Toward economic growth without emissions growth: the role of urbanization & industrialization in Pakistan

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Abstract
The dynamic relationship between economic activity (economic growth) and environmental impact (carbon dioxide emissions) is the most debated topic in the present world. The global world is intended to curb environmental impact up to a threshold level of the 1990s while maintaining the same pace of economic growth. This study analyzes the decoupling of economic activity from environmental impact and its main driving forces from 1980 to 2018 for Pakistan. The decoupling status is examined using Tapio decoupling elasticity analysis. The cointegration and Impulse Response Function (IRF) are employed to explore the role of main decoupling drivers. The Tapio decoupling results exhibit that Pakistan experienced Expensive Negative Decoupling (END) for multiple years. Similarly, the Johanson Juselius (JJ) Cointegration assures the presence of a long-term relationship between the selected variables. The long-term regression estimates show that carbon intensity and urbanization are the main decoupling drivers. The industrialization and economic growth also weaken the decoupling progress in Pakistan. The value addition of the paper is that it exposes industrialization and urbanization as the two prominent factors of both economic growth and carbon emissions. Further, the industrial sector of Pakistan operates on polluted industrial stock, which needs to be replaced with energy-efficient technological stock. The study also added that renewable energy needs to be indulged in the industrial and urban sectors.

Keywords Decoupling · Urbanization · Industrialization · Johanson cointegration · Climate change

Introduction
The rising trend of greenhouse gas (GHG) emissions poses a serious threat to the lives of all humans on the earth through the increasing level of global warming. One of the major reasons behind this rising trend is the usage of conventional energy in economic activities worldwide (Ozturk et al., 2021). These economic activities have raised the GHG emissions level across the globe nearly triple time from 1960 to 2014, i.e., 9385.8 MT (million tonnes) to 36,138.3 MT (Shuai et al., 2019). The rising level of GHG emissions can be evidenced by the International Panel on Climate Change (IPCC) report, which states that the last five decades are considered the warmest decades (IPCC, 2014).

The continuous up-trending of the global economic growth driven by massive energy consumption was paused with the emergence of Corona Virus Disease in 2019 (COVID-19). According to Lai et al. (2020), COVID-19 threatens human lives and negatively impacts global economic growth. Further, Gopinath (2020) predicted the risk of a recession in 2020 due to an expected drop-down in economic activities by 3% worldwide. The reduction in economic growth is mainly contributed by the shutting down the transportation system, which drastically affected the logistics business worldwide. Similarly, Wang and Su (2020) highlighted that the restrictions on economic

Highlights
• Pakistan experienced mostly Expensive Negative Decoupling due to fossil fuel-based energy consumption.
• Urbanization and industrialization are the two most prominent drivers of carbon emissions in Pakistan.
• Fossil fuel-based energy consumption leads to higher carbon intensity in Pakistan.
• Pakistan needs to take strong measures to decouple carbon emissions from economic growth.

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activities would limit the environmental impact, improving environmental quality across the globe.

It is evident from the Global Carbon Project (PCG) (2021) that global carbon emissions dropped down by 7% in 2020 compared to 2019. The International Energy Agency (IEA) report also confirmed the improvement in environmental quality. Further, Wang et al. (2022a, b, c) mentioned that in the first half of 2020, global carbon emissions dropped by 8.8%. The real discussion demonstrates that COVID-19 has significantly improved the environmental quality; however, it was gained at the cost of low economic growth. Furthermore, as the COVID-19 restrictions normalized worldwide, economic activities resumed, again devastating the global environment.

The prior discussion on the rising level of GHG emissions devotes our attention to the causes behind the such increase. It is noticed that the consumption of conventional energy is considered a key driving factor of global GHG emissions. It is also observed that primary energy consumption drives 95% of global climate change. Various academic literature (Sari & Soytas, 2009; Majeed & Mazhar, 2019b; Khan & Majeed, 2019; Meinshausen et al., 2009) state that primary energy consumption is the core driver of climate change through the exponential consumption of primary energy sources. The degrading environmental quality is challenging for developed and developing nations; however, conditions are more disastrous in developing countries (Majeed & Mazhar, 2019b; Majeed, 2018). In this regard, British Petroleum also states that developed countries experienced a decline in GHG emissions by $1.1 \times 10^9$ tons; however, developing countries depicted an increase in their GHG emissions by $6.1 \times 10^9$ tons (British Petroleum, 2019). The above statistics confirm that developed countries are trying to reverse climate change while developing countries offset the impact of developed countries.

Urbanization is considered a key factor that affects the environmental quality as well as the economic structure of the country. The migration of societies to urban areas from rural areas is termed urbanization; it also includes the adaptation of change and innovation by the society (Sharif & Raza, 2016). The share of the urban population reached 50% of the global population in 2010, which shows 50%, while it reached 55% in 2017, which is about 4.1 billion population of the entire world (Desa, 2018). Furthermore, this number could be increased to 6.4 billion by 2050, leading to exponential environmental impact, severe climatic change, and rapid depletion of natural resources. Further, the report of IEA (International Energy Agency, 2008) shows that the current urbanization trends consume 2/3 of world energy and are accountable for 70% of global CO$_2$ emissions (International Energy Agency 2008). In addition, Rosenzweig et al. (2010) also stated that 78% of the global energy-induced CO$_2$ emissions are due to energy consumption by urban areas.

Pakistan is also experiencing a higher urbanization growth rate. According to United Nations Development Programme (UNDP, 2019), 32.5% of the total population lived in an urban area in 1998; however, this figure reached 36.4% in 2017. The rising trend of urbanization enhances the economic growth of the country. Further, urbanization also negatively affects the environmental quality through an increase in energy consumption of the household and transport sector. It is also mentioned by Abdul and Yu (2020) that the urbanization trend in Pakistan has been increasing since the day of independence and that Pakistan is the 4th most populated country across the globe. The study further stated that the urban population will reach 50% by 2025.

