} \varphi_i \Delta(\mathrm{TOP})_{t-i} + \delta_1(\mathrm{ATPC})_{t-1} + \delta_2(\mathrm{RPC})_{t-1} + \delta_3(\mathrm{TS})_{t-1} + \delta_4(\mathrm{GDPPC})_{t-1} + \delta_5(\mathrm{TOP})_{t-1} + \psi \mathrm{ECM}_{t-1} + \upsilon_t \quad (1.2)$$

$$\Delta(\mathrm{NRD})_t = \alpha_0 + \sum_{i=1}^{p} \phi_i \Delta(\mathrm{NRD})_{t-i} + \sum_{i=0}^{q} \theta_i \Delta(\mathrm{ATPC})_{t-i} + \sum_{i=0}^{r} \lambda_i \Delta(\mathrm{RPC})_{t-i} + \sum_{i=0}^{s} \varphi_i \Delta(\mathrm{TS})_{t-i} + \sum_{i=0}^{s} \varphi_i \Delta(\mathrm{GDPPC})_{t-i} + \sum_{i=0}^{s} \varphi_i \Delta(\mathrm{PG})_{t-i} + \sum_{i=0}^{s} \varphi_i \Delta(\mathrm{TOP})_{t-i} + \delta_1(\mathrm{ATPC})_{t-1} + \delta_2(\mathrm{RPC})_{t-1} + \delta_3(\mathrm{TS})_{t-1} + \delta_4(\mathrm{GDPPC})_{t-1} + \delta_5(\mathrm{PG})_{t-1} + \delta_6(\mathrm{TOP})_{t-1} + \psi \mathrm{ECM}_{t-1} + \upsilon_t \quad (2.2)$$

$$\Delta(\mathrm{FDEP})_t = \alpha_0 + \sum_{i=1}^{p} \phi_i \Delta(\mathrm{FDEP})_{t-i} + \sum_{i=0}^{q} \theta_i \Delta(\mathrm{ATPC})_{t-i} + \sum_{i=0}^{r} \lambda_i \Delta(\mathrm{RPC})_{t-i} + \sum_{i=0}^{s} \varphi_i \Delta(\mathrm{TS})_{t-i} + \sum_{i=0}^{s} \varphi_i \Delta(\mathrm{GDPPC})_{t-i} + \sum_{i=0}^{s} \varphi_i \Delta(\mathrm{PG})_{t-i} + \delta_1(\mathrm{ATPC})_{t-1} + \delta_2(\mathrm{RPC})_{t-1} + \delta_3(\mathrm{TS})_{t-1} + \delta_4(\mathrm{GDPPC})_{t-1} + \delta_5(\mathrm{PG})_{t-1} + \psi \mathrm{ECM}_{t-1} + \upsilon_t \quad (3.2)$$

where ECM_{t-1} shows the first lag residual term while ψ shows short-run dynamics for analyzing the speed of adjustment over a long-term equilibrium.

Results and discussion

Table 3 shows the descriptive statistics of the studied variables. The statistics show that the average value of air transport passenger carried is 5,091,069, the maximum value is 9,628,354, and the minimum value is 1,451,800 with a standard deviation which is 1,791,204. The positive skewed distribution and high kurtosis value is associated with the trend observation. The average value of CO_2 emissions is about 0.6 metric ton per capita with a maximum value of 0.9 metric ton per capita and minimum value of 0.3 metric ton per capita. The country has an average per capita income is about 811.4 US$. The mean value of net forest depletion, natural resource depletion, and population growth is about 0.2% of GNI, 1.0% of GNI, and 2.5% respectively. The average value of railway passenger carried is 19,526.1 million passengers per kilometer, the maximum value is 25,621.0 million passengers per kilometer, the minimum value is 16,385.1 million passengers per kilometer with a standard deviation value which is 2748.78 million passengers per kilometer. The mean value of trade openness and travel services is about 33.3% of GDP and 13.8% of commercial service respectively.

