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Effects of human capital, natural resource, urbanization, energy consumption on carbon emissions in the top ten emitter countries

Yu-Chen Zhang[a], Xi-Hua Liu[b], Arif Ullah[c] and Usman Mehmood[d]

[a]College of Management and Economics, Tianjin University, Tianjin, China; [b]School of Economics, Qingdao University, Qingdao, China; [c]Department of Economics and Business Administration, University of Education, Faisalabad, Pakistan; [d]Remote Sensing, GIS and Climatic Research Lab (National Center of GIS and Space Applications), Center for Remote Sensing, University of the Punjab, Lahore, Pakistan

ABSTRACT

The entire world is facing the problem of changing climate and distortion of environmental quality due to the rapid increase in carbon emissions. Therefore, this study was planned to examine the world's top ten carbon emitter countries, and the time extent was from 1990 to 2019. We employed panel Kao cointegration and Pooled Mean Group (PMG) techniques to explore the effect of human development, natural resources, urbanization, and energy use on carbon emissions. The Kao cointegration test results reveal that endogenous variables in the study have robust cointegration with carbon emissions. The PMG techniques results suggest that natural resources, urbanization, and energy use positively impact carbon emission in the top ten carbon emitters countries. Conversely, human development has a negative impact on carbon emission in the selected sampled nations. Based on the study's outcomes, the officials and policymakers of the sampled selected countries must set a policy to ensure environmental sustainability despite slowing down the process of economic development. More efforts are required to improve the human development index in the sampled selected economies. The overexploitation of natural resources should be revoked immediately to avoid more environmental damage. Further, green energy and urbanization should be introduced and publicized more effectively among society.

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1. Introduction

Since the world has originated, many things have evolved. One of the major components of which is climatic changes. Sustainability and ecological conservation are getting more popular these days. These days, global economies try to decrease ecological deprivation and maintain sustainable growth (Ali et al., 2019; Razzaq et al., 2021;

CONTACT Yu-Chen Zhang 646485885@qq.com

Sharif et al., 2017, 2020). The major cause of climatic change is global warming. Globally, efforts have been made to deal with ecology and climate change threats (Ji et al., 2021). To decrease the dreadful effects of climate change globally, on various platforms, this issue has been addressed over time like in 1992, the Earth summit, 1997 the Kyoto protocol, 2010 the Cancun Agreement, 2011 Durban Platform for Enhanced Action, while in 2015 Paris Agreement in Rio de Janeiro, Japan, Mexico, South Africa, and France respectively.

The increasing demand of humans for their survival because of the increasing population and urbanization has put extra pressure on the industry and economic growth (Ji et al., 2021). Consequently, several countries are confronting the problems of sustainability to maintain environmental quality (Umar et al., 2021b). Therefore, sustainable development goals were developed by the United Nations (2018) to protect the environment from further degradation (Mehmood & Mansoor, 2021; Usman & Hammar, 2021; Zeng et al., 2020). In this scenario, the entire world focuses on environmental quality to mitigate the impacts of ongoing climate changes and achieve the sustainable development goals of the United Nations (2018) at an optimum level. More importantly, the issues of environmental degradation have greater concern with human health (Wang et al., 2020). In addition, the consumption pattern of human shifts due to the growing population and become the source of diminishing natural resources.

Furthermore, the overexploitation of natural resources may arise due to the increasing consumption patter (Ielasi et al., 2018; Su et al., 2021; Wang et al., 2020) of growing populations. As a result, more human demand for water, energy, and infrastructure leads to environmental degradation (Su et al., 2021). The excessive usage of energy and over-exploitation of natural resources enhances the amount of carbon dioxide emissions in the atmosphere (Akbostancı et al., 2011; Elliott, 2012). It is a common perception that human operations and activities damage the environment, but there are some other features such as human capital that can actively reduce environmental degradation (Umar, Su, et al., 2021). Thus, providing opportunities for education and disseminating the knowledge about mitigation of carbon dioxide emissions may revoke environmental degradation in the country (Yin & Su, 2021; Su et al., 2021; Yu et al., 2022). Therefore, consumption of natural resources in a sustainable manner and offering education to human capital can reduce environmental degradation (Godil et al., 2020; Khan, Chenggang, et al., 2020; Khan, Teng, et al., 2020).