Economic growth is a prime interest of economies across the globe, and a high pace of industrialization helps to attain it. However, industrialization also has a severe impact on environmental quality. In 1997, industrialized countries signed the Kyoto Protocol agreement to restrict the residuals of industrial output to reduce national level CO$_2$ emissions up to the level of the 1990s in 2008–2012 (Maamoun, 2019). Furthermore, developing countries, especially Asian countries, are severely affected by industrial residuals because of heavy industrial machinery and warm weather (Attari et al., 2016). Besides, due to improper financial and infrastructure conditions, developing countries cannot mitigate the environmental impact that leads to climatic change (IPCC 2007). Specifically, in the case of Pakistan, an increase in per capita income increases demand for industrial goods, enhancing energy consumption of the industrial sector and increasing CO$_2$ emissions, i.e., from 0.86 metric tons to 0.92 metric tons during 2005–2011 (Shahzad et al., 2017). Pakistan’s industrial sector is emerging rapidly among developing countries, which significantly increases the country’s economic growth. However, Ahmed and Long (2012) stated that the emergence of industrialization and economic growth in Pakistan is driven by extensive use of primary energy consumption, which deteriorates environmental quality. The study further stated that natural gas-based emissions of the industrial sector are responsible for half of the country’s emissions. In addition, higher economic growth leads to higher per capita income, resulting in higher emissions. Further, economic growth and industrialization necessitate commercial vehicles, which run on primary energy and deteriorate the environmental quality in the case of Pakistan. The study further stated that energy consumption in the industrial and manufacturing industry increased by 25 and 27% in 2018 and 2019.

The discussion on the paramount factors of economic growth and their impacts on global climatic variations alerts the global policymakers to propose and implement the policy of delinking economic activities from
environmental impact. The term decoupling was coined by United Nations Environmental Protection (UNEP (2011)), which states the concept of breaking the linkage between economic activity and the environment. However, the decoupling concept was first introduced by the Organization for Economic Co-operation and Development (OECD). It defines it as a mechanism of delinking economic activities from the environmental impact (OECD, 2002). According to Juknys (2002), the decoupling concept was first employed in delinking resource consumption from economic activities. However, some literature suggests that decoupling was first employed in delinking economic activities from energy consumption (Ozturk et al., 2021; Wang et al., 2018a, b; Zhao et al., 2017). However, when climate change threat was observed in the 1970s, decoupling phenomena also broadened its boundaries to the environment. One of the significant contributions to decoupling has been made by Tapio (2005), as he proposed and sub-divided decoupling elasticity into eight sub-categories, namely Strong Decoupling (SD), Strong Negative Decoupling (SND), Expansive Negative Decoupling (END), Weak Decoupling (WD), Weak Negative Decoupling (WND), Expansive Coupling (EC), Recessive Coupling (RC), and Recessive Decoupling (RD).

The above discussion demonstrates an alarming threat to the world due to the rising GHG emissions and climatic change driven by conventional energy consumption-based economic activities. The impact of economic activity on the environment and climate change led our interest to conduct a study on delinking economic activity from environmental impact, using decoupling and econometric analysis, in the case of Pakistan. There is rare literature available on using decoupling with econometric techniques, i.e., Wu et al. (2018); Wang et al. (2018a, b), for examining the relationship between carbon emissions and economic growth. However, specifically in the case of Pakistan, no such study combines decoupling elasticity with econometric techniques to determine the association between economic growth and environmental hazards. Thus, the current study is also adopted to fill this literature gap; further, the study added two paramount factors, urbanization, and industrialization, to check their relationship with decoupling indicators in the case of Pakistan. The reason is that urbanization and industrialization are the two rapidly growing phenomena in Pakistan, which significantly contribute to the national emissions of Pakistan.

In the light of the above discussion, the following research objectives are achieved in the current study.

- To identify the decoupling status between environmental impact and economic growth, in the case of Pakistan from 1980 to 2018.

- To examine the impact of industrialization and urbanization on the decoupling of economic activity and environmental impact in the case of Pakistan.

- To determine the cointegration between the decoupling elasticity and influencing factors of economic activity and environmental impact.

The remaining paper is structured as follows: The critical literature on the economic growth-environment nexus is reviewed in the “literature review” section. The study’s methodological approaches and data sources are gathered in the “Methodology and data sources” section. The “results and discussion” section depicts the outcome of the research study, while the “conclusion and policy recommendations” section concludes the study and offers policy recommendations.

**Literature review**

The global climate change driven by disastrous increases in GHG emissions provoked concerns of world leaders to decouple economic activity from environmental hazards. Since decoupling is not only related to economic/emissions growth, it also decouples/reduces resource use from economic growth. Since the decoupling phenomena round about OECD decoupling and Tapio decoupling indicator, proposed by OECD (2002) and Petri Tapio (2005). The literature suggests that the prior decoupling technique is comparatively easy compared to the latter. However, the OECD decoupling analysis is extremely vulnerable to change in the base year, and it also failed to provide a clear indication of decoupling due to economic activity and environmental impact changes. Due to such limitations, Tapio introduced a novel elasticity-based indicator that accurately predicts changes in economic growth and CO₂ emissions.

The disastrous impact of climate change on the lives of human beings on earth, the current paper will gather the academic literature concerning different economic/emissions growth perspectives. In this respect, critical literature about economic activity, urbanization, and industrialization-induced environmental impact will be gathered in this study, as these are the main variables of the study.

**Economic growth induced environmental impact**

There has been a long-lasting debate on the linkages between environmental impact and economic activity for decades; however, there is no accurate technique which can portray the reliable relationship between these two paramount factors. Some of the efforts of the researchers were put in this regard to assess the relationship between these paramount factors. In this regard, Khan and Majeed (2019) assess the
Economic growth in Pakistan is mostly driven by primary energy consumption negatively influencing environmental quality. Shahbaz et al. (2014) based on empirical evidence showed that economic growth deteriorates environmental quality. However, an emerging phenomenon of renewable energy consumption is gaining pace concerning economic growth and environmental impact. Such as Wang et al. (2022a, b, c) examined the impact of renewable energy on high-, middle-, and low-income countries and found that renewable energy consumption has a significant impact on economic growth. Similarly, Wang et al. (2022a, b, c) investigated the impact of renewable energy on the economic growth of the OECD countries. The study sets up a threshold level and mentioned that when the threshold level increases, renewable energy positively impacts economic growth.

**Industrial sector induced environmental impact**

The industrial sector is considered the backbone of any country and plays a vital role in the development of the economy. However, the pre- and post-industrial eras have had a more devastating impact on environmental quality. In terms of industrial performance, nations are ranked according to their industrial growth; in a 2015 report by the United Nations Industrial Development Organization (UNIDO), Pakistan has ranked 80th among the 148th global countries, while Bangladesh ranked (77), China (3), Iran (59), India (39), and Sri Lanka (75) (UNIDO, 2015). Wen et al. (2015) analyzed the ties between industrial growth and environmental harm, and findings suggest that iron and steel industry development leads to the rise of environmental impact in the short term, while in the long term, these industries led to the reduction of CO₂ emissions due to technological advancements. The same results were found between industrialization and CO₂ emissions by Shabbaz et al. (2014) based on the EKC hypothesis from 1975 to 2010. Raheem and Ogebe (2017) stated that industrialization is the key driver of environmental impact. However, the indirect effect of industrialization leads to better environmental quality through an increase in per capita income. Further, the study also elaborates that indirect effect is stronger than direct effect, concluding that industrialization improves environmental quality.

