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Financial development and environmental degradation: Do human capital and institutional quality make a difference?

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ABSTRACT

Emerging countries are heading towards economic prosperity; however, the process of development has enhanced their ecological footprint. Therefore, to safeguard the environment, it is essential to identify the factors that affect the ecological footprint (EF). In this perspective, this study explores the effect of financial development, human capital, and institutional quality on the EF in emerging countries. Furthermore, we explore the effect of financial development on EF through the channel of human capital. In addition, we investigate the role of institutional quality in the financial development-EF nexus. Using the panel data from 1984 to 2017, we employed the cross-sectional autoregressive distributed lag (CS-ARDL) technique to conduct the short-run and long-run empirical analysis. The empirical outcomes unveiled that financial development degrades the ecological quality by raising the EF. The findings further unfolded that human capital and institutional quality reduce the EF. Moreover, financial development fosters environmental sustainability through the channel of human capital. Additionally, institutional quality reduces the negative ecological impacts of financial development. The causality analysis suggested that any policy related to financial development, human capital, and institutional quality will affect EF but not the other way round. Based on these findings, emerging economies should promote environmental sustainability by promoting human capital and effectively using financial resources.

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1. Introduction

Climate change poses critical threats to the growth and survival of humanity, involving food shortage, species loss, and extreme weather (Khan et al., 2021b; Shahbaz and Sinha, 2019; Wang and Dong, 2019). Rapid economic growth and industrialization have made climate change more disastrous. Not merely the atmosphere environment, but also the ecology of the planet is under tremendous tension and crisis (Sharif et al., 2020). In 2017, the ecological footprint of the world has reached 2.77 global hectares per capita (GFN, 2020). The stress on available resources can be understood from the fact that if everyone lives like an ordinary citizen of a given country or region, it will take 1.73 earth to support the human footprint (Ahmed and Wang, 2019). This indicates that

the population footprint has begun to exceed the biological carrying capacity of the available area. If humans do not diminish their consumption and exploitation of ecological resources, the global ecological deficit will further expand, thus defeating the sustainable development goals. However, in the real world, factors such as financial and economic development and different consumption patterns between different regions are constantly affecting the “maximum ecological carrying capacity” of the Earth (Tawiah et al., 2021). Therefore, to address the issues of growing energy use and environmental deterioration, countries are formulating policies in light of the Paris Agreement (COP21) to curb global warming less than 2 °C.

In recent literature, studies suggest various environmental implications of financial development (hereafter FD). Generally, two different views exist regarding the role of FD in ecological sustainability. On the one hand, a well-developed financial system provides an opportunity to access capital and facilitates investment. This fosters economic activities and energy usage triggers environmental degradation (Anwar et al., 2021; Khan et al.,

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2021c). On the contrary, a sound and well-functioning financial system can provide funds for the purchase of advanced technologies and facilitate the adoption of energy-saving production processes, which in turn abate environmental degradation (Sharif et al., 2020; Ulucak et al., 2020; Sinha et al., 2021). Additionally, financial and capital markets may provide funds for renewable energy R&D and attract foreign firms that may have the capability to transfer the green technology to the host country (Ahmed et al., 2021b; Khan et al., 2021a).

Human capital is an important factor that may accelerate GDP and improve the quality of the environment. Educated people are generally better at using natural resources and financial services than unskilled and illiterate people (Hatemi-J and Shamsuddin, 2016). Human capital creates awareness about environmental challenges, which leads to pro-environment actions and behaviors, including energy conservation and recycling (Sinha and Sen, 2016; Ahmed et al., 2020). Recently, Zafar et al. (2019) claim that educated and skilled human capital enables countries to use sustainable natural resource exploration methods and reduce energy insecurity. Human capital also encourages communities to adopt environmentally friendly and energy-efficient technologies (Ahmed and Wang, 2019; Zafar et al., 2021). In theory, the underlying argument proposes that human capital could lead to a better understanding of environmental sustainability (Alvarado et al., 2021; Sharma et al., 2021a). On the dark side, the educated population may involve in energy-intensive activities, such as trade, manufacturing, and the use of polluting technologies (Balaguer and Cantavella, 2018; Sharma et al., 2021b).

