Environmental Science and Pollution Research (2019) 26:2929–2938
https://doi.org/10.1007/s11356-018-3803-3

RESEARCH ARTICLE

# Economic growth, natural resources, and ecological footprints: evidence from Pakistan

Syed Tauseef Hassan[1] · Enjun Xia[1] · Noor Hashim Khan[1] · Sayed Mohsin Ali Shah[2]

Received: 3 August 2018 / Accepted: 19 November 2018 / Published online: 29 November 2018



## Abstract

The ecological footprint, a measure of human demand on earth's ecosystems, represents the amount of biologically productive land and sea area that is necessary to supply the resources a human population consumes and to mitigate associated waste. This study estimates the impact of economic growth and natural resources on Pakistan's ecological footprint using an autoregressive distributive lag (ARDL) model for long-run estimation. The empirical findings indicate that natural resources have a positive effect on an ecological footprint that deteriorates environmental quality and that natural resources help to support the environmental Kuznets hypothesis (EKC). Bidirectional causality is found between natural resources and the ecological footprint, along with a long-run causality between biocapacity and the ecological footprint. The innovative findings have important implications for policy.


**Keywords** Natural resources · Ecological footprint · Economic growth · ARDL · Pakistan

## Introduction

Both developed and developing countries face challenges related to the balance between economic development and protection of the global environment. Greenhouse gasses increase the world's temperature, with most studies concluding that $CO_2$ emissions are the main culprit behind growing environmental degradation (Danish et al. 2017a). However, the ecological footprint is also responsible for environmental deterioration.

The idea of the ecological footprint was first defined in the 1990s as the use of land and water for production of all resources consumed by humans and for eliminating the waste material generated by the population. The ecological footprint is a comprehensive measure (Galli et al. 2012; Al-Mulali et al. 2015a) that studies have used as an indicator of environmental degradation (Wang et al. 2013; Mrabet and Alsamara 2016; Ozturk et al. 2016; Charfeddine 2017; Mrabet et al. 2017; Destek 2018). The ecological footprint helps to highlight the direct and indirect impacts of production and consumption activities on the environment (Ulucak and Bilgili 2018).

The literature has addressed the impact of economic growth on the ecological footprint (Ara et al. 2015; Charfeddine and Ben Khediri 2015; Kasman and Selman 2015; Omri et al. 2015; Tutulmaz 2015) in terms of the impacts of foreign direct investment (FDI) (Solarin and Al-mulali 2018), tourism (Katircioglu et al. 2018), social-political factors (Charfeddine and Mrabet 2017), and globalization (Rudolph and Figge 2017).

However, the literature has largely ignored how natural resources influence the ecological footprint. The abundance of natural resources continues to be a key component of the world economy, especially in developing countries that depend on the extracting them for a considerable part of their gross domestic product (GDP) (Hailu and Kipgen 2017). Natural resources and economic growth improve environmental quality (Balsalobre-Lorente et al. 2018), while other activities adversely influence the atmosphere, decrease the land's production capacity, and worsen the water quality. The land's surface is changed mostly through social activities (Charfeddine 2017). The ecological footprint is considered an integral indicator of environmental degradation in biologically productive areas (Solarin and Al-mulali 2018), so it is a logical device for considering the depletion of resources. It

Responsible editor: Philippe Garrigues

✉ Syed Tauseef Hassan
sthassan_bit@yahoo.com; syedtauseefhassan@bit.edu.cn

[1] School of Management and Economics, Beijing Institute of Technology, Beijing 100,081, China

[2] Central University of Finance and Economics, Beijing 100,081, China

can be used to estimate the limits of natural resources' consumption and the international distribution of world resources (Borucke et al. 2013). The ecological footprint depends on the natural resources, biological resources, and services that can be measured by the area of biological production. For example, it does not include the use of fresh water, soil destruction, greenhouse gas emissions, $CO_2$ emissions, and harmfulness (Borucke et al. 2013).

Given this background, this study analyzes the nexuses among natural resources, economic growth, and the ecological footprint (i) to create a more comprehensive measure of the role of $CO_2$ emissions in the ecological footprint and environmental degradation and (ii) to use human capital and biocapacity as control variables to observe $CO_2$ emissions' impact on the ecological footprint. The value of human capital as it relates to the environment is that education can influence the environment either positively or negatively.

The remainder of the study is organized as follows. The next section provides a literature review. Follow the literature review, the methodology section explains the data source, the model specification, and the econometric strategy. Then, the results and discussion section presents an analysis of the results and the last section concludes with policy suggestions.

## Literature review

In the early 1990s, Grossman and Krueger (1991) introduced the environmental Kuznets curve (EKC) hypothesis, which suggests an inverted U-shaped relationship between economic growth and pollution such that pollution increases with increases in economic growth until economic growth reaches an optimum level, at which pollution starts to decrease. The EKC hypothesis has been widely discussed in the literature and demonstrated in several countries through both time series analysis and panel data analysis (Alam et al. 2016; Narayan et al. 2016; Danish et al. 2017b; Alsamara et al. 2018). Economic growth and pollution have been analyzed with control variables that include energy consumption (Ara et al. 2015; Shahbaz et al. 2016; Danish and Baloch 2017; Danish et al. 2018a; Mirza and Kanwal 2017), corruption (Wang et al. 2018), financial development (Danish et al. 2018b; Xu et al. 2018) and financial instability (Baloch et al. 2018), and information and technology (Lee and Brahmasrene 2014; Ozcan and Apergis 2017; Danish et al. 2018c).