Besides, Attari et al., 2016; Shahab et al., 2013; Alam, 2010; and Rehman et al., 2021 stated that industrialization negatively impacts environmental quality. Attari et al. (2016) examined the relationship between industrial growth and environmental quality in Pakistan using time series data from 1971 to 2009 by adopting the EKC and ARDL cointegration technique. The results indicated a long-run relationship between industrial growth and environmental quality. In contrast, an inverted U-shaped relationship does not exist in the case of Pakistan, which highlights that industrialization deteriorates the environmental quality. Shahab et al. (2013) assess the influence of economic reforms and industrialization on the environmental quality in Pakistan by utilizing
the time series data from 1980–2011. The study finds out that industrialization deteriorates the environmental quality of Pakistan due to the use of primary energy sources in industrial operations. Rehman et al. (2021) analyze the interaction of environmental impact with industrialization and other factors in the case of Pakistan from 1971 to 2019. The study uses the quantile regression method and reveals that industrialization, in Pakistan’s case, increases carbon emission, which in turn deteriorates environmental quality. Alam (2010) found similar results to the study of Rehman et al. (2021) that industrialization drives carbon emissions and deteriorates the quality of the environment. The study further stated that industrialization is beneficial for economic growth; however, it negatively influences the environmental quality in Pakistan.

**Urbanization induced environmental impact**

The impact of urbanization on the environment is highlighted by various theoretical and academic sources, such as the economic modernization theory supporting the sustainable use of environmental resources to readapt economic and industrial growth. The theory supports the combination of both economy and environment, such as the efficient use of natural resources to sustain economic growth and environmental quality. In the modern world, ecological modernization can also be linked with urbanization and environmental relationship, i.e., prevention of population, reduction, and recycling of waste can alter the resource consumption to sustain the environmental quality. The compact city theory is another important theory that supports the efficient use of land resources, i.e., vertical construction, to reduce and mitigate the urban environmental impact. The compact city theory stresses that urban management needs to allocate resources where they can have maximum output and low environmental impact (Majeed & Mazhar, 2019a, b), such as the efficient use of public transport and low energy consumption to reduce air pollution.

Economic development directly impacts the transformation of rural areas into urban areas. Such transformation harms the environment through the increase in energy consumption and deforestation, leading to climate change. After the 1970s industrial revolution, the urbanization rate significantly increases. In this respect, Ehrhardt-Martinez et al. (2002) examined the influence of urbanization on the environmental condition for the period 1980–1995. The results stated that urbanization negatively affects the environment through increased deforestation. Besides, the study of Alam et al. (2007) links urbanization with energy consumption and assesses its impact on the quality of the environment. The analysis exhibits significant ties of urbanization with energy-induced environmental harms.

The same results between urbanization and energy-induced environment have been reported by Al-Mulali et al. (2014) for the Mena Region. Besides, a panel of 16 countries has been examined by Sadorky (2014) for the association between their urbanization rate and environmental harm during 1971–2009. The results depict that an increase in energy consumption in urban areas significantly increases environmental harm. Similarly, Zhang et al. (2014) reported that an increase in the urbanization rate negatively influences environmental harm. The ASEAN region has been examined by Khan and Majeed (2020), and the results state that population growth is the main driver which drives the environmental harm in the ASEAN region.

**Literature gap**

The brief and critical literature on the influence of economic growth, urbanization, and industrialization on environmental harm depicts the importance of the relationship between these paramount factors. However, the growing trend of decoupling economic growth from environmental harms led to our interest in conducting this research study. Further, in the case of Pakistan, there is no literature regarding delinking economic activity from environmental impact, specifically urbanization and industrialization-induced CO₂ emission. Further, the study combines the decoupling analysis with econometric analysis. The study will fill up the literature gap in this area and provide significant insights to policymakers to propose and implement suitable policies to mitigate climate change.

**Contribution of the study**

The current study contributes to the existing literature in many ways, such as it combines decoupling and econometric techniques to better examine the relationship between economic growth and carbon emissions. Besides, most existing literature adopts Kaya identity factors while examining economic growth and the carbon emissions relationship. However, the existing paper includes industrialization and urbanization as they are considered the prominent factors of Pakistan’s economic growth and carbon emissions. Despite such importance, there is no literature on decoupling economic growth from industrialization and urbanization-induced carbon emissions in Pakistan. Further, the paper also contributes to providing insights to the policymakers regarding the surge of renewable energy in industrial activities and urban areas.

**Econometric methodology and data sources**

**Specifications of decoupling**

Decoupling has become a hot topic of research in the last decade, and it is due to the emergence of the threat of
climate change across the globe. One of the main reasons behind the acceptance of decoupling in the environment and energy field is that it helps to identify the key drivers of environmental impact, and it also helps to mitigate the impact of the main driver on the environmental impact. There are two main models, i.e., Tapio and OECD decoupling model are considered the most appropriate techniques to assess the decoupling of economic activity from environmental impact. The term decoupling was first introduced OECD to decouple economic growth from carbon emissions. Equation (1) shows the OECD decoupling model.

\[
DE = 1 - \left( \frac{C_{t}}{GDP_{t}} \right) / \left( \frac{C_{0}}{GDP_{0}} \right)
\]

The “DE” in Eq. (1) shows the decoupling indicator, while “c” shows the carbon emissions and “GDP” is the economic growth and “0” and “t” is the initial and final period. The selection of the base year in the OECD decoupling model significantly impacts the assessment results. Furthermore, because the relevant factors for measuring the impact of decoupling are not clearly defined, the OECD decoupling model is susceptible to measurement error; when used in conjunction with the OECD decoupling model, Tapio plays a key role in overcoming its shortcomings, evaluating changes between years, and relating total indicator changes to relative index changes, resulting in more robust outcomes and maximizing policy implementation effectiveness. The decoupling model such as Tapio relies on indices rather than the absolute values of economic variables, which improves its robustness. The OECD decoupling model is used in various research; however, Zhao and Li (2013) highlighted that the benefits of the Tapio decoupling indicator could not be surpassed by OECD decoupling. Therefore, the Tapio decoupling model is preferred over the OECD decoupling model in current research.