Tables 9, 10, and 11 that are in appendix shows the Johansen cointegration estimates for all three models for ready reference. Table 4 shows ADF unit root estimates and found that, i.e., transport passengers carried, carbon dioxide emissions, per capita GDP, natural resources depletion, population growth, railways passenger carried, trade openness, and travel services are first differenced stationary, while net forest depletion is level stationary. Thus, it is confirmed that except net forest depletion, the remaining studied variables exhibit the first order integration, i.e., I(1) variable, while net forest deletion has a zero order of integration, as it is level stationary, i.e., I(0) variable. The mix order of integration gives good justification to used ARDL-bounds testing approach of cointegration for robust inferences.

Table 5 shows the ARDL estimates for carbon emissions model. The results show that there is a positive relationship between CO_2 emissions and per capita income in the short run while in the long run, the result is not much effected, i.e., in the short term, carbon emissions increased due to increment of per capita income, i.e., if there is 1% increase per capita income, CO_2 emissions increase by 0.660%, while in the long run, the result is disappeared due to insignificant explanatory power. Zaman and Abd-el Moemen (2017) concluded that economic growth and energy demand are the two main factors that negatively impact on natural environment via the channel of high mass population growth, financial and trade liberalization policies, unregulated environmental reforms, and sectoral growth emissions. Thus, the policies to sustained green growth development are pivotal for long-term growth. Asumadu-Sarkodie and Owusu (2017) found that financial development, unregulated industrial waste pollution, and electricity demand increase high mass carbon emissions, which need green financial policies, regulated industrial reforms, and renewable energy sources to conserve natural environment. Zaman et al. (2017a) argued that economic activities in the form of inbound tourism largely responsible to increase carbon emissions; however, it support country's economic growth in the form of generating revenues, while devising sustainable development policies, it is quite obvious that we need to device eco-tourism policies to support natural environment. de Vries and Ferrarini (2017) showed that environmental quality is largely affected by global supply chain,

Table 3 Descriptive statistics

Statistics	ATPC (numbers)	CO2 (metric ton-capita)	GDPPC (US$)	FDEP (% of GNI)	NRD (% of GNI)	PG (annual %)	RPC (million passenger-km)	TOP (% of GDP)	TS (% of commercial service)
Mean	5,091,069	0.68	811.41	0.23	1.02	2.59	19,526.12	33.36	13.84
Maximum	9,628,354	0.99	1178.79	0.81	2.12	3.36	25,621	38.90	28.65
Minimum	1,451,800	0.33	481.45	0.11	0.36	1.99	16,385.13	25.13	6.06
Std. dev.	1,791,204	0.20	199.16	0.13	0.50	0.49	2748.78	3.16	6.98
Skewness	0.26	− 0.22	0.03	3.05	0.76	0.23	0.79	− 0.48	0.71
Kurtosis	3.04	1.76	1.96	12.35	2.48	1.45	2.74	2.93	2.01

Table 4 ADF unit root estimates

Variables	Level	First difference	Decision
ATPC	− 0.329 (0.911)	− 6.626 (0.000)	First differenced stationary
CO2	− 1.514 (0.516)	− 6.397 (0.000)	First differenced stationary
GDP	0.194 (0.968)	− 3.945 (0.004)	First differenced stationary
FDEP	− 3.880 (0.004)	− 4.518 (0.000)	Level stationary
NRD	− 1.992 (0.288)	− 6.495 (0.000)	First differenced stationary
PG	− 2.099 (0.246)	− 2.809 (0.066)	First differenced stationary
RPC	− 1.506 (0.520)	− 4.942 (0.000)	First differenced stationary
TOP	− 2.046 (0.266)	− 7.064 (0.000)	First differenced stationary
TS	− 2.339 (0.165)	− 2.990 (0.044)	First differenced stationary

Note: small bracket shows probability value

technological advancement, and domestic consumption, which is largely associated with territorial emissions across countries.