Although most of the studies in the literature have used $CO_2$ emissions as their measure of environmental degradation, recent studies have used the ecological footprint. For example, Uddin et al. (2017) found positive correlation between economic growth, measured as real income, and the ecological footprint, and Wang et al. (2013) found that income and biocapacity affect the ecological footprint. The empirical findings of Ozturk et al. (2016) showed that tourism income contributes to the ecological footprint process and that the EKC hypothesis finds support in high- and middle-income countries. Furthermore, Ulucak and Lin (2017) found that the stochastic behavior of the ecological footprint in the USA reveals that ecological footprint process is non-stationary. Moreover, Mrabet and Alsamara (2016) provided empirical evidence to show that the impact of several indicators on the ecological footprint process differs from their impact on $CO_2$ emissions. Using evidence from Qatar, Mrabet et al. (2017) investigated the influence of economic growth on ecological footprint indicators and recommended that the long-run impact of economic growth on the ecological footprint is more significant than the short-run effect. For their part, Charfeddine and Mrabet (2017) explored the impact of social and political aspects of the ecological footprint process on the sustainable development of economic activities, finding that energy degrades the ecological footprint and that the impact of economic growth on the ecological footprint differs between oil-exporting countries and non-oil-exporting countries. According to Charfeddine (2017), trade liberalization, electricity consumption, financial development, and urban growth degrade environmental quality through the ecological footprint. Figge et al. (2017) analyzed the role of globalization in the ecological footprint process and found that different kinds of globalization have different influences on the ecological footprint process based on the dimension of the ecological footprint and that social globalization is negatively correlated when political globalization has an insignificant effect on the ecological footprint.

This literature review shows that several studies have used measures of pollution as ecological indicators, and various determinants of the ecological footprint have been found, including economic growth, FDI, globalization, and social factors. However, none of the studies has investigated the effect of natural resources on the ecological footprint. To fill this gap, the present study estimates the effect of natural resources on the ecological footprint in the context of Pakistan,

## Data source and econometric methodology

### Data source

This study uses annual data for 1970–2014 to analyze the nexus among natural resources, economic growth, and the ecological footprint in Pakistan. The ecological footprint is defined as people's use of productive biological surfaces that is, an area's biocapacity, which is measured as the ability of an ecosystem to provide natural resources and absorb the waste produced by humans. Data on the ecological footprint and biocapacity are collected from national account footprint (NFA 2014). Economic growth is calculated as GDP per capita (in constant 2010 USD per capita), and natural resources are measured as an composite index consisting of gas rents, oil rents, coal, rents, mineral rents, and forestry rents per capita. Urbanization is measured as the annual percentage of urban population growth. The natural resource data, urbanization figures, and economic growth are collected from World Data Indicator. Human capital is a measure of the skills, education, capabilities, and attributes of the workforce that affect their productive capacity and potential earnings. The data on human capital is collected from the Penn World Table, version 9.0. Figure 1 compares Pakistan's natural resources and ecological footprint from 1970 to 2014.

## Model specification

This empirical work investigates the contribution of natural resources to the ecological footprint, while controlling for urbanization, natural resources, and economic growth. The econometric form for the relationship between the underlying variables is shown in Eq. (1):

$$LogEF_t = \beta_0 + \beta_1 (LogGDP)_t + \beta_{2t} (LogGDP)^2{}_t + \beta_3 (LogNR)_t + \omega_t, \quad (1)$$

where EF is the ecological footprint, measured in hectares per capita and standing for environmental quality; NR is natural resources, measured as real natural resources per capita; and GDP is the economic growth per capita (in constant 2010 USD). In Eq. (1), the value of GDP allows for various kinds of relationships between economic growth and ecological footprint. For example, if $\beta_1 > 0$ and $\beta_2 < 0$, the relationship between income and the ecological footprint is an inverted U-shaped curve, confirming the EKC hypothesis. If the value of $\beta_1 < 0$ and $\beta_2 > 0$, it suggests for inverted U-shaped relationship between GDP and environmental pollution.

Incorporating human capital, urbanization and biocapacity into the model modifies Eq. (1) as follows:

$$(EF)_t = \beta_0 + \beta_1 (GDP)_t + \beta_2 (GDP)^2{}_t + \beta_3 (NR)_t + \beta_4 (BIO)_t + \beta_5 (HC)_t + \beta_6 (URB)_t + \omega_t, \quad (2)$$

where HC is the human capital, BIO is the biocapacity per capita, and URB is the urbanization, measured as the annual percentage growth in the urban population.

Next, we explain why we chose our variables and their contributions to the ecological footprint. The ecological footprint, a proxy for environmental degradation, has been applied in large numbers of empirical analyses. From the perspective of measurements, if is inclusive and easily understandable (Ulucak and Lin 2017). Human capital is a factor in the ecological footprint, and pollution is a side effect of an increase in physical capital. Environmental awareness, which can be assessed in terms of education, training, motivation, and labor skills, increases the effective use of materials in production. Well-educated employees use technologies to maintain clean production and improve environmental management. Therefore, human capital is not only useful for the individual but may also be helpful for society.