According to Tapio (2005), breaking the linkage between economic activity and environmental harm is decoupling. The decoupling index can be structured as follows,

\[
DE = \frac{(CO_{2t} - CO_{2t-1})/(CO_{2t-1})}{(GDP_{t} - GDP_{t-1})/(GDP_{t-1})} = \frac{\Delta CO_{2}/CO_{2t-1}}{\Delta GDP/GDP_{t-1}} = \frac{\%\Delta CO_{2}}{\%\Delta GDP}
\]

Equation (2) demonstrates the decoupling elasticity (DE), which is the outcome of the ratio of percentage change of environmental impact and economic activity. The DI is constructed following the continuous chaining method, besides DI and its sub-categories are shown in Fig. 1.

Various pieces of literature raise concerns about the decoupling of economic growth from energy consumption or environmental impact. Such as Bithas and Kalimeris (2013) stated that decoupling-based energy/GDP results are weaker than that of the contemporary literature. Similarly, Ward et al. (2016) also criticize the decoupling indicator that GDP cannot be decoupled from energy or environmental impact. However, Lenzen et al. (2016) and Schandl et al. (2016) suggested that urbanization and affluence results from decoupling are better than that economic growth. Another reason is that most of the decoupling and decomposition studies (Khan & Majeed, 2020; Khan et al., 2020) use Tapio
decoupling with Kaya identity, which is based on four main factors, i.e., population, affluence, carbon, and energy intensity. Therefore, the current study includes urbanization and industrialization besides energy intensity and affluence to examine better the impact of key variables on the decoupling progress of Pakistan.

Cointegration theory

In the literature, the decoupling indicator is mostly employed with LMDI decomposition techniques. However, LMDI decomposition is based on Kaya identity, which focuses on specific factors and cannot depict the accurate results for other variables such as industrialization and urbanization. Although, the current study uses the two most influential factors of the economic growth and environmental impact, i.e., urbanization and industrialization, to check their short and long-term relationship with the decoupling indicator in the case of Pakistan. Due to the need of the study, the researcher adopts Johanson Juselius (JJ) cointegration technique to examine the cointegration between the dependent and influencing variables.

There are several reasons for choosing the JJ cointegration technique for the current study. Such as Wang et al. (2018a, b) stated that JJ can examine the long-term relationship among numerous variables. The study further stated that the JJ cointegration technique is flexible in imposing constraints on the model’s coefficients. However, before examining cointegration, the stationarity of the data/variables needs to be checked to avoid spurious regression. For this purpose, researchers propose multiple methods such as Augmented Dickey-Fuller (ADF) test and Philips-Perron (PP) tests developed by Dickey and Fuller (1979) and Phillips and Perron (1988). However, the current study adopts the ADF test, which is mostly adopted to assess ties between environmental impact and economic growth.

Secondly, selecting a good lag is vital for guaranteeing the efficacy of cointegration among the dependent and influencing factors. The lag period should be sufficiently long in normal conditions to represent the association among the variables. However, the lag period is directly linked with the degree of freedom of the model; the longer the lag length, the lesser the degree of freedom, which will influence the reliability of the results (Michieka et al., 2013). This study uses the Vector Auto-Regressive (VAR) lag selection criteria to select the possible lag length of the model. The VAR model gives the five kinds of judgment criteria (Posada & Buckley, 2004), known as Akaike Information Criteria (AIC), Likelihood Ratio (LR), Final Prediction Error Criterion (FPE), the Schwartz Information Criterion (SC), and the Hannan Quinn Information Criterion (HQ). The current study uses the AIC criterion to select the lag length of the model, and the lag length having the lowest value of AIC will be used as an optimal lag length.

The current paper uses the Kaya identity model, which comprises four indicators, i.e., population, affluence, carbon, and energy intensity, as shown in Eq. (3).

\[ DE = Pop + EG + EI + CI \] (3)

The DE shows the decoupling elasticity, EG shows economic growth (Affluence), and energy and carbon intensity are shown by EI and CI. Extending the Kaya identity, the current paper includes urbanization and industrialization as key factors of economic growth and carbon emissions. As per Shaheen et al. (2020), urbanization and industrialization depict a higher contribution to climate change and carbon emissions in the case of Pakistan. Therefore, urbanization and industrialization are added in the current paper, as shown in Eq. (4). The current study uses the DE as an endogenous variable, while urbanization, industrialization, economic growth, and CO₂ emissions intensity are the exogenous variables.

\[ DE = \beta_0 + \beta_1 IND + \beta_2 URB + \beta_3 EG + \beta_4 CI + \epsilon_i \] (4)

In the above Eq. (4), DE represents decoupling elasticity. At the same time, the IND depicts industrialization (value added % of GDP), URB represents the urban population growth (annual %), EG represents economic growth. The CI represents the carbon emissions intensity.

Impulse Response Function

Impulse Response Function (IRF) refers to the reaction of endogenous variables at the time of the shock (change in an exogenous variable) and over subsequent points. It has certain advantages over cointegration estimates. It provides detailed dynamic correlations between the dynamic system’s input (an impulse) and output variables. In addition, it evaluates the direction and intensity of the impact, including capturing the delay in policy effects. Equation (5) shows the basic model for IRF.

\[ Y_t = \beta + E_t + F_1E_{t-1} + F_2E_{t-2} + \cdots + F_pE_{t-p} + \epsilon_i \] (5)

It is worth noting that Et denotes that the impulse variables influence the dependent variable over time (t); the standard version of matrix Ft is \( F_t = \sum_{i=1}^{p} A_i F_{t-i} \). The dynamic relationship between an influencing and endogenous variable is depicted by the IRF illustrations in this study, which is shown in Eq. (6):

\[ \text{IRF}_q = F_i S_i l_i = \sum_{i=1}^{p} A_i F_{i-1} S_i l_i = S_i \frac{dY_{i+1}}{dE_i} \] (6)
where \( q = S_i l_i \) is the impulse vector, whose intensity is a standard deviation in the IRF unit; possible lag length is shown by \( p \), and lag operator is shown by \( 1 \), whereas time duration is shown by \( I = 1, 2, 3, \ldots \) and so on.