The results further show that railways passenger carried and trade openness have a positive impact on increasing CO_2 emissions both in the short and long run, i.e., railways passengers carried has a greater magnitude (i.e., 0.250, $p < 0.050$ in the short run and 0.721, $p < 0.050$ in the long run) in terms of influencing carbon emissions as compared to trade openness (i.e., 0.131, $p < 0.050$ in the short run and 0.378, $p < 0.050$ in the long run). The results confirmed that transportation sector and trade liberalization policies both deteriorate the environment, which further confirmed the pollution haven hypothesis in a country. There is a substantial need for reducing carbon emissions via green transportation and regulated environmental laws for sustainable development. Alshehry and Belloumi (2017) concluded that road transportation energy causes transport

Table 5 ARDL estimates for CO2 model

Variable	Coefficient	Std. error	t-statistic	Prob.
Dln(ATPC)	− 0.035648	0.059532	− 0.598807	0.5537
Dln(GDPPC)	0.660508	0.272537	2.423557	0.0214
Dln(RPC)	0.250748	0.095119	2.636152	0.0130
Dln(TOP)	0.131672	0.060505	2.176202	0.0373
Dln(TS)	0.032788	0.035741	0.917393	0.3660
CointEq(−1)	− 0.347670	0.130837	− 2.657272	0.0123
Cointeq = Ln(CO2) - (0.2474*Ln(ATPC) + 0.4231*Ln(GDPPC) + 0.7212*Ln(RPC) + 0.3787*Ln(TOP) -0.1128*Ln(TS) -15.1869)				
Long-run coefficients				
ln(ATPC)	0.247380	0.178293	1.387491	0.1752
ln(GDPPC)	0.423131	0.395880	1.068835	0.2934
ln(RPC)	0.721224	0.282394	2.553964	0.0158
ln(TOP)	0.378726	0.165635	2.286509	0.0292
ln(TS)	− 0.112768	0.044064	− 2.559190	0.0156
C	− 15.186926	2.686912	− 5.652185	0.0000

associated emissions, which largely affected country's economic growth and sustainable development reforms that required electrified vehicles and green transportation agenda to delimit high mass carbon emissions. Saleem et al. (2018) confirmed that transportation sector initially increases carbon emissions, while its second order coefficient decreases carbon emissions to confirm non-linear relationship between them, while railways passengers carried, in general, increases GHG emissions, which may cause serious threat to the environment in the form of global warming. Shahzad et al. (2017) confirmed the inverted U-shaped relationship between energy demand and carbon emissions under trade liberalization policies, while trade and financial development under low environmental friendly policies largely escalates carbon emissions, which cause serious threats to the United Nations sustainability agenda for resource conservation. The error correction term shows that there is long-run convergence in the model, as the variables converge toward equilibrium with adjustment coefficient of 34.76%. Table 6 shows the ARDL estimates for natural resource depletion.

The results show that high economic growth support to decrease resource depletion both in the short and long run, while travel services has a greater magnitude in terms of depleting natural resources, which need to rectify it by launching a green travel service agency in a country. The impact of air and railways transportation on natural resource depletion is quite visible in the long run with a magnitude value of 1.920 and 2.355% respectively. Finally, both in the short and long run, it is clearly shown that population growth is not responsible to deplete natural resources, as the impact of population growth on natural resource depletion is negative, which holds the genius principle. Hernandez et al. (2017) argued that expansion of electrified vehicles largely affected natural resource assets, which required optimized transportation sector by green vehicles policies across countries. Tian et al. (2017) concluded that trade policies largely affect natural resource base during the search of new potential trade markets, while large flows of natural resources between the countries aggravate the problem of resource depletion that need to be covered with sustainable trade policies across countries. Nassani et al. (2017) opined that investment in green transportation system is one of the roadways of sustainable policy agenda to conserve natural resource base. Fischer (2018) emphasized the need to combat climate change with sustainable policy instruments in order to protect natural resource assets, which further need technical and financial resources to conserve global environmental and resource agenda. The error correction model shows that there is a long-run convergence in the model and the variables converge toward equilibrium with adjustment coefficient of 78.46%. Table 7 shows the ARDL estimates for net forest depletion model.