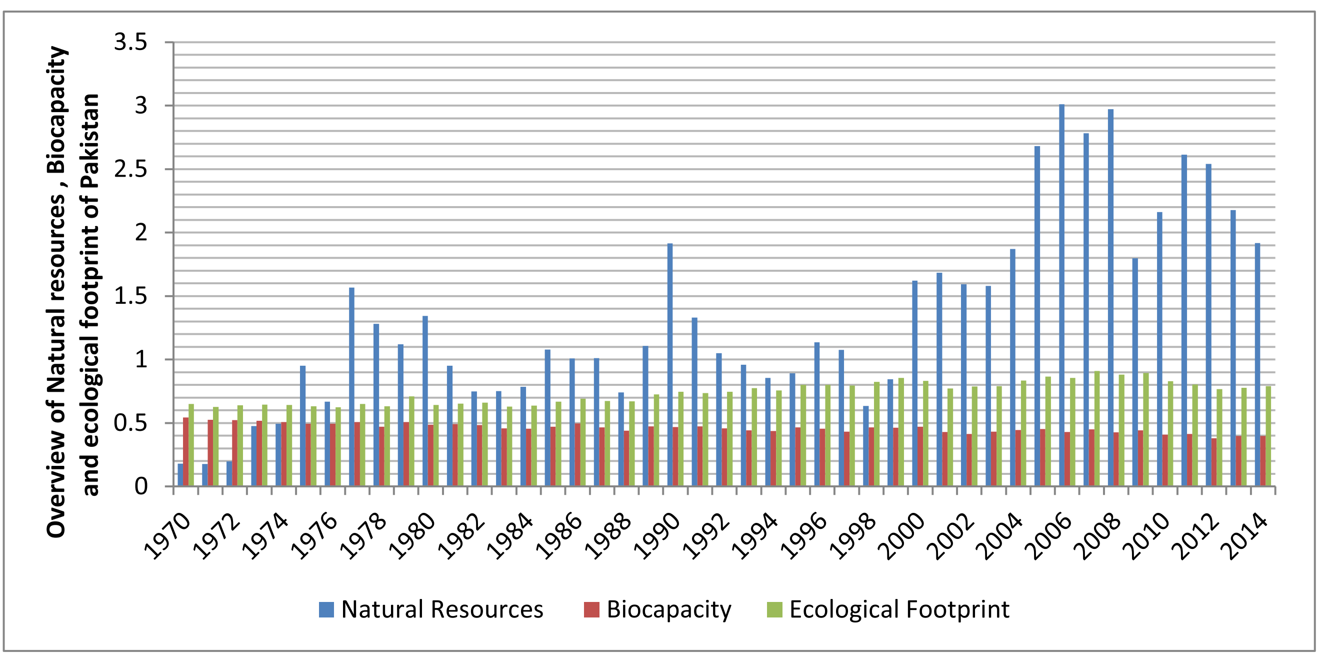


**Fig. 1** Trend in Pakistan's natural resources, biocapacity, and ecological footprint per capita from 1970 to 2014

The reduction of natural resources and environmental degradation are common throughout the world. There are many reasons to work on these issues, such as climate disasters, population high growth in urbanized areas, forest deforestation, industry explosion, smoke and toxic gasses from heavy and small vehicles, air pollution, and waste material in lakes and rivers (Kapur 2016). In downtown areas, the reduction of natural resources is higher than that in suburban areas. Natural resources are reduced through production and the industrialization process, and urban areas are the primary source of such physical products.

Biocapacity is an important part of the ecological footprint. Biocapacity refers to the biologically productive areas of agriculture, forests, pastures, croplands, and fisheries. Unsustainability rises if the ecological footprint is greater than biocapacity (Rashid et al. 2018).

## Econometric strategy

### The ARDL bound testing approach

Consistent with Danish and Baloch (2017) and Danish et al. (2018d), we use the autoregressive distributive lag (ARDL) bound testing approach (Pesaran et al. 2001) to estimate the long-run relationship between variables and whether the variables are integrated I(0) or not I(1). Selection and application of proper lag length addresses the problem of endogeneity and serial correlation. ARDL is also an accurate estimation method when used in a small sample of data, and it can produce both long-run and short-run estimates simultaneously. Because of these advantages, ARDL is the best econometric method for estimating long-run and short-run estimates of underlying variables. An ARDL representation of selected variables is shown in Eq. (3):

$$\begin{aligned}\Delta LogEF_t = {} & \theta_0 + \lambda_1 LogGDP_{t-1} + \lambda_2 Log\left(GDP^{\hat{}2}\right)_{t-1} + \lambda_3 LogNR_{t-1} + \lambda_4 LogBIO_{t-1} + \lambda_5 LogHC_{t-1} \\ & \lambda_6 LogURB_{t-1} + \sum_{i=1}^{p} \pi_1 \Delta LogEF_{t-i} + \sum_{j=0}^{p} \pi_2 \Delta LogGDP_{t-i} + \sum_{j=0}^{p} \pi_3 \Delta Log\left(GDP^{\hat{}2}\right)_{t-i} + \\ & \sum_{j=0}^{p} \pi_4 \Delta LogNR_{t-i} + \sum_{j=0}^{p} \pi_5 \Delta LogBIO_{t-i} + \sum_{j=0}^{p} \pi_6 \Delta LogHC_{t-i} + \sum_{j=0}^{p} \pi_7 \Delta LogURB_{t-i} + ECT_{t-1} + \mu\end{aligned} \tag{3}$$

where Δ is the first difference operator, $\lambda$ is the long-run coefficients, and $\theta$ and $\varepsilon$ are the short-run coefficients and error terms, respectively. The joint null hypothesis of a no cointegration relationship is $H_0$: $\pi_1 \neq \pi_2 \neq \pi_3 \neq \pi_4 \neq \pi_5 \neq \pi_6 \neq \pi_7 \neq 0$. The alternative hypothesis of a cointegration relationship is $H_0$: $\pi_1 = \pi_2 = \pi_3 = \pi_4 = \pi_5 = \pi_6 = \pi_7 = 0$. The ARDL approach begins with testing the hypothesis of no cointegration using the $F$ statistic. Narayan (2005) introduced the lower bound and upper bound values on which the $F$ statistic decision is based. An $F$ statistic above the upper bound is a rejection of no cointegration, while an $F$ statistic below the lower bound value means no cointegration. The result is unsatisfactory if the $F$ statistic lies between the upper bound and the lower bound. The next step after cointegration is the estimation of long-run and short-run dynamics. Several diagnostic tests are also applied to check the model's reliability and validity.

### The VECM Granger causality approach

We employ the Granger causality model to identify the directions of causality among the ecological footprint, the abundance of natural resources, biocapacity, economic growth, human capital, and urbanization. Engle and Granger (1987) claimed that there must be a causality link between variables, at least from one side, when variables are cointegrated with a single integration order. Therefore, we use the vector error correction model (VECM) Granger causality approach, which also shows the relationships between long-term and short-term variables. This empirical study of the causality link between the long-run and short-run variables is useful in designing general policy implications. Equation (4) shows the VECM Granger causality model (Wang et al. 2018):

$$\begin{bmatrix} LogEF \\ LogNR \\ LogGDP \\ LogBio \\ LogHC \\ LogURB \end{bmatrix} = \begin{bmatrix} \beta_1 \\ \beta_2 \\ \beta_3 \\ \beta_4 \\ \beta_5 \\ \beta_6 \end{bmatrix} = \begin{bmatrix} \beta_{11k}\beta_{12k}\beta_{13k}\beta_{14k}\beta_{15k}\beta_{16k} \\ \beta_{21k}\beta_{22k}\beta_{23k}\beta_{24k}\beta_{25k}\beta_{26k} \\ \beta_{31k}\beta_{32k}\beta_{33k}\beta_{34k}\beta_{35k}\beta_{36k} \\ \beta_{41k}\beta_{42k}\beta_{43k}\beta_{44k}\beta_{45k}\beta_{46k} \\ \beta_{51k}\beta_{52k}\beta_{53k}\beta_{54k}\beta_{55k}\beta_{56k} \\ \beta_{61k}\beta_{62k}\beta_{63k}\beta_{64k}\beta_{65k}\beta_{66k} \end{bmatrix}$$