In recent times, many researchers identified that environmental degradation and deterioration phenomenon results in changes in temperature degree and rainfall patterns (Kaiser & Welters, 2019; Umar et al., 2022). Accordingly, it is argued that Greenhouse gas (GHGs) emissions are responsible for these changes on earth (Umar et al., 2021a). In this context, 2016 was recorded as Earth's warmest year (Harper, 2017; Renner et al., 2018). The major contributors to GHGs emissions are water vapor (H_2O), nitrous oxide (N_2O), chlorofluorocarbons (CFCs), carbon dioxide (CO_2), and methane (CH_4). However, about 81% of GHGs are from CO_2 emissions. As per a report, globally, CO_2 emissions raised to 33,444.0 (Mtoe) in 2017 (Petroleum, 2018). Natural resources (NAT), human capital (HDI), and urbanization

(UR) are acknowledged as the main resources of the increase in CO_2 emissions (Dong et al., 2019; Nathaniel 2021; Nathaniel et al., 2020; Ulucak & Khan, 2020).

In previous literature, CO_2 emissions (Churchill & Ivanovski, 2020; Fodha & Zaghdoud, 2010; Omri, 2014; Stern, 2004). Using the Environmental Kuznets curve (EKC) hypothesis, the linkage between CO_2 emissions and economic growth can be explored (Aboagye, 2017; Alam et al., 2016; Dong et al., 2019; Kwakwa & Adu, 2015; Shahbaz et al., 2016) and the ecology-energy-growth nexus (Doğan et al., 2020; Mardani et al., 2019; Sarkodie et al., 2019). Some studies suggest that the effects of CO_2 emissions can be determined by financial development (Bekhet & Othman, 2017; Gokmenoglu & Sadeghieh, 2019; Shahbaz et al., 2020; Wang & Dong, 2019). The nexus between CO_2 and urbanization has been observed in Pacific and East Asian countries (Mehmood & Mansoor, 2021). Results show that in Mongolia, Hong Kong, Japan, and China, urbanization is decreasing CO_2 emissions. Furthermore, in South Korea, Macao, and Singapore, CO_2 emissions increase with the increase in urbanization (Mehmood & Mansoor, 2021). However, to the best of our knowledge and abilities, none of the researchers have simultaneously established a relationship between CO2 and human capital, natural resource, urbanization, and energy consumption in the top ten emitters countries (Dorfleitner & Grebler, 2022).

The inclusion of natural resource variables in the study has a significant association with economic growth because to maintain environmental quality, natural resource restoration is mandatory along with the progression of economic growth (Aye & Edoja, 2017; Danish & Zafar-Ul-Hye, 2019; Desha et al., 2015; Hussain et al., 2020). Similarly, energy consumption is an important variable concerning CO_2 emissions because non-renewable energy usage such as coal and wood is the main source of high CO_2 emissions (Su et al., 2020). The other variable in the study is human capital. Human capital can play a role in maintaining environmental quality because the skilled and educated person has more ability to adapt to the rules and regulations of the environmental agencies on a priority basis. This will help reduce further degradation's environmental degradation (Adedoyin & Zakari, 2020; Padhan et al., 2020).

Against this backdrop, this manuscript investigates the impact of human capital, natural resources, urbanization, and energy consumption on carbon emissions in the top ten carbon emitter countries (Wang et al., 2020). The rest of the sub-section of the manuscript is designed as given below. The subsequent section is all about the literature review followed by methodology. The fourth section demonstrates the analysis results and is followed by comparative analysis and study discussions. The last section of the paper is conclusions and policy implications.

2. Literature review

According to previous literature, natural resources (NAT), human capital (HDI), urbanization (UR), and Energy consumption (EN) have been linked with CO_2 emissions. So, in our literature, we have made two subheadings.