**Decomposition of variance**

It will be used to decompose the variation in the dependent variable due to the change in the influencing factors. Variance decomposition, on the other hand, can be used to evaluate and compare the relative contributions of multiple factors to an economic factor.

**Variable description and data source**

The data for the current study has been taken from the World Bank (World Bank 2019) from 1980 to 2018. The variable description, data sources, and definitions of the variables are given in Table 1. In contrast, Table 2 demonstrates the descriptive statistics of the economic variables that are used in the current study.

**Empirical results and discussions**

**Decoupling status of Pakistan**

The Tapio decoupling elasticity analysis (Table 1) reveals the existence of four decoupling statuses in Pakistan, i.e., SD, EC, WD, and END. However, END is the most prominent decoupling status, which threatens that emissions growth is much higher than the growth in economic activities. WD demonstrates relative decoupling, i.e., emissions growth is relatively lesser than economic growth. At the same time, EC status demonstrates that emissions and economic growth are coupled.

The END status of decoupling is because of the combustion of primary energy such as oil and coal in the industrial and household sectors. The study of Mahmood and Shahab (2014) supports our results, which states that coal and oil are the two prominent energy sources used in the industrial and household sector, which greatly impact Pakistan’s environmental quality. According to Energy Information Administration, due to lack and shortage of electricity, 1/3 of Pakistan’s population depends on biomass and waste energy consumption, which results in higher carbon emissions. Similarly, Butt et al. (2013) stated that 62% of Pakistan’s population has no access to clean energy, due to which they must run their household activities on biomass energy. Likewise, the growing consumption of oil as an energy source also leads to a disastrous impact on the country’s environmental impact. As per Husnain et al. (2020), Pakistan’s oil consumption significantly reached 431,000 b/d in 2015, which outpaced the domestic production, i.e., 95,000 b/d. In terms of coal consumption, Pakistan was one 138th position in 2016.

Similarly, the study by Khan et al. (2020) stated that a 1% increase in coal energy consumption significantly increases the carbon emissions to 6.70% in Pakistan. The study further stated that a 1% increase in natural gas consumption leads to

| Table 1 Decoupling statuses in Pakistan |
|----------------------------------------|
| Pakistan | Time period | \( \Delta C/C_0 \) | \( \Delta G/G_0 \) | Decoupling indicator | Decoupling status |
|-----------|-------------|----------------|----------------|---------------------|------------------|
| 1979–1980 | 0.13        | 0.10           | 1.32           | END                |
| 1980–1981 | 0.07        | 0.08           | 0.92           | EC                 |
| 1981–1982 | 0.08        | 0.07           | 1.33           | END                |
| 1982–1983 | 0.07        | 0.07           | 1.15           | EC                 |
| 1983–1984 | 0.06        | 0.05           | 1.25           | END                |
| 1984–1985 | 0.10        | 0.08           | 1.33           | END                |
| 1985–1986 | 0.04        | 0.06           | 0.88           | EC                 |
| 1986–1987 | 0.08        | 0.06           | 1.28           | END                |
| 1987–1988 | 0.08        | 0.08           | 1.15           | EC                 |
| 1988–1989 | 0.04        | 0.05           | 0.95           | EC                 |
| 1989–1990 | 0.12        | 0.04           | 2.80           | END                |
| 1990–1991 | -0.004      | 0.05           | -0.09          | SD                 |
| 1991–1992 | 0.06        | 0.08           | 0.86           | EC                 |
| 1992–1993 | 0.07        | 0.02           | 4.08           | END                |
| 1993–1994 | 0.08        | 0.04           | 2.34           | END                |
| 1994–1995 | -0.004      | 0.05           | -0.08          | SD                 |
| 1995–1996 | 0.11        | 0.05           | 2.43           | END                |
| 1996–1997 | 0.02        | 0.01           | 0.28           | WD                 |
| 1997–1998 | 0.03        | 0.03           | 1.22           | END                |
| 1998–1999 | 0.02        | 0.04           | 0.76           | WD                 |
| 1999–2000 | 0.06        | 0.04           | 1.42           | END                |
| 2000–2001 | 0.01        | 0.02           | 0.87           | EC                 |
| 2001–2002 | 0.05        | 0.03           | 1.66           | END                |
| 2002–2003 | 0.04        | 0.05           | 0.87           | EC                 |
| 2003–2004 | 0.10        | 0.07           | 1.45           | END                |
| 2004–2005 | 0.03        | 0.08           | 0.50           | WD                 |
| 2005–2006 | 0.06        | 0.06           | 1.12           | EC                 |
| 2006–2007 | 0.08        | 0.05           | 1.82           | END                |
| 2007–2008 | 0.001       | 0.02           | 0.07           | WD                 |
| 2008–2009 | -0.001      | 0.03           | -0.05          | SD                 |
| 2009–2010 | 0.01        | 0.02           | 1.00           | EC                 |
| 2010–2011 | 0.003       | 0.03           | 0.13           | WD                 |
| 2011–2012 | 0.009       | 0.04           | 0.27           | WD                 |
| 2012–2013 | 0.005       | 0.04           | 0.12           | WD                 |
| 2013–2014 | 0.01        | 0.05           | 0.26           | WD                 |
| 2014–2015 | 0.06        | 0.04           | 1.36           | END                |
| 2015–2016 | 0.10        | 0.05           | 1.87           | END                |
| 2016–2017 | 0.09        | 0.05           | 1.70           | END                |
| 2017–2018 | 0.05        | 0.05           | 0.92           | EC                 |
a 3.05% rise in carbon emission. Therefore, the use of coal and oil in economic activities leads to a severe threat to the environmental sustainability of Pakistan.

Further, the study also evidences the existence of SD (1991; 1995 & 2009). According to Malik (2012), the SD of 1991 is the energy supply shortage to the commercial and industrial sectors; further labor-intensive technology also reduces emissions and increases economic growth in the respective year. The SD of 1995 and 2009 is supported by the bailout package of the International Monetary Fund (IMF), which pressurizes the industrial sector through taxes resulting in low emissions, and the use of labor-intensive technology helps the industrial sector to be main the momentum of growth (Khan & Majeed, 2019). Further, Aziz and Ahmad (2015) stated that 2009 SD is accommodated by 8–9% annual GDP growth due to the government’s progressive policies. At the same time, emissions growth was lesser than economic growth. The analysis further reveals the existence of EC status, which shows that economic and emissions growth are coupled in the respective years. Further, WD is also observed in different years, demonstrating that economic and emissions growth goes side by side; however, emissions growth is higher than economic growth.