$$= \begin{bmatrix} \Delta LogEF_{it} \\ \Delta LogNR_{it} \\ \Delta LogGDP_{it} \\ \Delta LogBIO_{it} \\ \Delta LogHC_{it} \\ \Delta LogURB_{it} \end{bmatrix} = \begin{bmatrix} n_1 \\ n_2 \\ n_3 \\ n_4 \\ n_5 \\ n_6 \end{bmatrix} = ect_{it-1} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \\ \varepsilon_{6t} \end{bmatrix} \tag{4}$$

where $t$ is the time interval (1970–2014); $I$ is $i = 1, 2, 3, \ldots, 33$; and − 1 is the lag error correction term, where the negative sign is long-run causality and denotes the disturbance term. The statistical significance of the $ect_{t-1}$, the result of the $t$ statistic confirms the existence of long-run causality, and a significant association indicates the direction of the short-run causal relationship in the first difference of the variables. For example, $b12,k \neq 0\ \forall i$ shows that NR Granger causes EF, and the ecological footprint Granger causes NR if $b21,k \neq 0\ \forall i$.

## Results analysis and discussion

### Descriptive statistic

The descriptive statistics of the underlying variables are presented in Table 1. The deviation from the mean value is not very high for any variable. Significant correlation is observed among the underlying variables.

### Unit root analysis

A preliminary step before investigating cointegration among the economic variables is to check the level of stationarity to avoid serious regression and second to determine whether any variable is integrated at order 2. For example, any integrated variable at order 2 would restrict us from applying the ARDL method. Ng and Perron's (2001) unit root test is used to check the level of stationary, and the results, presented in Table 2, show that none of the variables is integrated at order 2, so the ARDL method can be used.

### The bound testing approach

The order of interaction at the first order suggests applying the bound testing approach to examine the cointegration among the variables under consideration. The results of the bound testing approach with a diagnostic test for the ecological footprint model and the ecological carbon footprint model are given in Table 3. In pursuing ARDL *F* statistics, the lag length is selected before the cointegration approach is applied. The Akaike information criterion is used to select the lag length because of its strong explanatory ability with empirical evidence (Danish et al. 2018d). Under the VAR criteria, lag length four is selected for the ecological footprint model and lag length six is selected for the ecological carbon footprint model. Table 3 shows that the null hypothesis of no cointegration can be rejected for both models, so cointegration exists among the variables under consideration. For the level of significance, we rely on the upper and lower bounds proposed by (Narayan 2005). The outcome from the bound testing approach, shown in Table 3, indicates that the *F* statistic for the ecological footprint is greater than the critical value, suggesting the presence of cointegration among the variables under consideration.

### Long-run estimates

This study investigates the impact of natural resources on the ecological footprint. Ecological footprint per capita was used as the dependent variable in the model, while the economic growth, natural resources, human capital, biocapacity, and urbanization were used as independent variables. This study adds to the existing body of knowledge in the context of Pakistan. Because all the variables are converted into a logarithmic form, the coefficient estimates of GDP, NR, URB, BIO, and HC are statistically equal to the elasticities of the ecological footprint concerning economic growth, natural resources, urbanization, biocapacity, and human capital, respectively. The results of the long-run and short-run estimates are shown in Table 4.

In the long run, economic growth (GDP) has a positive and significant effect on the ecological footprint, and the square of GDP ($GDP^2$) has a negative and significant impact on the

**Table 1** Results of descriptive statistic

| | LOGEF | LOGGDP | LOGNR | LOGURB | LOGHC | LOGBIO |
|---|---|---|---|---|---|---|
| Mean | 0.739922 | 2.863147 | 1.340368 | 0.555842 | 1.466255 | 0.460648 |
| Median | 0.746688 | 2.896413 | 1.107047 | 0.543929 | 1.393996 | 0.463513 |
| Maximum | 0.908394 | 3.045791 | 3.011373 | 0.654547 | 1.799724 | 0.542270 |
| Minimum | 0.622925 | 2.656855 | 0.177466 | 0.479296 | 1.191760 | 0.378075 |
| Std. dev. | 0.086873 | 0.122479 | 0.750495 | 0.059009 | 0.219420 | 0.036789 |
| Skewness | 0.162574 | − 0.252781 | 0.655386 | 0.193171 | 0.446145 | 0.022251 |
| Observations | 45 | 45 | 45 | 45 | 45 | 45 |
| Correlation matrix | | | | | | |
| LOGEF | 1 | | | | | |
| LOGGDP | 0.8859 | 1 | | | | |
| LOGNR | 0.6977 | 0.7664 | 1 | | | |
| LOGURB | − 0.9039 | − 0.8460 | − 0.5857 | 1 | | |
| LOGHC | 0.8774 | 0.9368 | 0.8440 | − 0.8667 | 1 | |
| LOGBIO | − 0.6349 | − 0.8827 | − 0.6877 | 0.6693 | − 0.8290 | 1 |

**Table 2** Results of Ng-Perron unit root test

| Variables | At level | | | | First difference | | | |
|---|---|---|---|---|---|---|---|---|
| | MZa | MZt | $MS_B$ | $MP_T$ | MZa | MZt | $MS_B$ | $MP_T$ |
| LOGEF | − 1.97529 | − 0.9068 | 0.45907 | 11.4725 | − 21.281* | − 3.25047 | 0.15274 | 1.19146 |
| LOGNR | − 5.64127 | − 1.6284 | 0.28866 | 4.49282 | − 21.365* | − 3.24770 | 0.15201 | 1.21869 |
| LOGGDP | 0.99566 | 0.83234 | 0.83597 | 50.6129 | − 13.844** | − 2.59708 | 0.18760 | 1.89953 |
| LOGHC | − 3.48403 | − 1.0969 | 0.31486 | 6.97406 | − 6.4640*** | − 1.75590 | 0.27164 | 3.93068 |
| LOGBIO | 1.41552 | 1.20890 | 0.85403 | 56.7162 | − 19.647** | − 3.12578 | 0.15909 | 1.27739 |
| LOGURB | − 2.29996 | − 0.9979 | 0.43388 | 10.1418 | − 11.356* | − 2.38242 | 0.20979 | 2.15927 |

*, **, and *** indicate rejection of null hypothesis at 1%, 5%, and 10% level of significance, respectively

ecological footprint in the long run. These results tend to confirm the quadratic relationship between economic growth and ecological footprint and to suggest that, in the early stage of economic growth, pollution levels increase in terms of the ecological footprint; however, after reaching the optimum level, economic growth is helpful in reducing pollution, confirming the EKC hypothesis in Pakistan. The result is consistent with Charfeddine and Mrabet (2017), Ulucak and Bilgili (2018), and Danish et al. (2017a, b), who also confirm the EKC hypothesis for Pakistan.