Institutional quality is another critical aspect that could, directly and indirectly, influence ecological quality. A strong institutional framework improves the management of public finance, helps to enforce law and order, opposes corruption, and minimizes military interference in politics (Danish and Ulucak, 2020). Therefore, the institutional role in environmental sustainability is valuable and imperative and supports the belief that countries can lower the cost of increasing growth and enjoy high income by improving environmental quality (Hassan et al., 2020). Solid institutional guidelines and rigid rules of law can compel organizations to curtail their carbon emissions (Shahbaz et al., 2021). Thus, institutional quality is crucial to minimize ecological degradation and achieve sustainable development goals.

Why emerging economies? This study focuses on these emerging countries due to several reasons. Firstly, emerging countries have achieved remarkable economic growth during the last two decades, covering 59% of the total population and representing 40% of the world's GDP. Secondly, these economies are incredibly liable for worsening the environmental quality, and their ecological footprint has increased from 2.36 (global hectares per capita) to 3.18 during 1984–2017 (see Fig. 1). Moreover, emerging economies face both internal and external pressure to reduce environmental degradation because rapid economic growth has created far-reaching ecological issues. Thirdly, the literature on the link between FD and EF is scant and displays dissent. Earlier studies used single or traditional proxies of FD, which may provide biased results. Svirydzenka (2016) claim that the conventional measures of FD such as stock market capitalization and domestic credit could not capture all dimensions and sectors in the financial system. Fourthly, despite the value of human capital and institutions, weather and how these factors affect the association between ecological footprint and FD remains a literature gap. Therefore, this study is especially vital because of the scarcity of studies on human capital and institutions' role in the relationship between FD and ecological footprint (hereafter EF).

Based on the aforementioned arguments, this paper enriches the current literature in the following ways. (i) It examines the linkage between FD, human capital, institutional quality, and EF

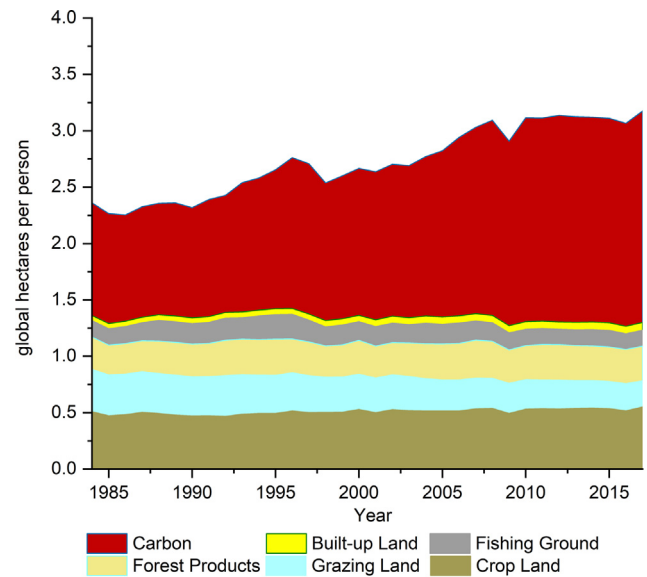


Fig. 1. Annual trend of ecological footprint in emerging countries over 1984–2017. Data Source: GFN (2020).

