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ORIGINAL PAPER

Investigating the interaction effect of urbanization and natural resources on environmental sustainability in Pakistan

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Abstract

Natural resource extraction has raised serious environmental-related concerns among policy analysts and environmental economists. To further clarify whether or not natural resource rent affects environmental sustainability, this study investigates the potential impact of natural resource rent on environmental sustainability by addressing the interaction effect of urbanization and natural resource rent for data spanning from 1971 to 2017 in the context of Pakistan. Ecological footprint, carbon emissions, and carbon footprint are used as indicators for environmental sustainability. The application of the dynamic autoregressive distributive lag method infers that the natural resource rent contributes to carbon emission and alternatively urbanization helps pollution mitigation. The interaction between urbanization and natural resource rent plays a moderating role in reducing carbon dioxide (CO_2) emissions, ecological and carbon footprint. The co-efficient value of natural resources, urbanization and interaction effect of urbanization with natural resource ranging from 0.021 to 0.788; 0.287 to 1.689 and 0.033 to 0.320, respectively. The study invites the attention of policymakers toward more sophisticated policies regarding sustainable natural use, controlling environmental pollution, and keeping urbanization intact.

Keywords Natural resource rent · Urbanization · Environmental sustainability · Moderating effect · Dynamic autoregressive lag simulation method

Introduction

Climate change mitigation has become a global phenomenon and it plays an important part in accomplishing sustainable development as an alternative for humankind to survive. Hence climate change mitigation becomes an analytical part of different policy initiatives (Ulucak et al. 2019). Recently, the issue of climate change is a significant ongoing concern due to the adverse effects of global warming and catastrophic climatic events that continue to devastate the entire planet (Danish et al. 2017). Also, environmental degradation imitates human drastically lives around the world (Destek and Sarkodie 2019). Both developed and developing countries face difficulties in balancing environmental and economic goals. On the one hand, the growing needs of people to improve their economies inevitably require the support of the natural resources of the environment. But on the other hand, irresponsible exploitation of natural resources and the unlimited desire for human consumption threaten future economic growth by damaging the environment (Pata et al. 2021).

Natural resources influence the environment in two distinct ways. First, natural resources are used for production and consumption purposes; however, unsustainable natural resource utilization through farming, deforestation, and mining affect the country's environment. The extraction of natural resources releases waste material and chemicals into the water and air (Hassan et al. 2019). Besides, human activities including industrialization, deforestation, and mining lead to excessive consumption of natural resource that affects environmental quality. Incorporating sustainable management practices into production and consumption processes reduce natural resources depletion rate, and resources can be redeveloped later (Ulucak et al. 2020).

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Second, natural resources influence environmental quality through economic growth. The accelerating economic growth expedites natural resource extraction that increases ecological footprint (ECF) (Panayotou 1993). Many countries rely on natural resources for a large portion to increase the rate of gross domestic product (GDP) (Hailu and Kipgen 2017). However, GDP indirectly relates to natural resource consumption (Betz et al. 2015). According to the traditional EKC hypothesis, during the scale effect of production, a rise in extraction and production of natural resources generates pollution. In the early stage of economic development resident of a country consumes more goods and services (Abubakr et al. 2020). For instance, economic development drives industrialization and natural resource consumption, ecological deficit, and waste generation increases (Sarkodie and Strezov 2018). Deforestation, water scarcity, and climate change increase the extraction of natural resources and cause serious environmental problems and climate change in both developing and developed countries (Danish et al. 2019).

Urbanization postulates remarkable openings in economies of scale and the efficient use of natural resources (Anser et al. 2020). However, urbanization and the activity expansion of production levels in the pursuit of urbanization and economic growth not only increase CO_2 emissions but also threaten human health and sustainable development (Asongu and Odhiambo 2019). Besides, urbanization provides better job opportunities, technological innovations enhance research and development activities, and higher living standards (Khan et al. 2021a) and that leads to improving environmental quality. Urbanization increases transportation activities and industrialization raises the energy demand and thus causes to increase in ecological footprint. Higher urbanization rates expand economically activates at the expanse of natural resource exploitation and distressing public health. Urbanization generates positive externalities, provision of public services, upsurges purchasing power, and together with all these turn to an increase in energy efficiency that might reduce ecological footprint (Danish et al. 2020).