Next, we turn natural resources. The elasticity of the ecological footprint concerning the abundance of natural resources is positive, and natural resource abundance increases the ecological footprint. The positive value of the coefficient of natural resource abundance suggests that countries with few natural resources should import to fossil fuel energy (e.g., petrol or gas) to grow an economy that influences the environment (Balsalobre-Lorente et al. 2018). These results suggest that Pakistan is not using its natural resources effectively and is using weak energy strategies that cannot reduce the country's dependence on conventional energy sources. It is possible to attribute the effect of natural resource abundance to the ecological footprint in Pakistan, particularly in its mining activities. Pakistan is struggling to develop ecological footprint standards for major sectors of the economy to accomplish environmental objectives without compromising the country's growth.

Urbanization has a significantly negative impact on the ecological footprint, suggesting that urbanization is elastic to the ecological footprint in Pakistan. A 1% increase in urbanization decreases the ecological footprint by 1.93%, perhaps because, in Pakistan, a large amount of agriculture land has been converted to housing schemes that may reduce the land's capacity to absorb waste and pollution, so the ecological footprint declines. Urbanization also promotes innovation, advanced technology, and environmentally friendly equipment, such as vehicles, communication system, machines, and utilities. The results obtained here are similar to those of (Al-Mulali et al. 2015b) and (khan et al. 2018) . The effects of both biocapacity and human capital on the ecological footprint are statistically insignificant. Since this study focuses on long-run effects, we do not focus on short-run results.

The study applies several diagnostic tests, including χ2-ARCH, χ2-LM, and χ2-RAMSEY for heteroscedasticity and autocorrelation. The results of diagnostic tests presented in Table 4 confirm that our model is free of autocorrelation and heteroscedasticity problems. Moreover, to ensure the stability of the model, the study uses a cumulative sum (CUSUM) and the cumulative sum of square (CUMSUMsq). Referring to Figs. 2 and 3, it shows that the model is well developed and can be used for policy suggestions.

## Granger causality results

The ARDL estimates provide long-run results but do not give the direction of causality. The VECM Granger causality is applied to analyze the causal link among the variables under consideration. The result of the VECM Granger causality results, shown in Table 5, indicates a long-run causality between biocapacity and the ecological footprint. Bidirectional causality is also found between natural resources and ecological

**Table 3** Results of bound testing and diagnostic tests

| Model | Bound testing approach | | | Diagnostic tests | | |
|---|---|---|---|---|---|---|
| | *F* value | Lag order | Decision | χ2-ARCH | χ2-LM | χ2-RAMSEY |
| LOGEF LOGGDP LOGBIO LOGHC LOGNR LOGURB | 3.675** | 1, 2, 1, 0, 2, 1 | Conclusive | 0.025915 [0.8729] | 1.580284 [0.3232] | 1.058720 [0.3130] |

** e is an indication of 5% level of significance. For *F* value, it refers to Narayan (2005)

**Table 4** ARDL long-run and short-run estimations

| | Long-run analysis | | | Short-run analysis | | | |
|---|---|---|---|---|---|---|---|
| | Coefficient | *t* statistic | Prob. | Variable | Coefficient | *t* statistic | Prob. |
| Variable | | | | | | | |
| LOGGDP | 13.0743** | 2.2223 | 0.0348 | D(LOGGDP) | 1.0103** | 3.4400 | 0.0019 |
| LOGGDP^2 | − 2.34655** | − 2.1552 | 0.0402 | D LOGGDP^2 | − 0.0092 | − 0.1740 | 0.8631 |
| LOGBIO | 0.29081 | 0.4361 | 0.6662 | D(LOGBIO) | 0.1822 | 1.2675 | 0.2158 |
| LOGHC | − 0.04936 | − 0.2744 | 0.7858 | D(LOGHC) | − 0.7062** | − 3.1082 | 0.0044 |
| LOGNR | 0.05460** | 2.4296 | 0.0220 | D(LOGNR) | − 0.0194** | − 2.9763 | 0.0061 |
| LOGURB | − 1.93686* | − 3.5957 | 0.0013 | D(LOGURB) | − 0.1419 | − 0.4457 | 0.6594 |
| C | − 16.4598** | − 2.0826 | 0.0469 | CointEq(-1) | − 0.5097* | − 5.7444 | 0.0000 |
| Sensitivity analysis | | | | | | | |
| $R^2$ | 0.977794 | | | | | | |
| Adjusted $R^2$ | 0.965458 | | | | | | |
| *F* statistic | 79.26015 | | | | | | |
| Prob (*F* statistic) | 0.000000 | | | | | | |
| Durbin-Watson stat | 2.484721 | | | | | | |
| Robust check | | | | | | | |
| Ramsey reset | 1.058720 | [0.3130] | | | | | |
| LM test | 1.580284 | [0.3232] | | | | | |
| ARCH test | 0.025915 | [0.8729] | | | | | |
| CUMSUM | Stable | | | | | | |
| $CUMSUM_{sq}$ | Stable | | | | | | |

Values in parenthesis are probabilities

*Indicates significance at the 1% level

**Indicates significance at the 5% level

footprint, and urbanization and the ecological footprint Granger cause each other. However, we found no causality between human capital and the ecological footprint. In the short run, there is bidirectional causality between the ecological footprint and biocapacity and no causal relationship between the rest of the variables and the ecological footprint.