2.1. Natural resources, human capital, and CO_2 emissions

HDI can be a solution for ecological sustainability as it is a linkage between ecological degradation and NAT. A linkage between ecology and NAT has been explored for BRICS countries using Dynamic and fully modified OLS, i.e. DMOLS and FMOLS techniques (Ulucak & Khan, 2020). According to the author, in the nexus, HDI is not a potential variable, while in the betterment of the ecology of BRICS countries, NAT is a major contributor. In G7 countries, the impact of HDI on ecology from 1971-to 2014 has been observed (Ahmed, Zafar, et al., 2020). It was found out that HDI is linked with ecological sustainability. According to (Ahmed, Zafar, et al., 2020), a linkage between ecological quality, HDI, and NAT has been explored using Auto-Regressive Distributed Lag (ARDL) technique in China. This shows that HDI improves the ecology while NAT worsens it.

It is investigated that NAT and HDI affect ecology while controlling for Foreign Direct Investment (FDI) in the USA from 1970-to 2015 (Zafar et al., 2019). It was found out that these variables add to the quality of ecology. Using the ARDL technique impact of HDI and biodiversity has been observed in Pakistan from 1971-to 2014 (Hassan et al., 2019). Contradictory to early findings, it was found that biodiversity and HDI contribute to ecological degradation. It was also found that NAT contributes to ecological degradation (Hassan et al., 2019). A causality between CO_2 emissions and NAT exists. For BRICS countries AMG technique has been applied (Danish & Zafar-Ul-Hye, 2019). It was observed that two-way causation prevails between CO_2 emissions and NAT. also, except in India, it was observed that NAT intensifies CO_2 emissions.

2.2. Urbanization, energy consumption, and CO_2 emissions

The association between CO_2 emissions, EN, and UR has been explored multiple times, having diverse results. For example, in G7 countries, data spanned from 1970-2015, EN contributes to CO_2 emissions (Liu, Ma, et al., 2020; Liu, Ren, et al., 2020). According to (Shahbaz et al., 2019), for G7 countries, generalized methods of moments (GMM) have been used. Trade, institutional quality, and FDI (foreign direct investment) reduce CO_2 emissions. (Acheampong et al., 2019) also conclude the same result for sub-Saharan Africa (SSA) countries (Mehmood & Mansoor, 2021; Shahbaz et al., 2019; uz Zaman et al., 2021) explored that with the increase in EN, CO2 emissions are reduced in china. ARDL and FMOLS technique has been used for analysis, and both techniques show that these variables are negatively correlated. While on the contrary, it is observed by (Wasti & Zaidi, 2020) that in Kuwait increase in CO_2 emissions significantly increases the EN. Also, a bidirectional causality has been observed between these two variables using the Granger causality test.

Furthermore, (Bansal & Kumar, 2021; Salahuddin et al., 2019) investigated the influence of UR and CO_2 emissions over 44 SSA nations. Results show that they are positively correlated. (Saidi & Mbarek, 2017) have taken the data from 19 emerging countries from 1990-2013. Moreover, found that UR negatively correlates with CO_2 emissions. (Al-Mulali et al., 2015; Bansal & Kumar, 2021) investigated the relationship between UR, trade openness, GDP growth, and financial development with CO_2

emissions over 23 countries of Europe from 1990-2013. Panel data cointegration techniques have been used for analysis. According to FMOLS, a long-run positive correlation between UR and CO_2 emissions is observed. (Nathaniel et al., 2021) investigate the relationship of CO_2 emissions with UR, HDI, and EN in Latin American Caribbean Countries (LACC) from 1990-2017. The author observes that UR accompanied by EN is a cause of an increase in CO_2 emissions. Also, an increase in UR will increase HDI.

3. Data and methodology

Globally, carbon emissions are the significant constituent of greenhouse gas emissions and consistently deteriorate environmental quality. Therefore, it was obligatory to examine the status of the top ten carbon emitter countries over the time extent of 1990 to 2019. Most countries have done various exercises to excel in their economies. Our panel economies consist of Indonesia, Saudi Arabia, South Korea, Iran, Germany, Japan, Russia, India, the United States, and China. The CO_2 emission was used as an endogenous variable and computed in metric tons per capita. The exogenous variables encompass human development, natural resources, urbanization, and energy consumption. Only the human development index data was taken from the united nation development program (Canton, 2021), whereas the rest of the series data were taken from the world development indicator (Bank, 2020). The total natural resources and urbanization variables were measured in percentages of GDP and total populations, respectively. The energy use was measured in kg of oil equivalent per capita for the sampled selected countries.