The results show that air transportation and travel services both are largely responsible to deplete forest resources; however, air transportation has a greater magnitude in terms of depleting forest resources as compared to the travel services, both in the short and long run. The impact of country's

Table 6 ARDL estimates for NRD model

Variable	Coefficient	Std. error	t-statistic	Prob.
Dln(ATPC)	0.732698	0.582365	1.258143	0.2177
Dln(GDPPC)	− 3.666323	1.577216	− 2.324554	0.0268
Dln(RPC)	0.007413	0.956850	0.007747	0.9939
Dln(TOP)	0.579585	0.622916	0.930438	0.3593
Dln(TS)	0.524354	0.283515	1.849474	0.0739
Dln(PG)	− 3.788401	1.523546	− 2.486568	0.0185
CointEq(−1)	− 0.784664	0.167008	− 4.698360	0.0001
Cointeq = LOG(NRD) - (1.9201*LOG(ATPC) -4.6725*LOG(GDPPC) + 2.3559*LOG(RPC) + 0.7386*LOG(TOP) + 0.6683*LOG(TSE) -4.8281 *LOG(PG) -21.4043)				
Long-run coefficients				
ln(ATPC)	1.920146	0.879271	2.183794	0.0367
ln(GDPPC)	− 4.672476	2.115512	− 2.208674	0.0347
ln(RPC)	2.355917	1.255619	1.876299	0.0701
ln(TOP)	0.738641	0.749427	0.985607	0.3320
ln(TS)	0.668253	0.317799	2.102753	0.0437
ln(PG)	− 4.828055	1.675306	− 2.881894	0.0071
C	− 21.404322	11.041276	− 1.938573	0.0617

Table 7 ARDL estimates for FDEP model

Variable	Coefficient	Std. error	t-statistic	Prob.
Cointegrating form				
Dln(ATPC)	1.202999	0.623949	1.928040	0.0625
Dln(GDPPC)	− 7.196739	2.960539	− 2.430888	0.0207
Dln(RPC)	− 0.270675	0.794046	− 0.340881	0.7354
Dln(TS)	0.483255	0.215634	2.241086	0.0319
Dln(PG)	− 3.007213	1.181116	− 2.546077	0.0157
CointEq(−1)	− 0.847181	0.176718	− 4.793980	0.0000
Cointeq = LOG(FDEP) - (1.4200*LOG(ATPC) -4.2321*LOG(GDPPC) -0.3195 *LOG(RPC) + 0.5704*LOG(TS) -3.5497*LOG(PG) + 9.9868)				
Long-run coefficients				
ln(ATPC)	1.420002	0.710733	1.997939	0.0540
ln(GDPPC)	− 4.232073	1.658182	− 2.552237	0.0155
ln(RPC)	− 0.319501	0.921407	− 0.346753	0.7310
ln(TS)	0.570427	0.232818	2.450096	0.0198
ln(PG)	− 3.549668	1.171252	− 3.030661	0.0047
C	9.986770	9.218495	1.083341	0.2865

Table 8 ARDL-bounds test for CO2, NRD, and FDEP models

Test statistics	CO2 model	NRD model	FDEP model
F statistic	1.634	4.284**	2.820
Critical bound value			
Significance	I(0) bound	I(1) bound	
10%	2.26	3.35	
5%	2.62	3.79	
2.5%	2.96	4.18	
1%	3.41	4.68	