## Conclusion and policy implications

This study determines the effect of natural resources, GDP, and the ecological footprint in Pakistan, controlling for human capital, biocapacity, and urbanization from 1970 to 2014. The study uses the ARDL method for

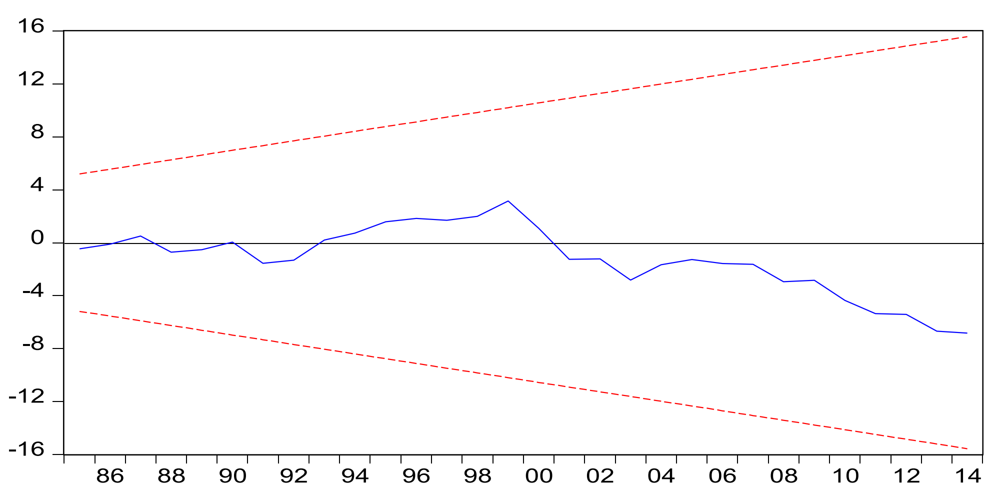


**Fig. 2** The results of cumulative sum (CUMSUM). The red line indicates the 5% level of significance

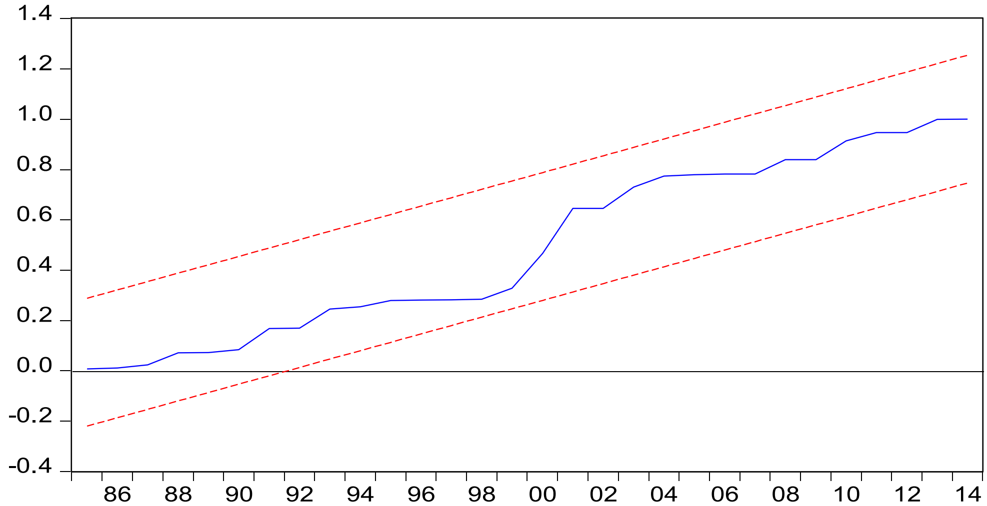


**Fig. 3** The results of the cumulative sum of square ($CUMSUM^2$). The red line indicates the 5% level of significance

the long- and short-run estimations and the VECM grange causality method for the causality analysis.

## Main findings

The study has four primary empirical results:

i. Economic growth initially increases the ecological footprint, but later economic growth improves environmental quality, confirming the EKC hypothesis in Pakistan.
ii. Natural resources have a positive and significant effect on the ecological footprint.
iii. Human capital and biocapacity do not enhance the ecological footprint process in Pakistan.
iv. There is bidirectional causality between the ecological footprint and biocapacity.

## Policy implications

This study has several policy implications. Pakistan's government should encourage people to change their consumption behavior to control the exploitation of natural resources to reduce excessive fishing, deforestation, and the destruction of land and to maintain pasture land. The government should also provide needed investment in the agriculture sector and encourage innovation in technology and the production of renewable energy, as Pakistan can be self-sufficient with renewable energy resources, and production of renewable energy would reduce the country's dependence on imported energy. As for natural resources, illegal activities are common in the field of mining and deforestation, so increased environmental awareness and strict regulations are required to control these illegal activities. The government should also reconsider the registration process that small-scale miners must undertake to make it easier to get the required licenses. In addition,

**Table 5** Results of a long-run and short-run causality analysis

| | Short-run causality Wald statistic | | | | | | Long-run causality ($t$ statistic) |
|---|---|---|---|---|---|---|---|
| Variables | LOGBIO | LOGEF | LOGGDP | LOGGHC | LOGNR | LOGURB | $ecm_{t-1}$ |
| LOGBIO | – | 7.402* (0.000) | − 0.124 (0.902) | − 1.499 (0.142) | 0.663 (0.511) | − 0.619 (0.540) | − 0.764* (0.000) |
| LOGEF | 8.666* (0.000) | – | 0.396 (0.693) | 0.469 (0.641) | 0.287 (0.775) | − 0.690 (0.494) | − 0.436* (0.002) |
| LOGGDP | − 0.199 (0.843) | 0.383 (0.703) | – | 0.349 (0.729) | 0.256 (0.799) | − 0.057 (0.954) | − 0.025 (0.781) |
| LOGHC | − 0.128 (0.898) | 0.156 (0.876) | 0.740 (0.463) | – | 1.610 (0.115) | − 1.164 (0.251) | − 0.083 (0.185) |
| LOGNR | − 0.991 (0.327) | 0.879 (0.384) | 0.386 (0.701) | 1.084 (0.285) | – | 1.244 (0.221) | − 0.737* (0.000) |
| LOGURB | 1.048 (0.301) | − 1.702*** (0.097) | 0.917 (0.364) | − 2.788** (0.008) | 1.8 82*** (0.068) | – | − 0.172** (0.042) |

Value in parenthesis shows the probability values

*Indicates significance at 1% level

**Indicates significance at 5% level

***Indicates significance at 10% level

policymakers should pay attention to natural resource-extraction activities when they deal with national energy security issues by encouraging companies that extract natural resources to use energy-efficient equipment in their activities. Decision makers should balance the supply of and demand for natural resources by maintaining the ecological footprint and natural resources that depend on environmental awareness, safety, education, science and technology, seminars, workshops, and investment in vocational training.