controlling for GDP and energy consumption. To the best of our knowledge, previous studies have not researched this relationship in the context of emerging countries. (ii) Further, we examine the indirect effect of FD through the channel of human capital. This will not only help policymakers to understand the internal mechanism of the finance-footprint nexus but also facilitate the formulation of reasonable policies considering the joint effect of these two variables. Despite the negative ecological effects of FD, it can foster human capital development that may lessen ecological pressure. Therefore, it would be useful to gauge the indirect effect of FD on EF through the channel of human capital. (iii) We also checked the moderating role of institutional quality in the relationship between FD and ecological degradation. Environmental policies of nations are managed by the institutions of countries, and policy-making for the sustainability of the financial sector is impossible without a strong role of institutions. Hence, it is sensible to check whether institution quality reduces the negative ecological consequences of FD. (iv) As an alternative to CO₂ emissions, the current study uses EF to indicate environmental degradation. Considering the climate goals, focusing simply on CO₂ emissions may not give a comprehensive view of actual ecological degradation. Therefore, the current study analyses environmental degradation from a broader perspective, rather than simply focusing on air pollution. Lastly, this work used an advanced panel data estimation technique that counters potential panel data problems such as slope heterogeneity and cross-section dependence.

2. Literature review

The literature review is divided into the following sections. (i) Financial development–ecological footprint nexus (ii) Human capital–ecological footprint nexus (iii) Institutional quality and ecological footprint relationship.

2.1. Financial development–ecological footprint nexus

A vibrant financial sector is important for the human and economic development of an economy, it is also important to gauge the impact of FD on the environment. The studies concerning the linkage between FD and environmental quality are indeed available with contradictory results. The deposited money (bank assets)

as a share of GDP, the liquid liabilities, and domestic credit to the private sector are predominantly used to measure FD (Bilgili et al., 2020; Saud et al., 2019; Shahbaz et al., 2018). The first strand of the literature indicates that FD significantly enhances environmental sustainability by reducing environmental degradation. For instance, Tamazian et al. (2009) investigated the influence of FD on carbon emission in BRICS economies. They revealed that FD enhances environmental quality by decreasing carbon emissions. Likewise, Jalil and Feridun (2011) found a positive relationship between FD and environmental deterioration. Regarding China, Salahuddin and Alam (2015) found the mitigating effect of FD on carbon emissions. Similarly, Dogan and Seker (2016) examined the association between FD and environmental quality in 23 countries. Using the FMOLS and DOLS approach, they revealed that FD fosters environmental quality through alleviating environmental deterioration.

The second strand of the literature documents a positive relationship between FD and environmental degradation. For instance, Boutabba (2014) concluded the positive impact of FD on emissions in the case of India. Their results portrayed that FD is decreasing environmental degradation by exacerbating carbon emissions. Likewise, Javid and Sharif (2016) investigated the effect of FD on environmental quality in Pakistan from 1972 to 2013. Their results indicate that FD significantly pollutes ecological quality. Likewise, using the non-linear estimation techniques, Ahmed et al. (2021b) unfolded a positive effect of FD on ecological degradation in Japan.

Similarly, Abbasi and Riaz (2016) also documented a positive relationship between pollution and FD in the context of Pakistan. The positive connection between FD and environmental degradation is also reported by Shahbaz et al. (2016) for Pakistan, Charfeddine and Ben Khediri (2016) for the UAE, Baloch et al. (2019) for 59 BRI economies, and Saud et al. (2020) for 49 countries.

In comparison, the third strand of the literature suggests that FD does not significantly affect environmental quality. For instance, Ozturk and Acaravci (2013) explored the effect of FD on emissions in Turkey spanning 1960–2007. Their results indicated that FD has no vital effect on the environment. Similarly, Destek and Sarkodie (2019) found no significant relationship between FD and environmental quality. Table 1 shows the summary of the literature regarding FD and environmental quality nexus.

2.2. Human capital-ecological footprint nexus

Although human capital and environmental quality have critical ecological implications, this area lacks adequate investigation. Therefore, further research is needed to examine its impact on the environment to achieve sustainable development goals. Danish et al. (2019) examined the relationship between human capital and EF in Pakistan from 1971 to 2014. The outcomes unveiled that human capital negatively affects EF in the short-term only, while an insignificant effect in the long run is found. Likewise, Zafar et al. (2019) analyzed the influence of human capital, GDP, and biocapacity on the EF in the United States. Their results revealed that human capital improves environmental quality by decreasing EF. Economic growth and biocapacity were found in favor of increasing EF. In the case of China, Ahmed et al. (2020) inspected the effect of urbanization, human capital, and economic growth on EF. The results revealed that human capital negatively affects EF, while economic growth and urbanization degrade environmental quality by increasing EF.