**Unit root analysis**

Before testing the dynamic relationship between the variables, it is necessary to check the stationarity of the variables. In this regard, ADF is used for the current study, and researchers intensively use it in the literature due to its reliability and robustness (Dickey & Fuller, 1979; Liu & Bae, 2018). Table 3 represents the unit root test results of the economic variables used in the current study.

| Variable(s)            | Symbol | Definition                                      | Source  |
|------------------------|--------|------------------------------------------------|---------|
| Decoupling indicator   | DI     | The ratio of %ΔCO₂ to %ΔGDP                    | WB, (2021) |
| Economic growth        | EG     | Annual percentage growth                      | WB, (2021) |
| Urbanization           | LUP    | % of the total population                      | WB, (2021) |
| Industrialization      | LIND   | % of GDP                                       | WB, (2021) |
| Carbon intensity       | LCI    | Metric tonnes of oil equivalent               | BP, (2021) |

The unit root results are shown in Table 3, and it can be observed that the variables have a mixed integration order, i.e., the dependent variable is level stationary. In contrast, the independent variables are first difference stationary. The sign of cointegration between the dependent and independent variables is depicted by the unit root results in this case. As a result, the JJ test will be used in this study to check for cointegration between the variables. To proceed with the cointegration, an appropriate lag length should be chosen to affirm the validity of the results. Table 4 shows the lag selection based on the VAR model, and the lag length is determined using the AIC.

Lag selection is one of the steps before checking for cointegration. There are different lag selection criteria, such as Hannan Quin Criterion, SIC, and AIC. Though among the proposed lag selection criteria, AIC is one of the most used lag selection criteria. Therefore, the current study also adopts the AIC lag selection criteria. The results of the VAR lag selection model (Table 4) suggest that the model with the 5 lags has the minimum AIC value and is preferred among the other models.

| Country | Series | At level |          |          |          | Order of integration |
|---------|--------|----------|----------|----------|----------|----------------------|
|         |        | t-stat   | Prob     | t-stat   | Prob     |                      |
| Pakistan| DE     | −11.81856| 0.0000   | −3.630073| 0.0411   | I−(0)                |
|         | URB    | −2.074756| 0.5423   | −7.004803| 0.0000   | I−(1)                |
|         | IND    | −2.587979| 0.2876   | −6.138812| 0.0001   | I−(1)                |
|         | CI     | −2.294967| 0.4264   | −3.252356| 0.0902   | I−(1)                |
|         | EG     | −1.689042| 0.7361   |          |          |                      |

| Model | Lag(s) | Akaike information criteria |
|-------|--------|-----------------------------|
| Pakistan| 1      | 41.59609                    |
|        | 2      | 40.38256                    |
|        | 3      | 40.51709                    |
|        | 4      | 40.04285                    |
|        | 5      | 39.82489*                   |
**Co-integration results**

The JJ cointegration technique is used in this study to examine the cointegration between variables (Table 5). The current study analyzes the cointegration between variables using trace and maximum eigenvalue statistics. According to the trace statistic, the JJ analysis reveals four cointegration equations between decoupling elasticity and industrialization, urbanization, economic growth, and carbon intensity at a level of 5% significance. Whereas at a 5% significance level, the maximum eigenvalue statistic reveals three cointegration equations between the study variables. The JJ cointegration test reveals cointegration between the dependent and independent variables.

The existence of cointegration is examined using the JJ technique and discussed in the preceding section; however, the long-term association between the variables must be investigated. Therefore, the current study employs the Ordinary Least Squares method (OLS), and the results are discussed in the forthcoming section.

\[
DE = 1.746438URB + 0.059815IND + 0.004497EG + 1.05565CI.
\]

The results of the OLS estimator show that almost all the variables worsen the decoupling status in Pakistan. However, carbon intensity is one of the leading drivers which weakens the decoupling elasticity in the case of Pakistan. Khan and Majeed (2019) support the results of our study, i.e., energy consumption in Pakistan is highly dependent on fossil fuel energy, which leads to higher carbon emissions in Pakistan. Similarly, the study by Ozturk et al. (2021) stated that the industrial sector of Pakistan mainly relies on conventional energy consumption, which ends in the exponential growth of emissions in the case of Pakistan. The second most important driving factor of environmental impact is urbanization, which weakens the decoupling progress of Pakistan. Thus, with this increasing rate of urbanization, energy consumption by households and by transport increases which drives the environmental impact. However, our results differ from the study of Zhu et al. (2017), which demonstrates that population growth (urbanization) is negatively correlated with carbon emissions. It is because the increase in urbanization leads to an increase in cleaner and sustainable energy, which in turn reduces carbon emissions.

Similarly, Ali et al. (2017) and Huo et al. (2020) stated that urbanization reduces environmental degradation due to initiating environmentally friendly policies and technologies. Besides, Wang and Su (2020) mentioned that urbanization tends to decrease carbon emissions in developed countries since they have achieved a strong decoupling relationship between carbon emissions and economic growth. In continuation, Muñoz et al. (2020) and Zhang et al. (2020) claimed that the urbanization-based scale effect of the economy drives the expansion of renewable energy, which ultimately reduces carbon emissions.

The same results are also depicted by industrialization and economic growth; however, these variables’ impact is lesser than the carbon intensity and urbanization. The impact of economic growth on environmental hazards is also proven by the study of Khan and Majeed (2020). The study’s findings observed the positive relationship between economic growth and the environment and state that per capita economic growth increases carbon emissions; this also supports the results of our study. Similarly, the Ministry of Finance of Pakistan also stated that Pakistan’s economy is consumption-driven, and most of the earnings are devoted to consumption (Sajid, 2020). Therefore, the economic growth also worsens the decoupling status in Pakistan, as large manufacturing and production units are required to meet the increasing demand.