Amongst the top 10 high-population countries the land pressure increases in Pakistan. An abundance of natural resources is available in Pakistan but still, environmental degradation is growing at a higher rate. Pakistan is not poor but its miss management makes it so. Further increasing environmental pollution is a threat to human health and the ecological security of the country (Wang et al. 2018). Pakistan has an agrarian economy and more than 70% of its population depends on agriculture and livestock management for their livelihoods, which makes natural resources under stress. Hence population balancing economic growth with satisfactory environmental quality is a timely issue, particularly in Pakistan. Currently, Pakistan is passing through the process of rapid urbanization with a rate of almost doubled from 32.5 to 61.4% during 1990–2014. Urbanization increases the income of level of urban residents; however, it also enhances the energy demand, and a country with a lack of natural resources relies on energy imports which comprise fossil fuels (Mi et al. 2016). Excessive use of fossil fuels leads to environmental degradation.

Against the above backdrop, the current study introduces the interaction effect of urbanization and natural resource rent as a determinant of environmental sustainability. Ecological footprint, carbon footprint, and CO_2 emission are considered determinants of environmental sustainability. The study is different while investigating the role of natural resource rent and urbanization in environmental sustainability for the first time in Pakistan. This research makes some valuable contributions to existing literature; the current study evaluates the effect of natural resources on environmental pollution accounting for the moderating role of urbanization between natural resource rent and environmental sustainability. It provides policymakers with a new direction concerning whether natural resources help balance economic growth and environmental quality. This study adopted a newly developed time series econometric strategy, the dynamic Auto-Regressive distributive lag model (DARDL) proposed by Jordan and Philips (2018), for long- and short-term estimation. The dynamic ARDL simulation method resolves the complexity of the existing ARDL model. To provide guidance considering climate change mitigation the key focus of the study to study is to Investigating the interaction effect of urbanization and natural resources on environmental sustainability in Pakistan.

The remaining paper proceeds as follows; previous literature related to the study is discussed in Sect. 2, model specification, econometric methodology, and data, are explained in Sect. 4. Further Sect. 4 discussed results and finally, Sect. 5 comprises of conclusion and policy implication.

Literature review

Over the last few years, natural resources in carbon emissions gained importance in the literature. In this sense, several studies have been conducted using time series and panel data, various control variables, and econometric tools. Several studies have found that natural resources contribute to environmental pollution, for instance, Khan et al., (2020) and Hussain et al. (2020) revealed detrimental effect of natural resources on environment for belt and road countries; Wang et al. (2020) for G-7 countries; Joshua and Bekun (2020) for South Africa; Bekun et al., (2019) for 16-EU countries; Danish, (2019a, b) considered for Pakistan. Recently, Shen et al. (2021) highlighted the impact of green innovation, natural resources, and financial development using provincial-level data for China. The CS-ARDL results show that natural resources in harmful to the environment. Nathaniel and Nathaniel (2020) employed AMG empirical method to explore the natural resource and CO_2 emission nexus considering globalization and urbanization in Latin American and Caribbean countries. Findings suggest natural resources are among the factors behind pollution. Danish et al. (2020) concluded heterogeneous effect of NRR on CO_2 emission for BRICS countries. Abubakr et al. (2020) considered the moderating effect of natural resource dependence (NRD) and income on the income-CO_2 emissions linkage in Malaysia. The output from the ARDL method suggests that the moderating effect of income and NRD weakling strengthen the linear relationship between income and emission whereas weakening the quadratic relationship between them. However, few studies have found natural resources rent reduce pollution. Balsalobre-lorente et al. (2018) estimated positive role of natural resource rent in the environment for European Union countries; Khan et al. (2021b) for the United States and Danish et al. (2020) for BRICS countries.