Pata and Caglar (2021) researched the effect of human capital, economic growth, globalization, and renewable energy consumption on EF in China. The study confirms that an upsurge in human capital significantly decreases environmental deterioration, while economic growth and globalization positively affect

EF. Renewable energy consumption poses no impact on the quality of the environment. Pata et al. (2021) also revealed that human capital and renewable energy enhance environmental quality, while natural resources stimulate ecological damage. On the other hand, Nathaniel et al. (2021) used the AMG method to investigate the effect of human capital, economic growth, and natural resources on EF. Their estimates confirmed that human capital poses a favorable but insignificant impact on EF, while economic growth and natural resources increase the degradation of the environment. On the contrary, Zhang et al. (2021) explored the association among human capital, economic growth, natural resources, and EF in Pakistan from 1985 to 2018. They concluded that human capital and economic factor have a positive, whereas natural resources have a negative effect on EF. Similarly, Ahmed et al. (2021a) revealed that human capital upsurges environmental deterioration because education enables individuals to earn more money which is used for adopting a luxurious lifestyle, particularly in the absence of ecological awareness from educational curriculums.

2.3. Institutional quality and ecological footprint nexus

A growing body of literature underlines that the quality of institutions plays an important role to ensure the sustainability of a country. Whereas, the empirical outcomes regarding the institutional quality and environmental quality nexus are mixed. Some scholars discovered that institutional quality increases ecological degradation (Hassan et al., 2020; Yamineva and Liu, 2019), while others argued that various aspects of institutional quality, such as control of corruption and democracy pose a favorable impact on environmental quality (Adams and Klobodu, 2017; Danish and Ulucak, 2020; Rizk and Slimane, 2018). For instance, Tamazian and Bhaskara, (2010) analyzed the effect of IQ on CO₂ emissions in 24 transition countries and observed that institutional quality reduces environmental pollution. Likewise, Abid (2016) found that institutional quality is negatively related to environmental degradation in Sub Sahara African countries. According to Adams and Klobodu (2017), democracy and bureaucratic quality significantly reduce CO₂ emissions in 38 African countries. On the contrary, Dasgupta and De Cian (2018) highlighted that institutions and governance are liable for environmental deterioration. Similarly, Hassan et al. (2020) underlined that institutional quality increases environmental degradation in Pakistan. Table 2 shows the summary of the literature on the relationship between institutional quality and environmental degradation.

Summarizing the above-mentioned empirical studies, we can conclude that although a growing body of literature investigates the impact of financial development on environmental degradation, some research gaps still exist. First, previous studies mostly used single or traditional measures of financial development, which could not capture all dimensions and sectors in the financial system. Second, in addition to the direct impact, the financial development may indirectly impact ecological footprint through the channel of human capital and institutions. However, previous studies have not explored such indirect impacts. Third, prevailing literature widely used CO₂ emissions and other pollutants as a proxy of environmental degradation; however, these indicators cannot reflect the complex nature of environmental deterioration. More precisely, insufficient studies on underlying variables, contradictory conclusions, and deficiencies in adopted methodologies motivate us to examine the linkage between financial development, human capital, institutional quality, and EF for the panel of emerging countries.

Table 1
Literature survey on financial development–environmental degradation nexus.