### Table 5: Johanson co-integration results

| Hypothesized No. of CE(s) | Eigenvalue   | Trace statistic | 0.05 critical value | Prob.** |
|---------------------------|--------------|----------------|---------------------|---------|
| None *                    | 0.774443     | 124.8924       | 69.81889            | 0.0000  |
| At most 1 *               | 0.587643     | 71.28182       | 47.85613            | 0.0001  |
| At most 2 *               | 0.476199     | 39.39063       | 29.79707            | 0.0029  |
| At most, 3 *              | 0.300482     | 16.11147       | 15.49471            | 0.0403  |
| At most 4                 | 0.086231     | 3.246402       | 3.841466            | 0.0716  |

Trace test indicates 4 cointegrating eqn(s) at the 0.05 level
* Denotes rejection of the hypothesis at the 0.05 level

| Hypothesized No. of CE(s) | Eigenvalue   | Max-eigen statistic | 0.05 critical value | Prob.** |
|---------------------------|--------------|---------------------|---------------------|---------|
| None *                    | 0.774443     | 53.61056            | 33.87687            | 0.0001  |
| At most 1 *               | 0.587643     | 31.89120            | 27.58434            | 0.0131  |
| At most 2 *               | 0.476199     | 23.27915            | 21.13162            | 0.0246  |
| At most 3                 | 0.300482     | 12.86507            | 14.26460            | 0.0822  |
| At most 4                 | 0.086231     | 3.246402            | 3.841466            | 0.0716  |

Max-eigenvalue test indicates 3 cointegrating eqn(s) at the 0.05 level
* Denotes rejection of the hypothesis at the 0.05 level
of customers/consumers, increasing carbon emissions. However, the results are contrary to the studies of (Aguir Bar-
egaoui et al., 2014; Hashmi & Alam, 2019), who stated that economic growth is one of the main factors that control or reduce carbon emissions through the development of science and technology. Further, the EKC hypothesis also suggested that higher economic growth tends to reduce carbon emis-
sions in the long run through technological advancements (Cole et al., 1997).

The analysis further reveals that industrialization also weakens the decoupling progress in Pakistan. However, the impact of industrialization is smaller; the main reason behind this is the shortage of energy supplies to the industrial sector of Pakistan. The results are consistent with the study of Majeed et al. (2020). Besides, the industrial sector uses primary energy sources, positively contributing to the country’s carbon emissions. The analysis overall states that all four variables weaken the decoupling relationship between economic growth and carbon emissions, which is an alarming threat to the government of Pakistan. It is because of the climate threat to the world, and Pakistan is the most affected country by climate change due to its geographical location.

**Stability of the model**

Before the Impulse Response function and variance decom-
position, first, we should have to check the stability of the model/dependent variable. So, to check the stability, the current paper uses the Cusum and Cusum square test. The results of Figs. 2 and 3 represent the stability results of the model/dependent variable.

Figures 2 and 3 show the results of the Cusum and Cusum square test, which states that our model/dependent variable is stable. The blue line of the Cusum and Cusum square test must be between the red lines, demonstrating the model’s stability.

**Impulse Response Function**

The Impulse Response Function (IRF) is used to assess the response in the dependent variable due to shocks in the independent variables. Figure 4 shows the results of the IRF, which depicts the response of the decoupling indicator toward shock in the independent variables. The horizontal axis of the IRF figure shows the period, which is set to be 10 years; however, the vertical axis demonstrates the per-
centage change in the response variable. Furthermore, the black line shows the IRF of the response variable, and the red line shows the standard deviation in both the positive and negative terms.

The shock in the standard deviation of industrialization depicts a negative influence on the decoupling indicator in the short run; however, it also captures the positive effect on the decoupling elasticity in the long run. The figure depicts that industrialization leads to a decrease in environmental impact in the short run; however, in the long run, it also causes to increase in CO₂ emissions. Now, as far as the car-
bon emission intensity is concerned, it also positively influ-
ces the decoupling indicator in the short run; however, after period 5, it tends to decrease the decoupling elasticity and make it below zero. Carbon emissions intensity leads to decreasing CO₂ emissions in the long run due to the energy crises in Pakistan.

The effect of shock in the standard error of urbanization on DE depicts a negative influence throughout the study period; however, in some of the intervening years, it causes to increase in decoupling elasticity, but it is always below zero. In the long run, it leads to increased decoupling elas-
ticity for just one period. Urbanization causes a decrease in the environmental impact through the environmentally
friendly policies and encouragement of public transport that will lead to a decrease in the bulk of energy used to run private vehicles. The impact of shocks in the standard deviation of economic growth has a mixed impact on the DI, depicting a decrease in the decoupling elasticity in the short run and then increases in the intervening years. However, in the long run, it again tends to decrease decoupling elasticity. In the case of Pakistan, economic growth tends to decrease the environmental impact in most of the study periods due to the labor-intensive technology in the production sector. However, in the long run, it tends to decrease the decoupling elasticity, depicting the increase in environmental impact due to the extensive use of primary energy-based technology in economic activities.

Table 6 demonstrates the exogenous factors’ contribution to the decoupling indicator’s variance. Besides period 1, where DI 100% contributes to the DI, the 2nd period shows that industrialization contributes about 1.7% to the change in the variance of the DI and holds the most influential factor among the others throughout the study period. The second most influential factor that contributes to the change in the variance of the DI is the carbon emissions intensity (CI).

| Period | S.E | DE  | IND  | URB  | CI   | EG   |
|--------|-----|-----|------|------|------|------|
| 1      | 0.558889 | 100.0000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| 2      | 0.804213 | 95.75880 | 1.744611 | 2.103088 | 0.181246 | 0.212254 |
| 3      | 0.896688 | 77.57843 | 19.82307 | 1.699559 | 0.727398 | 0.171540 |
| 4      | 0.983661 | 73.21899 | 17.11707 | 3.711637 | 5.669329 | 0.282978 |
| 5      | 1.279350 | 54.32299 | 15.08792 | 2.547830 | 27.81514 | 0.226120 |
| 6      | 1.302495 | 55.38356 | 14.87322 | 2.646016 | 26.87778 | 0.219426 |
| 7      | 1.374772 | 56.55408 | 13.60532 | 2.522017 | 27.07662 | 0.241966 |
| 8      | 1.379865 | 56.13742 | 13.83617 | 2.818880 | 26.87847 | 0.329074 |
| 9      | 1.389485 | 55.41174 | 13.68149 | 2.799723 | 27.77223 | 0.334820 |
| 10     | 1.391913 | 55.21898 | 13.76793 | 2.908698 | 27.67717 | 0.427223 |
which significantly contributes from 0.18% in the short run up to 27% in the long run to the variance of the DI and shows continuous rise throughout the study period. After the industrialization and carbon emissions intensity, urbanization and economic growth contribute to the change of the variance of DI between 0–2% and 0–1% throughout the study period. The most influential factor of the DI in Pakistan’s case is the intensity of carbon emissions and industrialization.