Some studies in the literature have used ecological footprint as measure of environmental degradation while studying the effect of natural resource rent on the environment. Among those, Ahmed et al. (2020) estimated the impact of natural resources on ecological footprint controlling for urbanization, human capital, and economic growth in China. The output of the study recommends that natural resources deteriorate the quality of the environment through an increase in ecological footprint. Ulucak et al. (2020) considered the effect of natural resource rent (NRR) on the environment for OECD countries. Results approved the positive role of NRR in carbon emission mitigation while NRR does not influence ecological footprint and carbon footprint. Likewise, Ahmad et al. (2020) employed AMG and CS-ARDL panel data empirical methods and concluded the detrimental effect of natural resources on ecological footprint is observed.

From the above-aforementioned studies, it is concluded natural resource impacts on environmental degradation are unclear and need further investigation. The inconclusive result may be due to the differences in estimation techniques, dataset, and country or region. Due to the diverse nature of the region in terms of large population and abundantly available natural resources, single-country analysis for Pakistan would provide a specific guideline regarding the situation in Pakistan to the policymakers. None of the studies in the literature has considered the moderating role of natural resources and urbanization in environmental sustainability. Further, the dynamic ARDL simulated technique is not applied to the nexus between natural resources and environmental sustainability.

Table 1 Descriptive statistics

Variable	Obs	Mean	SD	Min	Max
Log CO_2	47	0.6625	0.2254	0.3086	0.9910
Log ECF	47	− 0.1853	0.2459	− 0.9892	0.1639
Log CF	47	− 0.6118	0.1609	− 0.8697	− 0.3663
Log Y	47	2.8801	0.1264	2.6568	3.0789
Log NRR	47	1.3712	0.7146	0.1774	3.0113
Log URB	47	0.5581	0.0169	0.4792	0.6987
Log (URB*NRR)	47	0.7424	0.3420	0.7424	1.4586

Material and methods

Data

The study used the data from 1971 to 2017 for Pakistan. The proxy of environmental sustainability is CO_2 emissions (measured in metric tons per capita), ecological footprint, and carbon footprint. Ecological footprint and carbon footprint are widely used proxies for environmental degradation (see Aluko et al. 2021; Baloch et al. 2019, 2020). Economic growth is represented by GDP reflected per capita (constant 2010 USD). Total natural resources rents indicated by (NRR) and using the proxy for (oil rent, coal rent, forest rent, mineral rents, and gas rent), similarly, urbanization is represented by URB and selected the proxy of the percentage of the total population. Data for the indicated variables are withdrawn from the world development indicator database of the World Bank (World Bank 2019). The descriptive statistics of the data series are shown in Table 1.

Econometric method

The empirical model of the present inquiry is adapted from (Danish et al. 2019) by including the interaction effect of natural resources and urbanization. The relationship between indicated variables can be shown in the equation as:

$$\text{Log}(CO_2)_t = \alpha + \beta_1\text{Log}(Y)_t + \beta_2\text{Log}(Y^2)_t + \beta_3\text{Log}(\text{NRR})_t + \beta_4\text{Log}(\text{URB})_t + \beta_5\text{Log}(\text{URB}^*\text{NRR})_t + \varepsilon_1 \quad (1)$$

$$\text{Log}(\text{ECF})_t = \alpha + \beta_1\text{Log}(Y)_t + \beta_2\text{Log}(Y^2)_t + \beta_3\text{Log}(\text{NRR})_t + \beta_4\text{Log}(\text{URB})_t + \beta_5\text{Log}(\text{URB}^*\text{NRR})_t + \varepsilon_2 \quad (2)$$

$$\text{Log}(\text{CF})_t = \alpha + \beta_1\text{Log}(Y)_t + \beta_2\text{Log}(Y^2)_t + \beta_3\text{Log}(\text{NRR})_t + \beta_4\text{Log}(\text{URB})_t + \beta_5\text{Log}(\text{URB}^*\text{NRR})_t + \varepsilon_3 \quad (3)$$

where CO_2 carbon dioxide emissions, GDP is a gross domestic product, NRR is natural resource rent, while URB denotes urbanization, further ω and t are stochastic error terms and time respectively.