Double asterisks "**" indicates 5% significance level

economic growth and population on forest depletion is negative, which confined that country's economic activities largely balanced forest resources for greater environmental associated programs to sustained long-term growth, while it further hold genius principle, i.e., population considered forest resources as a natural assets that is imperative for sustained livelihood and for environmental resource conservation. Janić (2018) argued that greening commercial air transportation would bring environmental reforms in the form of substantial reduction in carbon emissions and GHG emissions by adopting liquid hydrogen fuels substituted to conventional kerosene oil and paraffinic kerosene, which deteriorate environment more than the assigned global agreed threshold to conserve environment. Zaman et al. (2017b) found the following macroeconomic factors that harm the environment and natural resources and produce greater carbon emissions and GHG emissions, i.e., conventional use of energy sources—mostly used non-renewable energy sources, oil rents, mineral rents, natural resource rents, and gas rents. The results further indicate that climate change, economic growth, and air pollution largely depleted natural resources in the form of net forest depletion. The study emphasized the need to balanced economic resources in a way to mitigate carbon emissions through sustainable instruments, including cleaner production technologies and tight environmental regulations. Riekhof et al. (2018) concluded that trade liberalization policies and economic activities deplete renewable natural resources under alternative institutional settings, while expansion of trade negotiations with other countries in bilateral and multilateral negotiations increase the base of depleting natural resources, which needs to re-correct institutional matters in to open access. Kurniawan and Managi (2018) argued that per capita wealth declination is merely visible due to depleting the natural capital assets, while the rate of sustainable development is far less than the human development growth, which needs substantial investment in human capital to sustained economic growth and conserve natural capital for long-term sustainable growth. The error correction term shows that there is long-run convergence in the model and the variables converge toward equilibrium with adjustment coefficient of 84.71%. Table 8 shows bounds testing approach of cointegration for CO2, NRD, and FDEP models.

The result shows that *F* statistics for CO_2 model is greater than the 5% critical value, hence we accept the null hypothesis of no cointegration, which presume that the variables have no long-run relationship between the variables. It is due to structural shocks prevailing in the given time period. The result of NRD model shows that *F* statistics is less than the 5% critical value, hence we may accept the alternative hypothesis of cointegration, which presume that the variables have a long run relationship between the variables. Finally, for forest depletion model, the results shows that *F* statistics is greater than 5% critical value, hence we may accept the null hypothesis of no cointegration which presume that the variables have no long run relationship between the variables.

Conclusions

The transportation has been increased in the whole world in the last two decades. Although it has shortened the distances but has some drawbacks, it affects environment badly so that climate change occurs. The emission of carbon dioxide severely affects ozone layer. The objective of the study is to examine the dynamic linkages between air-railways transportation, trade openness, travel services, population growth, and environmental and natural resource depletion in the context of Pakistan by using a time series data from 1975 to 2016. The results show that railways passenger carried, trade openness, and per capita income is associated with high mass carbon emissions to confirm transport associated emissions and pollution haven hypothesis, while air-railways transportation and travel services largely influenced natural resource assets of the country. Forest resources largely affected by air transport passengers carried and travel services, while it hold genius principle, where population is sensibly used forest and natural resources in the sustainable consumption and production system. The general and country specific policy implications are presented for sustainable development, i.e.,

i) Green transportation fuel system like liquid hydrogen fuels should be used to mitigate carbon emissions.
ii) Sustainable consumption and production is imperative for sustainable development.
iii) Trade liberalization policies should be environmental regulated to support natural resource capital of a country.
iv) Economic activities should be environmental friendly and based upon cleaner production technologies, certified ISO certification, tax imposition of dirty polluting

industries, subsidies given to environmental quality assurance companies, and healthy economic reforms across countries.

v) Human development program should be initiated in a way to invest on human capital that translated in to achieving high economic growth and conserve natural environment.

The country-specific policy implications should be result oriented, i.e., the solutions can found for bringing pollution to tolerable level. But it can only be achieved if: vehicle inspection and examiner department is strengthened by the Federal Government in Consultation with Ministry of Transport and Communication. The Electric Power Assisted Steering (EPA) ensures the desirable condition of the vehicles on roads. With that, Quality Control agency should help provincial governments to certify quality of gasoline. Various stations where gasoline is sold should be checked regularly to ensure quality.