This study uses a very famous approach by (Pesaran et al., 1999) known as the PMG technique. The PMG and MG are the two key techniques to assess the non-stationary dynamic panels. The factors of these are heterogeneous amongst the group. The PMG technique has the best feature to prefer over MG estimates. The PMG can pool and take the mean of the coefficient to be employed. Previous researchers have used this technique (Danish & Zafar-Ul-Hye, 2019; Hassan et al., 2019; Liu, Ma, et al., 2020; Nathaniel et al., 2021; Zafar et al., 2019), but non of them have used these four variables, i.e. human development, natural resources, urbanization, and energy consumption simultaneously. Equation (1) presents the functional relationship between endogenous and exogenous variables.

$$CO_2 = f\ (\text{HDI},\ \text{NAT},\ \text{UR},\ \text{EN}) \qquad 1$$

$$\ln CO_{2i,t} = \beta + \gamma_1 \ln HDI_{i,t} + \gamma_2 \ln NAT_{i,t} + \gamma_3 \ln UR_{i,t} + \gamma_4 \ln EN_{i,t} + \mu_{i,t} \qquad 2$$

Equation (1) was transformed into a logarithmic function. Further, the symbol such as $\ln CO_2$, lnHDI, lnNAT, lnUR, and lnEN represent the carbon dioxide emission, total natural resource, urbanization, and energy use, respectively, in Equation (2). Moreover, β is the intercept term, γ shows the partial slope co-efficient, and μ denotes the residual term in the model.

The simple ARDL does not overcome the problem of biases in the panel approach using individual impact because of the average differenced independent variables and association between the white noise term. Therefore, PMG/ARDL technique was preferred and proposed by (Pesaran et al., 1999).

$$\ln Y_{i,t} = \vartheta_i ECT_{i,t} + \sum_{j=1}^{q-1} \Delta \ln X_{i,t-j} \beta_{i,j} + \sum_{j=1}^{p-1} \delta_{i,j} * \Delta \ln Y_{i,t-j} + \varepsilon_{i,t} \quad 3$$

$$ECT_{i,t} = Y_{i,t-1} - X_{i,t}\theta \quad 4$$

The dependent variable shows the expression of carbon dioxide emissions, denoted with the symbol 'Y' in Equation (3). The independent variables are expressed with the symbol 'X'. These variables include human development, natural resources, urbanization, and energy consumption. Further, I represent with reference to the time t, while the co-efficient of adjustment is denoted with ϑ. The symbol θ shows the co-efficient of long-run producing β in the model while the difference operator is represented with Δ and the error term is denoted with ε. And δ shows the estimates because of convergent occurred in the model.

4. Analysis results

Before starting the formal panel data analysis, we first examine the selected top carbon emitter countries' correlation analysis and descriptive statistics. The correlation analysis in Table 1 shows a positive and monotonically relationship between the variables except for human development and natural resources. The descriptive analysis of the study shows that all the data are normally distributed. Hence there is nothing wrong with the data. This means that none of the outliers are present in the data. The carbon dioxide mean is 8.96 metric tons per capita, ranging from 0.71 to 24.4. Further, the human development index average value was figured out to be 0.75,

Table 1. Correlation analysis and descriptive statistics of the variables.