The literature has suggested several econometric methodologies to determine the existence of cointegration among investigated variables (Engle and Granger 1987; Johansen 1988; Phillips and Hansen 1990). Following the recent studies of (Danish and Ulucak 2019) and (Hassan et al. 2020), this study relies on the co-integration approach of Pesaran et al., (2001) using the procedure of Kripfganz and Schneider (2018) for upper and lower limit values. Further for long and short-run estimation most recent and innovative econometric tools, dynamic ARDL algorithm by Jordan and Philips (2018) is preferred due to some of its characteristics. The first dynamic ARDL resolved the complexities in an already existing model of ARDL by Pesaran et al. (2001). However, the dynamic ARDL estimation strategy is the most suitable for a small sample of data. Second, this newly developed method can stimulate, estimate, and visually predict automatically specious changes in the response variable by a regressor keeping other factors constant (Jordan and Philips 2018). For the application of dynamic ARDL, the data should be of order one and contain a level of the relationship among the indicated variable of the study. These methods can handle up to 5000 simulations of the vector of parameters by utilizing multivariate normal distribution.

The general form of dynamic ARDL is expressed as:

$$\Delta(y)_t = \alpha_0 + \lambda_0(y)_{t-1+}\lambda_1(x_1)_{t-1} + \cdots + \lambda_t(x_k)_{t-1+}\sum_{i=1}^{p}\alpha_i\Delta(y)_{t-1} + \sum_{j=1}^{q_1}\beta_{1j}\Delta(x_1)_{t-j} + \cdots + \sum_{j=1}^{q_1}\alpha_{kj}\Delta(x_k)_{t-j} + \mu_t$$

where (y) represents variation independent variables, ($\alpha 0$) is the intercept and $t-1$ shows the independent variables with P as a maximum level of lags qk. Also, (Δ) is the first-differences operator, (μ) and t the error term and time respectively.

The estimation procedure of the dynamic ARDL model for the indicated variable of the study can be shown in Eqs. (4–6):

$$\begin{aligned}\Delta\text{Log}(\text{CO}_2)_t =& \alpha_0\Delta\text{Log}(CO_2)_{t-1} + \beta_1\Delta\text{Log}(Y)_t \\ &+ \theta_1\Delta\text{Log}(Y)_{t-1} + \beta_2\Delta\text{Log}(Y^2)_t \\ &+ \theta_2\Delta\text{Log}(Y^2)_{t-1} + \beta_3\Delta\text{Log}(\text{NRR})_t \\ &+ \theta_3\Delta\text{Log}(\text{NRR})_{t-1} + \beta_4\Delta\text{Log}(\text{URB})_t \\ &+ \theta_4\Delta\text{Log}(\text{URB})_{t-1} + \beta_5\Delta\text{Log}(\text{URB}^*\text{NRR})_t \\ &+ \theta_5\Delta\text{Log}(\text{UURB}^*\text{NRR})_{t-1}\end{aligned} \tag{4}$$

$$\begin{aligned}\Delta\text{Log}(\text{ECF})_t =& \alpha_0\Delta\text{Log}(\text{ECF})_{t-1} + \beta_1\Delta\text{Log}(Y)_t \\ &+ \theta_1\Delta\text{Log}(Y)_{t-1} + \beta_2\Delta\text{Log}(Y^2)_t \\ &+ \theta_2\Delta\text{Log}(Y^2)_{t-1} + \beta_3\Delta\text{Log}(\text{NRR})_t \\ &+ \theta_3\Delta\text{Log}(\text{NRR})_{t-1} + \beta_4\Delta\text{Log}(\text{URB})_t \\ &+ \theta_4\Delta\text{Log}(\text{URB})_{t-1} + \beta_5\Delta\text{Log}(\text{URB}^*\text{NRR})_t \\ &+ \theta_5\Delta\text{Log}(\text{UURB}^*\text{NRR})_{t-1}\end{aligned} \tag{5}$$