Government should establish weigh bridges on all important highways and road to check overloading. In this respect, National Highways Authority (NHA) and Motorway Police (MP) can be useful. There should also be a policy structure for the conversion of dirty fuel, i.e., diesel on road transport to clean fuel. Petrol, Diesel, LPG, or CNG vehicle testing and tuning centers should be established in all the small and big cities. Fuel substitution strategy must be adopted by a LPG and supplies from in-house refineries be increased. There should be alternate source to import LPG through pipelines, it could be made possible by signing contract with neighboring countries. Road shoulder improvement like concrete pavement, vegetation, traffic control, and cleaning of road by mechanical sweepers or vacuum cleaners should be undertaken by the municipalities of the city to control particulate emissions. Introduction of cheap urban transport system run on clean fuel would also decrease the traffic burden from roads, and will definitely improve the air quality in the long run.

All of the above recommendations are very practical and feasible if implemented. For minimizing air pollution, a serious mind set is required not only from the government but also from the local people. Until and unless they have awareness, and with awareness, sense of responsibility toward their country as well as toward the environment in which they breathe, nothing can be done tangibly. Knowingly, crossing the limits and not maintain standards is not a good approach. Everyone should partake this process of cleaning the air. Otherwise, 1 day, it will be difficult even to breathe and fresh air would be a dream.

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Appendix

Table 9 Cointegration estimates for CO2 emissions model

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical value	Prob.**
$r = 0$*	0.910593	334.0945	197.3709	0.0000
$r \leq 1$ *	0.797988	237.5122	159.5297	0.0000
$r \leq 2$ *	0.729118	173.5351	125.6154	0.0000
$r \leq 3$ *	0.646792	121.2922	95.75366	0.0003
$r \leq 4$ *	0.575575	79.66423	69.81889	0.0067
$r \leq 5$	0.396163	45.38345	47.85613	0.0838
$r \leq 6$	0.333837	25.20544	29.79707	0.1542
$r \leq 7$	0.197234	8.956606	15.49471	0.3694
$r \leq 8$	0.004215	0.168941	3.841466	0.6810

5 cointegrating equations at the 0.05 level significance

Table 10 Cointegration estimates for NRD model

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical value	Prob.**
$r = 0$ *	0.907542	317.8077	197.3709	0.0000
$r \leq 1$ *	0.791130	222.5676	159.5297	0.0000
$r \leq 2$ *	0.690486	159.9259	125.6154	0.0001
$r \leq 3$ *	0.628034	113.0159	95.75366	0.0019
$r \leq 4$ *	0.555603	73.45783	69.81889	0.0249
$r \leq 5$	0.397368	41.01638	47.85613	0.1882
$r \leq 6$	0.240320	20.75845	29.79707	0.3729
$r \leq 7$	0.192372	9.764139	15.49471	0.2993
$r \leq 8$	0.029991	1.218011	3.841466	0.2698

Single asterisk "*" indicates 5 cointegrating equations at the 0.05 level significance

Table 11 Cointegration estimates for NFD model

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical value	Prob.**
$r = 0$ *	0.929337	344.2621	197.3709	0.0000
$r \leq 1$ *	0.836261	238.2689	159.5297	0.0000
$r \leq 2$ *	0.725456	165.8897	125.6154	0.0000
$r \leq 3$ *	0.652384	114.1839	95.75366	0.0015
$r \leq 4$ *	0.549452	71.91757	69.81889	0.0337
$r \leq 5$	0.369001	40.02595	47.85613	0.2216
$r \leq 6$	0.315418	21.60792	29.79707	0.3208
$r \leq 7$	0.139074	6.450071	15.49471	0.6423
$r \leq 8$	0.011439	0.460214	3.841466	0.4975

Single asterisk "*" indicates 5 cointegrating equations at the 0.05 level significance

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