	CO_2	HDI	NAT	UR	EN
		Correlation Analysis			
CO_2	1.00	0.74	0.24	0.79	0.97
HDI	0.74	1.00	−0.12	0.91	0.81
NAT	0.24	−0.12	1.00	0.14	0.12
UR	0.79	0.91	0.14	1.00	0.82
EN	0.97	0.81	0.12	0.82	1.00
		Descriptive Statistics of the variables			
Mean	8.96	0.75	8.81	65.74	3467.62
Median	9.29	0.77	2.69	74.09	3850.20
Skewness	0.32	−0.53	1.70	−0.87	0.24
Std. Dev.	5.70	0.13	12.43	19.28	2186.83
Sum	2686.64	225.80	2642.68	19722.38	1040286.00
Sum Sq. Dev.	9724.65	5.04	46215.35	111117.70	1430000000.00
Minimum	0.71	0.43	0.01	25.55	350.08
Kurtosis	2.36	2.32	5.23	2.33	2.16
Jarque-Bera	10.37	19.88	206.34	43.83	11.84
Probability	0.01	0.00	0.00	0.00	0.00
Observations	300	300	300	300	300

Source: Author's own calculation.

ranging from 0.43 to 0.94. The natural resource percent of the GDP mean value shows 8.81, and the minimum and maximum values were documented as 0.01 and 55.52, respectively. Similarly, urbanization shows that, on average, 65.74 people live in urban areas ranging from 25.55 to 91.70. The average energy consumption was documented as 3467.62 kg of oil equivalent per capita ranging from 350.08 to 8056.86 in the panel of top ten carbon emitter countries. In addition, the natural resource shows high positive skewness, followed by carbon dioxide and energy consumption. However, the human development index and urbanization show negative skewness. The distribution based on the kurtosis shows that all the variables have positive values. This suggests that all the variables are distributed on the right side.

Initially, the basic statistical properties of the data are examined with the help of the standard procedure of panel tests, following the PMG approach in this study. Therefore, the panel unit root test is the primary condition to conduct for onward analysis. The results of the unit root test are provided in Table 2. We performed two types of panel unit root tests. The first one is (Levin et al., 2002), and the second one is (Im et al., 2003) unit root tests. Based on both the Levin-Lin-Chu and I'm, Pesaran, Shin tests confirmed that carbon dioxide, human development index, total natural resources, urbanization, and energy consumption series are stationary at the first difference (I∼1). These tests results are quite suitable for onward performing the analysis in this study.

We used the cointegration test to test the long-term association between the exogenous and endogenous variables. The cointegration test decision is set after performing the panel unit root tests. Therefore, we performed the Kao cointegration test developed by (Kao, 1999). Due to size distortion, (Larsson et al., 2001; McCoskey & Kao, 1998) test fails to provide good approximations; that is why (Kao, 1999) cointegration test is preferred as it assumes no cross-sectional dependence. The outcomes of the Kao cointegration test are reported in Table 3. The results show that cointegration was revealed between the independent and dependent variables among the panel's countries. Further, these results suggest that the alternative assumption of cointegration is accepted at a significant level of 1%. This means that robust cointegration exists between the exogenous and endogenous variables across the independent constituents of the penal based on the Kao cointegration test.

Table 2. Unit root tests.

	Im, Pesaran, Shin		Levin-Lin-Chu Unit Root Test	
Variable	I(0)	I(1)	I(0)	I(1)
$lnCO_{2t}$	−4.17	−16.28***	−3.77	−13.57***
$lnHDI_t$	−1.32	−1.82***	−5.16	−2.14***
$lnNAT_t$	−0.26	−2.24***	1.92	−9.26***
$lnUR_t$	−2.66	−20.22***	−11.23	−16.49***
$lnEN_t$	−0.02	−4.81***	−2.67	−6.53***

Source: Author's own calculation. Note: *** represents a 1% level of significance.

Table 3. Kao co-integration test.

	ADF	HAC variance	Residual variance
t-Statistic	−12.82***	0.49	0.5
Prob.	0		

Source: Author's own calculation. Note: *** represents a 1% level of significance.

Table 4. Hausman test.

Test	PMG vs MG	PMG vs DFE
Statistics	1.75	1.8
P-Value	0.91	0.62
Decision	PMG method	PMG method

Source: Author own calculation. Note: ***, **, and * represent 1%, 5%, and 10% level of significance.

Table 5. PMG estimations.