$$\begin{aligned}\Delta\text{Log}(\text{CF})_t =& \alpha_0\Delta\text{Log}(\text{CF})_{t-1} + \beta_1\Delta\text{Log}(Y)_t \\ &+ \theta_1\Delta\text{Log}(Y)_{t-1} + \beta_2\Delta\text{Log}(Y^2)_t \\ &+ \theta_2\Delta\text{Log}(Y^2)_{t-1} + \beta_3\Delta\text{Log}(\text{NRR})_t \\ &+ \theta_3\Delta\text{Log}(\text{NRR})_{t-1} + \beta_4\Delta\text{Log}(\text{URB})_t \\ &+ \theta_4\Delta\text{Log}(\text{URB})_{t-1} + \beta_5\Delta\text{Log}(\text{URB}^*\text{NRR})_t \\ &+ \theta_5\Delta\text{Log}(\text{UURB}^*\text{NRR})_{t-1}\end{aligned} \tag{6}$$

where Δ is the first difference operation. The null hypothesis of no cointegration H0: $\theta 1 + \theta 2 + \theta 3 + \theta 4 + \theta 5 = 0$ is to be tested against alternative hypothesis of H1: $\theta 1 + \theta 2 + \theta 3 + \theta 4 + \theta 5 \neq 0$. The co-integration exists if the F-state exceeds the upper bound in support of probability value calculated through the method (Kripfganz and Schneider 2018). Recently, the dynamic ARDL is widely used for time series data estimation.

Table 2 Result of Unit root test

Regressor	PP unit root test		DFGLS unit root test	
	$I(0)$	$I(1)$	$I(0)$	$I(1)$
Log CO_2	− 0.104 [0.9490]	− 7.684[a] [0.0000]	− 2.085	− 4.571[a]
Log ECF	− 3.717 [0.0039]	− 7.321[a] [0.0000]	− 2.188	− 5.402[a]
Log CF	− 0.587 [0.8738]	− 5.913[a] [0.0000]	− 2.122	− 3.684[a]
Log Y	− 0.685[0.8506]	− 5.976[a] [0.0000]	− 1.398	− 4.674[a]
Log NRR	− 2.252 [0.1877]	− 7.309[a] [0.0000]	− 2.766	− 7.321*
Log URB	− 0.839 [0.8075]	− 5.134[a] [0.0000]	− 0.833	− 5.602[a]
Log (URB[a]NRR)	2.518 [0.1112]	− 7.528[a] [0.0000]	2.911	− 5.490[a]

*Is significance level at 1%

$I(0)$ = integration order at level; $I(1)$= intergration order at first difference

Values in parenthesis [] MacKinnon approximate p-value

Empirical results and discussion

For applying dynamic ARDL first step is to examine whether the data series contains a unit root. The Phillips–Perron (PP) and Dickey-Fuller generalized least-squares (DGLS) unit root tests are employed and the results are shown in Table 2. Both PP and DGLS unit root tests successfully reject the null hypothesis of stationary at the first difference (i.e., $I(1)$), hence it is meant to estimate the empirical results.

The next level of the relationship among the indicated variables is estimated using the bound testing approach with the support of upper and lower boundary limited accompanied by the probabilities. As shown in Table 3 the findings of pssbounds contain critical values which give us strong support and reject the null hypothesis no level of relationship is rejected among study variables. In other words, the co-integration relationship exists between CO_2 emissions, GDP, NR, and URB (Table 3).

To better understand the practical implication of the empirical estimation, we introduce the dynamic ARDL simulation method. The environmental sustainability index is measured through CO_2 emissions, ecological and carbon footprint. After confirming the pre-requisite condition, the dynamic ARDL algorithm is applied for long-run and short-run estimation and the reported result can be seen in Table 4. The environmental impact of per capita GDP is positive and significant in the long run. In other words, per capita GDP (income) increase carbon emissions, ecological footprint, and carbon footprint. This could be linked to an increase in per capita GDP promotes structural changes, technological progress, and increases awareness among the country's residents. The acquired result for income and carbon emissions is desirable and true from a theoretical perspective since with increased income economic activities such as agriculture, industrialization, and natural resource extraction increase, together all these contribute to environmental degradation. Since growing income stimulates human activities for instance consumption of water and land use required to produce consumer goods that increase ecological and carbon footprint. Most of the studies found similar results to our study. Of them, Ulucak and Bilgili (2018) confirmed EKC between GDP and ecological footprint for 45 countries; Arshad et al. (2020) for the overall sample of Asian countries and Ahmad et al. (2020) for emerging economies. On the contrary, Dogan et al. (2020) for BRICS countries and (Caglar et al. 2021) for top pollutant footprint countries, did not find evidence for the EKC relationship.