## References


Alam MM, Murad MW, Noman AHM, Ozturk I (2016) Relationships among carbon emissions, economic growth, energy consumption and population growth: Testing Environmental Kuznets Curve hypothesis for Brazil, China, India and Indonesia. Ecol Indic 70:466–479. https://doi.org/10.1016/j.ecolind.2016.06.043

Al-Mulali U, Tang CF, Ozturk I (2015a) Estimating the environment Kuznets curve hypothesis: evidence from Latin America and the Caribbean countries. Renew Sust Energ Rev 50:918–924. https://doi.org/10.1016/j.rser.2015.05.017

Al-Mulali U, Weng-Wai C, Sheau-Ting L, Mohammed AH (2015b) Investigating the environmental Kuznets curve (EKC) hypothesis by utilizing the ecological footprint as an indicator of environmental degradation. Ecol Indic 48:315–323. https://doi.org/10.1016/j.ecolind.2014.08.029

Alsamara M, Mrabet Z, Saleh AS, Anwar S (2018) The environmental Kuznets curve relationship: a case study of the Gulf Cooperation Council region. Environ Sci Pollut Res 25:33183–33195. https://doi.org/10.1007/s11356-018-3161-1

Ara R, Sohag K, Mastura S et al (2015) CO2 emissions, energy consumption, economic and population growth in Malaysia. Renew Sust Energ Rev 41:594–601. https://doi.org/10.1016/j.rser.2014.07.205

Baloch MA, Danish MF et al (2018) Financial instability and CO2 emissions: the case of Saudi Arabia. Environ Sci Pollut Res 25:26030–26,045. https://doi.org/10.1007/s11356-018-2654-2

Balsalobre-Lorente D, Shahbaz M, Roubaud D, Farhani S (2018) How economic growth, renewable electricity and natural resources contribute to CO2 emissions? Energy Policy 113:356–367. https://doi.org/10.1016/j.enpol.2017.10.050

Borucke M, Moore D, Cranston G, Gracey K, Iha K, Larson J, Lazarus E, Morales JC, Wackernagel M, Galli A (2013) Accounting for demand and supply of the biosphere's regenerative capacity: the National Footprint Accounts' underlying methodology and framework. Ecol Indic 24:518–533. https://doi.org/10.1016/j.ecolind.2012.08.005

Charfeddine L (2017) The impact of energy consumption and economic development on Ecological Footprint and CO2 emissions: evidence from a Markov Switching Equilibrium Correction Model. Energy Econ 65:355–374. https://doi.org/10.1016/j.eneco.2017.05.009

Charfeddine L, Ben Khediri K (2015) Financial development and environmental quality in UAE: cointegration with structural breaks. Renew Sust Energ Rev 55:1322–1335. https://doi.org/10.1016/j.rser.2015.07.059

Charfeddine L, Mrabet Z (2017) The impact of economic development and social-political factors on ecological footprint: a panel data analysis for 15 MENA countries. Renew Sust Energ Rev 76:138–154. https://doi.org/10.1016/j.rser.2017.03.031

Danish, Baloch MA (2017) Dynamic linkages between road transport energy consumption, economic growth, and environmental quality: evidence from Pakistan. Environ Sci Pollut Res 25:1–12. https://doi.org/10.1007/s11356-017-1072-1

Danish, Wang Z, Zhang B et al (2017a) Role of renewable energy and non-renewable energy consumption on EKC: evidence from Pakistan. J Clean Prod 156:855–864. https://doi.org/10.1016/j.jclepro.2017.03.203

Danish, Zhang B, Wang Z, Wang B (2017b) Energy production, economic growth and CO2 emission: evidence from Pakistan. Nat Hazards 90:1–24. https://doi.org/10.1007/s11069-017-3031-z

Danish, Baloch MA, Suad S (2018a) Modeling the impact of transport energy consumption on CO2 emission in Pakistan: evidence from ARDL approach. Environ Sci Pollut Res 9461–9473. https://doi.org/10.1007/s11356-018-1230-0

Danish, Saud S, Baloch MA, Lodhi RN (2018b) The nexus between energy consumption and financial development: estimating the role of globalization in Next-11 countries. Environ Sci Pollut Res 25:18651–18661. https://doi.org/10.1007/s11356-018-2069-0

Danish, Baloch MA et al (2018c) The effect of ICT on CO2 emissions in emerging economies: does the level of income matters? Environ Sci Pollut Res 25:1–11. https://doi.org/10.1007/s11356-018-2379-2

Danish, Wang B, Wang Z (2018d) Imported technology and CO2 emission in China: collecting evidence through bound testing and VECM approach. Renew Sust Energ Rev 82:4204–4214. https://doi.org/10.1016/j.rser.2017.11.002

Destek MA (2018) Analyzing the environmental Kuznets curve for the EU countries : the role of ecological footprint

Engle RF, Granger CWJ (1987) Co-integration and error correction : representation, estimation, and testing published by : the Econometric Society stable URL : http://www.jstor.org/stable/1913236. Yet drift too far apart. Typically economic theory will propose forces which tend to. Econometrica 55:251–276. https://doi.org/10.2307/1913236

Figge L, Oebels K, Offermans A (2017) The effects of globalization on Ecological Footprints: an empirical analysis. Environ Dev Sustain 19:863–876. https://doi.org/10.1007/s10668-016-9769-8

Galli A, Kitzes J, Niccolucci V, Wackernagel M, Wada Y, Marchettini N (2012) Assessing the global environmental consequences of economic growth through the Ecological Footprint: a focus on China and India. Ecol Indic 17:99–107. https://doi.org/10.1016/j.ecolind.2011.04.022

Grossman GM, Krueger AB (1991) Environmental impacts of a North American free trade agreement. Natl Bur Econ Res Work 3914:1–57. https://doi.org/10.3386/w3914