Variables	Coefficient	Std. Error	t-statistics	P-Value
$lnHDI_t$	−5.68***	0.69	−8.18	0.00
$lnNAT_t$	0.17***	0.16	3.12	0.00
$lnUR_t$	0.65***	0.51	7.63	0.00
$lnEN_t$	0.81***	0.23	4.68	0.00
		Short run		
ECT^{-1}	−0.35***	0.11	−3.18	0.00
$lnHDI_t$	−2.55	11.22	−0.22	0.82
$lnNAT_t$	1.55	2.05	0.75	0.45
$lnUR_t$	1.31**	0.70	1.85	0.06
$lnEN_t$	0.13**	0.66	0.96	0.04

Source: Author own calculation. Note: ***, **, and * represent 1%, 5%, and 10% level of significance.

The transformation of the series into a logarithmic function would provide us with direct elasticities of the coefficients of the variables during the MG and PMG approach in the long and short-run form. Our panel consists of the top ten carbon emitters of the countries, and thus the total number of observations was recorded at 300 in the panel data set. Further, we employed the Hausman test of endogeneity. This test would compare the estimator for consistent and appropriate tested models. The findings of the Hausman test are provided in Table 4 and show that all the long-run homogeneity of the coefficients is appropriate and consistent across the cross-sections. However, to choose the best method approach and efficient estimator PMG was preferred over MG and DFE because the Hausman test p-values (0.91 & 0.62) results are insignificant. Table 5 presents the PMG model estimates. According to the PMG long-run estimates, the total natural resources, energy consumption, and urbanization variables increase the carbon emissions. This means that these variables have a positively substantial impact on carbon emissions. Nevertheless, the coefficient of energy consumption (0.81) is higher, followed by urbanization (0.65) total natural resources (0.17) in the panel data economies. Nonetheless, the PMG long-run estimates show that the human development index decreases carbon emission. This suggests human development index has not positive effect on carbon emissions. The coefficient of the human development index is −5.68. The coefficient value of the human development index in the PMG model long-run estimates is quite low compared to the short-run estimates of the model.

Furthermore, the speed of adjustment, which shows the transformation from short to long-run form in the system, is detected by the error correction term (ECT_{-1}). The P-value of the ECT is negatively significant, which means that model is stable and at an equilibrium position in the system. In the short-run form of the PMG, estimates show that urbanization and energy consumption significantly impact carbon emissions. However, in short-run estimates of the PMG model, the coefficients value of the total natural resource (1.55) is higher compared to urbanization (1.31).

In addition, in the short-run form of the PMG, the total natural resource positively impacts carbon emission. The coefficient of energy consumption was figured out at 0.13. Similarly, the human development index negatively impacts carbon emission in the short-run form of the PMG estimation, which supports the long-run form of the PMG estimates.

5. Comparative analysis and discussion

The analysis results of the PMG long-run estimates reveal that there exists a positive and substantial correlation between carbon emissions and the total natural resources, urbanization, and energy. However, according to the PMG long-run estimates, the human development index has a negative impact on carbon emission. More interpretation of these findings proposes that a 1% increase in the total natural resources, urbanization, and energy consumption would enhance 0.17, 0.65, and 0.81% carbon emissions in the top ten carbon emitters. In contrast, a 1% increase in the human development index would decrease 5.68% carbon emission in the PMG long-run form estimates. This alludes to the study that overexploitation of natural resources affects environmental quality. Energy consumption leads to environmental degradation. This result is in line with the finding of (Cetin et al., 2018). This outcome aligns with the study of (Ahmed, Zafar, et al., 2020; Bekun et al., 2019; Hassan et al., 2019; Pata et al., 2021; Tan et al., 2020). In contrast, some researcher opposes our result, such as (Balsalobre-Lorente et al., 2018; Danish & Zafar-Ul-Hye, 2019; Joshua & Bekun, 2020).