Author	Period	Country	Method	Measure	Results
Jalil and Feridun (2011)	1953–2006	China	ARDL	Liquid liabilities/GDP	FD improves environmental quality
Ozturk and Acaravci (2013)	1960–2007	Turkey	ARDL, Granger causality	Domestic credit to the private sector/GDP	FD has no significant effect on CO ₂ emissions
Boutabba (2014)	1971–2008	India	ARDL, VECM	Domestic credit to the private sector/GDP	FD decreases environmental quality
Salahuddin and Alam (2015)	1980–2012	6 Gulf countries	FMOLS, DOLS	Credit to the private sector/GDP	FD decreases CO ₂ emissions
Al-Mulali et al. (2015)	1980–2011	129 countries	GMM	Domestic credit to the private sector/GDP	FD increases environmental quality
Javid and Sharif (2016)	1972–2013	Pakistan	ARDL	Domestic credit to the private sector	FD degrades environmental quality
Abbasi and Riaz (2016)	1971–2011	Pakistan	VECM, Granger causality	Stock market capitalization/GDP, Domestic credit/GDP	FD decreases environmental quality
Dogan and Seker (2016)	1985–2011	23 countries	FMOLS, DOLS	Domestic credit to the private sector/GDP	FD decreases CO ₂ emissions
Charfeddine and Ben Khediri (2016)	1975–2012	United Arab Emirates	ARDL, VECM	domestic credit to the private sector/GDP	FD decreases the environmental quality
Shahbaz et al. (2016)	1985Q1–2014Q4	Pakistan	NARDL	financial development index	FD increases CO ₂ emissions
Nasreen et al. (2017)	1980–2012	5 South Asian countries	ARDL	Financial stability index,	FD decreases CO ₂ emissions
Dogan et al. (2019)	1971–2013	4 MINT economies	ARDL, Granger causality	domestic credits by the financial sector/GDP	FD reduces emissions
Destek and Sarkodie (2019)	1977–2013	11 countries	AMG	Domestic credit to the private sector/GDP	FD has no vital impact on CO ₂ emissions
Baloch et al. (2019)	1990–2016	59 Belt and Road countries	PMG	Domestic credit to the private sector/GDP	FD deteriorates environmental quality
Saud et al. (2020)	1990–2014	49 countries	PMG	Domestic credit to the private sector/GDP	FD increases EF
Ahmad et al. (2020)	1990–2017	90 countries	DK	FD index	FD increases EF
Nasir et al. (2021)	1980–2014	Australia	Causality, VECM	FD index	Bidirectional causality exists between FD and environmental quality.

Abbreviations: ARDL, autoregressive distributive lag estimator; AMG, augmented mean group; BRICS, South Africa, China, India, Russia, Brazil; DK, Driscoll-Kraay; DOLS, dynamic ordinary least square; EF, ecological footprint; FD, financial development; FMOLS, fully modified OLS estimator; GMM, generalized method of moments; energy; PMG, pooled mean group; VECM, vector error correction model.

3. Methodology and data

3.1. Theoretical framework and model construction

From a theoretical perspective, there are two distinct opinions on the role of financial development, particularly related to environmental degradation. First, FD may positively contribute towards environmental sustainability by allocating more funds towards clean energy and

mobilizing the capital required to invest in environmentally sustainable infrastructure and ensure its long-term viability

(Tamazian et al., 2009; Shahbaz et al., 2021)). Financial development also enables countries to use advanced technologies for environmentally friendly and clean production, which in turn improves regional and global environmental sustainability (Ahmad et al., 2021; Ulucak et al., 2020). On the contrary, a higher degree of FD may lead to environmental deterioration. Acheampong (2019) argues that financial development makes it easier for businesses and individuals to have access to cheap credits that enable them to start a new business or expand their existing business. This increases energy usage which adversely impacts environmental quality.

Table 2
Literature survey on institutional quality and environmental degradation.