Further, empirical estimation reported in Table 4 reveals that a 1% rise in natural resource rent contributes to CO_2 emission by 0.2062% in the long run. Likewise, a 1% rise in natural resources increases ecological footprint

Table 3 Results of ARDL bound test

	Statistic		10%		5%		1%		P value	
			I (0)	I (1)	I (0)	I (1)	I (0)	I (1)	I (0)	I (1)
Model 1: Log CO_2=f(Log Y, Log Y^2, Log NRR, log URB, log (URB*NRR))	F	10.086	2.616	3.807	3.149	4.479	4.390	6.025	0.000	0.000
	t	− 6.282	− 2.549	− 3.657	− 2.890	− 4.050	− 3.577	− 4.831	0.000	0.000
Model 2: Log ECF=f(Log Y, Log Y^2, Log NRR, log URB, log (URB*NRR))	F	9.566	2.516	3.985	3.080	4.776	4.453	6.686	0.000	0.001
	t	− 6.066	− 2.416	− 3.530	− 2.795	− 3.976	− 3.571	− 4.886	0.000	0.001
Model 3: Log CF=f(Log Y, Log Y^2, Log NRR, log URB, log (URB*NRR))	F	9.507	2.552	3.940	3.111	4.701	4.457	6.518	0.000	0.001
	t	− 5.792	− 2.547	− 3.569	− 2.826	− 4.001	− 3.578	− 4.877	0.000	0.002

Table 4 Result of dynamics ARDL (Long-and short-term) results

Regressor	CO_2 emissions Co-efficient [prob.]	Ecological footprint Co-efficient [prob.]	Carbon footprint Co-efficient [prob.]
Log *Yt*	1.7602* [0.000]	1.2955** [0.037]	0.6086* [0.000]
Δ Log *Yt* − 1	1.5175* [0.000]	0.6926 [0.321]	0.1359 [0.734]
Log (NRR)t	0.2062* [0.008]	0.7881** [0.021]	0.0217*** (0.058)
Δ Log (NRR)*t* − 1	0.0203 [0.838]	− 0.0646** [0.027]	− 0.0012 [0.857]
Log (URB*t*)	− 0.4827*** [0.084]	− 1.6896** [0.031]	− 0.2878*** [0.062]
Δ Log (URB)*t* − 1	0.0174 [0.947]	0.0090 [0.983]	− 0.3706** [0.034]
Log (URB*NRR)	− 0.3207** [0.028]	− 1.3243*** [0.089]	0.0337** [0.011]
Δ Log (URB*NRR)*t* − 1	− 0.1729 [0.244]	0.0223 [0.379]	− 0.0378* [0.006]
Constant	− 3.9586* [0.000]	4.4107*** [0.052]	− 1.8923 * [0.000]
Diagnostic tests			
χ LM-ARCH^2	0.047 [0.8278]	0.030 [0.8616]	0.005 [0.9424]
χ LM-Hetero	0.72 [0.3958]	0.20 [0.6515]	0.44 [5075]
*R*2	0.98	0.54	0.98
Sim	5000	5000	5000

*, ** & ***indicate 1%, 5% and 10% level of significance, respectively

and carbon footprint by 0.7881% and 0.0217% respectively. The detrimental role of natural resource rent guide toward exploitation of the natural resource in Pakistan that adversely affects the environment. Due to this Pakistan largely depends on energy imports fossil fuel (oil, gas, and coal) in particular. Poor management of natural resource consumption can also be associated with our results as natural resource extraction cause to increase in pollution. Efficient management and proper mechanism of natural resource extraction, and regulation are necessary to combat rising climate change and environmental challenges in Pakistan. A similar conclusion is drawn by Danish et al. (2019) for BRICS; Shen et al. (2021)for China; Joshua and Bekun (2020) for South Africa, and Pata et al. (2021) for the top ten countries with the largest ecological footprint. In contrast, Khan et al. (2021b) revealed that natural resources reduce carbon emission in the U.S.; Balsalobre-Lorente et al. (2018) for five EU countries.