The result of the short-run form of PMG estimates reveals that a 1% increase in total natural resources, urbanization, and energy consumption would increase 1.55, 1.31, and 0.13% carbon emission in the panel countries. Likewise, a 1% increase in the human development index would decrease 2.55% the carbon emission in the panel data set countries. Our findings are corroborated by the outcome of (Pata et al., 2021), who found that the human development index reduces environmental pressures. Investigating the impact of the human development index on carbon emission is quite innovative work because most of the previous researchers have used human capital. Therefore, compared to this study, previous researchers mostly support the results (Ahmed, Ashraf, et al., 2020; Ahmed & Wang, 2019; Ulucak & Bilgili, 2018; Zafar et al., 2019) who have used human capital in their respective studies. In contrast, a recent study was done by (Kassouri & Altıntaş, 2020) for MENA economies, and the study's outcome suggests that the human development index elevates environmental deterioration. MENA group countries are the opposite of our study's panel data set economies. This difference may be because social, economic, and political changes exist between the two different panel data set countries. These findings suggest that a person having a high human development index has a conversion approach towards a sustainable environment. It is a matter of fact that in this modern era, researchers and environmentalists prefer sustainable development instead of development. Furthermore, it is recommended that the top ten emitters must concentrate on the human development index. They should create more education opportunities on a priority basis to initiate the depletion of carbon emissions. The result favors (Bano et al., 2018) but contradicts the finding of (Sarkodie et al., 2020). Therefore, steps are required to improve the environmental quality instead of environmental damages. In this scenario, the human development index must be improved to educate more individuals to avoid environmental damage. Exploiting natural resources should be avoided as natural resources positively affect ecological quality.

6. Conclusion and policy implications

Generally, every country in the world prefers environmental quality and discouraging environmental damages. Further, it is the demand of every nation to avail clean and green environment. In the same context, the past literature reveals that limited research has been carried out to check the impact of natural resources and human development variables on ecological deprivation. Therefore, it was necessary to fill this gap, and this analysis was designed to examine the impact of human development, natural resources, urbanization, and energy consumption on carbon emission, taking the case of the top ten carbon emitter countries. The top ten emitter countries panel encompass China, the United States, India, Russia, Japan, Germany, Iran, South Korea, Saudi Arabia, and Indonesia. The time duration of the study was taken from 1990 to 2019. First, a penal unit root test was employed to investigate the relationship between endogenous and exogenous variables in the study. The stationary of the series was checked with the panel unit root standard procedure. The results of the unit root reveal that all the variables are stationary at first difference. The Kao cointegration test was performed to examine the co-integrating between the variables in the study. The outcome of this test confirmed that there is robust cointegration between HDI, natural resources, urbanization, energy consumption, and carbon emission. Moreover, the PMG long and the short-run test results show that in the long-run form of PMG, natural resources, urbanization, and energy consumption increase carbon emission, while human development eases the pressure of carbon emission in the top ten carbon emitter countries. Similar results have been found in the PMG short-run form, which as in-line with the results of the PMG long-run form of the model.

Based on the outcome of the analysis in the study ascertains, key policy implications emerged. As energy consumption enhances environmental pressure in the sampled selected countries. Therefore, policymakers in the sampled selected countries must regulate the tax laws and provide opportunities to use green energy. More subsidies should be provided to install more solar panels on public and private premises to reduce the emission of carbon in these countries. Extension in urbanization should be allowed only on the condition that the same area in a different location must be allocated and developed for a grassy plot and plantation. The policymakers should make a concrete policy to enhance the investment in human development. Moreover, reducing environmental pressures is obligatory to protect natural resources from over-exploitation usage in the economy. This will help to conserve more natural resources and ease pressure on the environment in the shape of carbon emissions. To preserve the environment, the planner of the countries should make comprehensive policies to maintain the balance between consumption patterns on the demand side and exploitation of natural resources on the supply side.

This study mainly focuses on the human development index, natural resources, urbanization, and carbon emissions. The penal data was taken from the top ten carbon emitter countries. The other researcher should study the identical variable for other countries using the panel data set. This would be interesting to compare the result of the panel data set with the results of the top ten carbon emitter countries. By conducting a similar study would help enhance the scope of the study at hand.

Disclosure statement

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ORCID

Usman Mehmood http://orcid.org/0000-0001-9034-5878

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