Author	Period	Country(s)	Method	Results
Tamazian and Bhaskara, (2010)	1993–2004	24 countries	GMM	Institutional development plays a substantial role in the mitigation of environmental degradation.
Abid (2016)	1996–2010	SSA region	GMM	Institutional quality decreases CO ₂ emissions.
Adams and Klobodu (2017)	1970–2011	38 African countries	DOLS	Democracy and bureaucratic quality are effective in reducing CO ₂ emissions.
Bhattacharya et al. (2017)	1991–2012	85 countries	GMM, FMOLS	Institutional quality decreases CO ₂ emissions.
Rizk and Slimane (2018)	1996–2014	146 countries	3-SLS	Institutional quality improves environmental quality.
Sarkodie and Adams (2018)	1991–2016	South Africa	ARDL	Political institutions significantly curb environmental degradation in South Africa.
Hassan et al. (2020)	1984–2016	Pakistan	ARDL	Institutional quality increases environmental degradation in Pakistan.
Danish and Ulucak (2020)	1992–2015	18 APEC countries	FMOLS, DOLS, DK	The institutional quality significantly reduces environmental pollution in APEC countries.

Abbreviations: APEC, Asia-pacific economic cooperation, BRICS, South Africa, China, India, Russia, Brazil; DK, Driscoll-Kraay; DOLS, dynamic ordinary least squares; EKC, environment Kuznets curve; FMOLS, fully modified OLS estimator; GMM, generalized method of moments.

To test the FD-footprint nexus, we followed the studies of [Shahbaz et al. \(2018\)](#) and [Nasir et al. \(2021\)](#) and constructed the following model.

$$\ln EF_{it} = \beta_1 \ln FD_{it} + \beta_2 \ln GDP_{it} + \beta_3 \ln EC_{it} + \beta_4 \ln HC_{it} + \beta_5 \ln IQ_{it} + \tau_{it} \quad (1)$$

where EF represents the ecological footprint and FD denotes the financial development. GDP indicates the gross domestic product, EC indicates the energy consumption, HC represents the human capital, and IQ denotes the institutional quality. Where t refers to the year (1984–2017), i indicates the countries (1.2.3.4.17), and ε denotes the error term.

We hypothesize that human capital moderates the relationship between financial development and EF. Therefore, the model given in equation (1) is extended to include the interaction term ($\ln FD * \ln HC$) to gauge the indirect impact of financial development on EF through the channel of human capital.

$$\ln EF_{it} = \beta_1 \ln FD_{it} + \beta_2 \ln GDP_{it} + \beta_3 \ln EC_{it} + \beta_4 \ln HC_{it} + \beta_5 \ln IQ_{it} + \beta_6 (\ln FD * \ln HC)_{it} + \tau_{it} \quad (2)$$

We hypothesize that institutional quality moderates the relationship between FD and environmental degradation. Therefore, to quantify whether institutional quality affects the relationship between FD and EF, this study extended the equation (1) to gauge the combined effect of FD and IQ by adding the interaction term ($\ln FD * \ln IQ$) in equation (3).

$$\ln EF_{it} = \beta_1 \ln FD_{it} + \beta_2 \ln GDP_{it} + \beta_3 \ln EC_{it} + \beta_4 \ln HC_{it} + \beta_5 \ln IQ_{it} + \beta_6 (\ln FD * \ln IQ)_{it} + \tau_{it} \quad (3)$$

The research examined the dynamic linkage between FD, human capital, institutional quality, economic growth, energy consumption, and EF in 17 emerging countries from 1984 to 2017. The countries taken into consideration involve Argentina, Colombia, Chile, China, Brazil, India, Malaysia, Poland, Mexico, Philippines, Pakistan, Peru, South Korea, South Africa, Saudi Arabia, Turkey, and Thailand. The selection of the starting period of 1984 is linked with institutional quality data, and the period ended in 2017 is knotted with the data accessibility of EF. The study employed the EF as a proxy of ecological footprint, and the data is acquired from the Global Footprint Network. Furthermore, the data on FD is extracted from International Monetary Funds. The institutional quality (IQ) data is extracted from Penn world tables. The data on GDP and energy consumption are acquired from the World Bank and BP statistical review of world energy. The variables' measurements and data sources are shown in [Supplementary Data](#), Table S1. [Fig. 2](#) depicts the distribution of data in box plots. The percentage of each graph are 25, 50, and 75, the lower and upper lines show the minimum and maximum, the circle indicates the median, and the square represents the mean values. [Fig. 3](#) portrays the spatial distributions of ecological footprint (per capita) in 2017, indicating that South Korea has the highest per capita EF among these countries.