**Conclusion and policy recommendations**

The current study investigates the decoupling and cointegration relationship between economic growth and its influencing factors, i.e., urbanization, industrialization, economic growth, and carbon intensity during 1980–2018. Tapio and JJ cointegration techniques are employed to achieve the study’s objectives. Besides, the study also employed OLS to examine the dynamic association of decoupling elasticity and its influencing factors. The IRF and variance decomposition are also applied to scrutinize the response of decoupling elasticity to the shocks of its influencing factors. The analysis reveals that Pakistan had four decoupling statuses, i.e., SD, WD, END and EC, throughout the analysis period. The most favorable SD occurred in (1991, 1995, and 2009) which indicates an increase in economic growth and a reduction in the environmental impact. Similarly, unfavorable decoupling status, i.e., END, is also observed in multiple years, which alerts the government of Pakistan. In these years, emissions growth is much higher than the economic growth and threatens the country's sustainability. The analysis also proposes that the government switch from conventional to green energy to eradicate the energy-induced environmental impact.

The JJ test confirms the existence of cointegration equations between decoupling elasticity and influencing factors in trace and maximum eigen statistics. Further, the quantitative relationship between the respective variables is computed through the employment of the OLS technique. In the case of Pakistan, the OLS results show that carbon intensity and urbanization are the primary drivers of decoupling. Similarly, industrialization and economic growth worsen the relationship between economic growth and carbon emissions, but their effect is smaller than the other variables.

According to the IRF findings, economic growth, urbanization, and carbon intensity all significantly impact the decoupling of economic growth from environmental impact in both the short and long run. All three variables tend to strengthen decoupling progress, but they often limit decoupling progress in Pakistan in some intervening years. In terms of industrialization, it tends to decrease the decoupling indicator in the short run while increasing it in the long run. This demonstrates that while industrialization helps to reduce environmental impact in the short run, it increases environmental impact in the long run.

Furthermore, the variance decomposition results suggest that industrialization followed by economic growth and carbon emissions intensity significantly contributes to the change in the variance of DI. Urbanization has the lowest contribution to the variance of the DI. However, industrialization held the most influential factor, which led to the change in the variance of DI throughout the study period. The findings of the paper help to identify the prime factors that affect the decoupling progress of Pakistan and help to provide deep insights into the policymakers regarding the mitigation of carbon emissions. First, improving technology in the industrial sector or introducing environmentally friendly technologies in the industrial sector will help reduce the environmental impact of the industrial sector. Second, urbanization also harms the decoupling progress in Pakistan, leading to increased environmental impact. To establish a substantial decoupling between economic growth and carbon emissions, the government should focus on the factors that have a greater influence than others.

**Policy recommendations**

The study’s results suggest that urbanization and industrialization are the two major factors restricting the decoupling progress of economic growth from carbon emissions in Pakistan. Therefore, it is recommended that the government focus on green technology in industrial activities to limit its impact on the environmental quality of Pakistan. Similarly, the government should initiate urban planning, such as vertical housing and the induction of a green transport system to reduce the environmental impact of household and transportation systems in urban areas. Further, it is also noted that carbon intensity restricts Pakistan from achieving strong decoupling. Therefore, the policy recommendation is to enhance the use of renewable energy in economic and household activities to limit the carbon footprint and improve environmental qualities.

**Contributions of the study**

The current study contributes in many ways, such as its open ways for the collective application of decoupling and econometric methodological approaches in the same study. The impact of urbanization and industrialization is also considered in the current study, while most of the previous research was based on decoupling and LMDI-based decomposition techniques. The study also contributes to the literature on decoupling economic growth from industrialization and urbanization along with other Kaya identity factors. The study also highlighted that urbanization is one of the main driving factors of carbon emissions in Pakistan. In
this respect, the study contributes to understanding that economic growth and energy consumption should be considered to limit urbanization’s impact. Similarly, industrialization is also observed as the main contributor to carbon emissions; therefore, the current paper contributes to the understanding that the government of Pakistan should properly look after the scale of industrial activities in Pakistan to limit the impact of industry-based carbon emissions on decoupling.

**Limitations of the study**

The current study addressed an alarming issue of decoupling economic growth from industrialization and urbanization-induced carbon emissions in the case of Pakistan for the period of 1980 to 2018. However, the study depicts certain limitations, such as the recent data on carbon emissions is unavailable. Besides, LMDI decomposition is not applied in the current paper with the econometric technique, leading to error terms in the results and not depicting the total impact of independent variables on the dependent variable.

**Scientific value added to paper**

The scientific value added by the current paper is that it sheds light on the two important factors of economic growth and carbon emissions, i.e., industrialization and urbanization. The result of the study enlightens the use of renewable energy in both industrial operations and urbanization, as they are run by fossil fuels which deteriorates the environmental quality of Pakistan. The study also highlighted that the industrial sector of Pakistan operates on polluted industrial stock, which increases carbon emissions. Therefore, the paper suggests changing these with more energy-efficient technological stock. Considering the impact of carbon intensity on decoupling, the paper added to the literature that green technology is the need of the hour for Pakistan to limit its industrial activity-induced environmental impact.

**Applicability of findings and results**

The respective paper identifies the key determinants affecting Pakistan’s decoupling progress, which guides the policy-makers in proper decision-making. The results suggest that carbon intensity weakens the decoupling in Pakistan, so the government needs to focus on it to achieve strong decoupling between carbon emissions and economic growth. One of the main reasons behind high carbon intensity is using fossil fuels such as coal, oil, and gas in industrial and household activities. Therefore, the industrial sector should focus on implementing green technologies in its operations to reduce the environmental impact of industrial activities. Similarly, Pakistan’s transport system or urban areas is one of the main reasons for high carbon emissions. It is suggested to incorporate an advanced public transport system so that people avoid private vehicles to reduce energy consumption. Because of the fossil fuel-based transport system of Pakistan, urban areas produce more carbon emissions, specifically from the transport system.

**Future research**

The current study uses the Kaya identity factors, including industrialization and urbanization, to examine the decoupling of economic growth from carbon emissions, specifically from industrialization and urbanization. However, it is suggested that future research can be conducted while considering renewable/clean energy and examining its impact on the decoupling of economic growth from carbon emissions, specifically on industrialization and urbanization. Further, it is suggested for future research to add the forestation factor as it is one of the factors directly linked with industrialization, urbanization, economic growth, and carbon emissions. Besides, more recent data should be used for future research to examine the relationship between economic growth and carbon emissions with more recent data.

**Declarations**

**Conflict of interest** The authors declare no competing interests.

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