The effect of urbanization on all three indicators of environmental sustainability is found negative and statistically significant in the long run. Hence, the growing rate of urbanization increases awareness among residents of the country toward a clean environment. These results are supported by ecological modernization theory. As the rate of urbanization increases inhabitants of the country become aware and consume environmentally friendly and energy-efficient goods and services. Urban residents' income is comparatively high, so they consume energy-efficient appliances and environmentally friendly products. In other words, urbanization in Pakistan is fruitful for environmental sustainability.

The study introduces the impact of the interaction effect of urbanization and natural resource rent on environmental sustainability which is the focal point of this study. Observing Table 4 it is concluded that urbanization plays moderating role in reducing the detrimental effect of natural resource rent on environmental sustainability. In other words, the interaction effect between urbanization and natural resource rent tends to reduce environmental degradation. More precisely, the coefficient of an interaction effect between urbanization and natural resource rent on CO_2 emissions, ecological and carbon footprint is negative and significant. Further, lifestyles, production/consumption patterns may change, awareness of a clean environment increase with an increase in income. Inhabitants in urban areas have more opportunities for attaining higher education. Waste recycling and clean technologies from human practices build capacity through technological impacts accompanying increase growth (Bilgili et al. 2020).

The advancement of information and communication technologies in an urban area may help to raise awareness regarding sustainable natural resource use, thus environmental degradation decreases. The outcome relates to proper biologically productive land utilization, more precisely controlling the over-exploitation of natural resources. In addition, urbanization is a positive source of externality and can increase return to scale, provision of public services such as piped water, sanitation, proper management of waste, and eco-friendly infrastructures all of these work together to make an urban environment comfortable to build, operate and maintain.

The short-run result demonstrates that the coefficient of indicated variables per capita GDP, natural resource, and urbanization are statistically not significant. In other words, the indicated variable took a long time to affect CO_2 emissions, ecological and carbon footprint. The result in Table 4 also reported a diagnostic test which shows that the model is reliable as the multicollinearity, autocorrelation, and heteroscedasticity issues do not exist.

Conclusion and policy implications

This paper addresses the effect of natural resources, urbanization, and per capita GDP on environmental sustainability in Pakistan. Environmental sustainability is measured through three indicators namely, carbon emissions, ecological footprint, and carbon footprint. The study has introduced the moderating role of urbanization between natural resource rent and environmental sustainability. For empirical estimation, a group of time series data econometric tools is used. Initially, unit root tests are used for checking stationery level of data series. Further, the dynamic ARDL empirical method is applied to discuss the long- and short-run relationship. The study highlights some important findings; first, natural resource rent has positive and significant impact on carbon emissions, ecological and carbon footprint in the long run. In other words, natural resource rent hurt environmental sustainability in Pakistan. Second, urbanization has negative and significant effect on environmental sustainability which benefit the environment through reduction of carbon emissions, ecological and carbon footprint. Further, the coefficient of interaction between urbanization and natural resource rent is negative and significant and plays a significant moderating role in environmental sustainability. In last, the application of ARDL validate the findings.

The empirical findings of the study call for significant policy recommendation. Natural resource depletion stimulates carbon emissions so, the government should introduce an awareness program among inhabitants regarding sustainable use of natural resources to reduce reliance on the import of fossil resources. We urge that government need to design a mechanism to rely more on its resources instead of depending on energy imports. The government of Pakistan needs appropriate changes particularly in the education sector to promote environmental sustainability awareness. We urge government should switch toward modern technologies from obsolete technologies that devour more natural resources. Similarly, Pakistan is also a developing country with a high rate of urbanization. Furthermore, should control expansion of cities which brings environmental pollution. Reforestation would be an effective plan to curb carbon emissions.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

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