Hailu D, Kipgen C (2017) The Extractives Dependence Index (EDI). Res Policy 51:251–264. https://doi.org/10.1016/j.resourpol.2017.01.004

Kapur R (2016) Natural resources and environmental issues. J Ecosyst Ecography 6:2–5. https://doi.org/10.4172/2157-7625.1000196

Kasman A, Selman Y (2015) CO2 emissions, economic growth, energy consumption, trade and urbanization in new EU member and candidate countries : a panel data analysis. Econ Model 44:97–103. https://doi.org/10.1016/j.econmod.2014.10.022

Katircioglu S, Gokmenoglu KK, Eren BM (2018) Testing the role of tourism development in ecological footprint quality : evidence from top 10 tourist destinations. Environ Sci Pollut Res 25:33611–33619. https://doi.org/10.1007/s11356-018-3324-0

Khan NH, Ju Y, Hassan ST (2018) Modeling the impact of economic growth and terrorism on the human development index: collecting evidence from Pakistan. Environ Sci Pollut Res 25(34):34661–34673

Lee JW, Brahmasrene T (2014) ICT, $CO_2$ emissions and economic growth: evidence from a panel of ASEAN. Glob Econ Rev 43:93–109. https://doi.org/10.1080/1226508X.2014.917803

Mirza FM, Kanwal A (2017) Energy consumption, carbon emissions and economic growth in Pakistan: dynamic causality analysis. Renew Sust Energ Rev 72:1233–1240. https://doi.org/10.1016/j.rser.2016.10.081

Mrabet Z, Alsamara M (2016) Testing the Kuznets Curve hypothesis for Qatar: a comparison between carbon dioxide and ecological footprint. Renew Sust Energ Rev 70:1366–1375. https://doi.org/10.1016/j.rser.2016.12.039

Mrabet Z, AlSamara M, Hezam Jarallah S (2017) The impact of economic development on environmental degradation in Qatar. Environ Ecol Stat 24:7–38. https://doi.org/10.1007/s10651-016-0359-6

Narayan PK (2005) The saving and investment nexus for China: evidence from cointegration tests. Appl Econ 37:1979–1990. https://doi.org/10.1080/00036840500278103

Narayan PK, Saboori B, Soleymani A (2016) Economic growth and carbon emissions. Econ Model 53:388–397. https://doi.org/10.1016/j.econmod.2015.10.027

NFA (2014) Working guidebook to the national footprint accounts: 2016 edition. Glob Footpr Netw Rep 73

Ng S, Perron P (2001) Lag length selection and the construction of unit root tests with good size and power. Econometrica 69:1519–1554

Omri A, Daly S, Rault C, Chaibi A (2015) Financial development, environmental quality, trade and economic growth: what causes what in MENA countries. Energy Econ 48:242–252. https://doi.org/10.1016/j.eneco.2015.01.008

Ozcan B, Apergis N (2017) The impact of internet use on air pollution: evidence from emerging countries. Environ Sci Pollut Res 25:4174–4189. https://doi.org/10.1007/s11356-017-0825-1

Ozturk I, Al-Mulali U, Saboori B (2016) Investigating the environmental Kuznets curve hypothesis: the role of tourism and ecological footprint. Environ Sci Pollut Res 23:1916–1928. https://doi.org/10.1007/s11356-015-5447-x

Pesaran MH, Shin Y, Smith RJ (2001) Bounds testing approaches to the analysis of level relationships. J Appl Econ 16:289–326. https://doi.org/10.1002/jae.616

Rashid A, Irum A, Malik IA, Ashraf A, Rongqiong L, Liu G, Ullah H, Ali MU, Yousaf B (2018) Ecological footprint of Rawalpindi; Pakistan's first footprint analysis from urbanization perspective. J Clean Prod 170:362–368. https://doi.org/10.1016/j.jclepro.2017.09.186

Rudolph A, Figge L (2017) Determinants of Ecological Footprints: what is the role of globalization? Ecol Indic 81:348–361. https://doi.org/10.1016/j.ecolind.2017.04.060

Shahbaz M, Mahalik MK, Shah SH, Sato JR (2016) Time-varying analysis of CO2 emissions, energy consumption, and economic growth nexus: statistical experience in next 11 countries. Energy Policy 98:33–48. https://doi.org/10.1016/j.enpol.2016.08.011

Solarin SA, Al-mulali U (2018) Influence of foreign direct investment on indicators of environmental degradation. Environ Sci Pollut Res 25:24845–24859. https://doi.org/10.1007/s11356-018-2562-5

Tutulmaz O (2015) Environmental Kuznets Curve time series application for Turkey: why controversial results exist for similar models? Renew Sust Energ Rev 50:73–81. https://doi.org/10.1016/j.rser.2015.04.184

Uddin GA, Salahuddin M, Alam K, Gow J (2017) Ecological footprint and real income: panel data evidence from the 27 highest emitting countries. Ecol Indic 77:166–175. https://doi.org/10.1016/j.ecolind.2017.01.003

Ulucak R, Bilgili F (2018) A reinvestigation of EKC model by ecological footprint measurement for high, middle and low income countries. J Clean Prod 188:144–157. https://doi.org/10.1016/j.jclepro.2018.03.191

Ulucak R, Lin D (2017) Persistence of policy shocks to Ecological Footprint of the USA. Ecol Indic 80:337–343. https://doi.org/10.1016/j.ecolind.2017.05.020

Wang Y, Kang L, Wu X, Xiao Y (2013) Estimating the environmental Kuznets curve for ecological footprint at the global level: a spatial econometric approach. Ecol Indic 34:15–21. https://doi.org/10.1016/j.ecolind.2013.03.021

Wang Z, Danish ZB, Wang B (2018) The moderating role of corruption between economic growth and CO2 emissions: evidence from BRICS economies. Energy 148:506–513. https://doi.org/10.1016/j.energy.2018.01.167

Xu Z, Baloch MA, Danish, Meng F, Zhang J, Mahmood Z (2018) Nexus between financial development and CO2 emissions in Saudi Arabia: analyzing the role of globalization. Environ Sci Pollut Res 25:28378–28390. https://doi.org/10.1007/s11356-018-2876-3