3.2. Estimation strategy

The estimation strategy is based on seven steps (see [Fig. 4](#)). We discuss the details of each step in the following sections.

3.2.1. Cross-sectional dependency test

The cross-sectional dependence (CD) is the most commonly associated problem in the panel time series analysis. The issue of CD may arise due to unobserved shocks, which can make the results biased. To handle this issue, we utilize the method introduced by [Pesaran \(2004\)](#). The test equation is given as follows:

$$CD = \sqrt{\frac{2T}{N(N-1)}} \left(\sum_{i=1}^{N-1} \sum_{j=i+1}^N \hat{\rho}_{ij} \right) \quad (4)$$

where $\hat{\rho}_{ij}^2$ indicate the pair-wise correlation residual sample estimate, and T and N are for cross-sections N and time.

3.2.2. Slope homogeneity tests

After examining the cross-sectional correlation, it is essential to examine the slope homogeneity because there can also be diversities across nations in terms of demographics, economic, and socio-economic structure. To pursue this goal, [Hashem Pesaran et al. \(2008\)](#) slope homogeneity test is used. The test equations are given below:

$$\tilde{\Delta}_{SH} = (N)^{\frac{1}{2}} (2K)^{-\frac{1}{2}} \left(\frac{1}{N} \tilde{S} - k \right) \quad (5)$$

$$\tilde{\Delta}_{ASH} = (N)^{\frac{1}{2}} \left(2k \left(\frac{T-k-1}{T+1} \right)^{-\frac{1}{2}} \left(\frac{1}{N} \tilde{S} - k \right) \right) \quad (6)$$

$\tilde{\Delta}_{SH}$ and $\tilde{\Delta}_{ASH}$ shows the delta tilde and delta tilde adjusted, respectively.

3.2.3. Unit root test

When confirming the CD and heterogeneity in slope parameters, the second-generation unit root tests are required to inspect the integrating properties of variables. In this regard, the cross-sectional augmented Dickey-Fuller (CADF) and I'm Pesaran-Shin (CIPS) unit test of [Pesaran \(2007\)](#) is used. These unit root tests are most suitable for heterogeneous panel data, and they also show better performance and consistency than the first-generation unit root test.

$$\Delta CA_{i,t} = \varphi_i + \varphi_i Z_{i,t-1} + \varphi_i \bar{CA}_{t-1} + \sum_{l=0}^p \varphi_{il} \Delta \bar{CA}_{t-1} + \sum_{l=0}^p \varphi_{il} \Delta CA_{i,t-1} + \mu_{it} \quad (7)$$

where \bar{CA}_{t-1} and $\Delta \bar{CA}_{t-1}$ are the cross-section averages. The CIPS test statistic as be written as

$$\widehat{CIPS} = \frac{1}{N} \sum_{i=1}^n CDF_i \quad (8)$$

3.2.4. Cointegration test

After the stationarity diagnostics, the next step is to identify the long-run cointegration association between the underlying variable. This study employs [Westerlund \(2007\)](#) ECM panel cointegration test. This test provides efficient results in the presence of heterogeneous slope and cross-sectional dependence. The [Westerlund](#) test is described as follows:

$$\alpha_i(L) \Delta y_{it} = \delta_{1i} + \delta_{2i} t + \alpha_i (y_{it-1} - \beta_i' x_{it-1} + \lambda_i(L)' v_{it} + e_{it} \quad (9)$$

In Eq. (9) α_i represent the cointegration vector between y and x, and β_i is an error correction coefficient and. Empirically test can be demonstrated as:

$$G_t = \frac{1}{N} \sum_{i=1}^N \frac{\alpha_i'}{SE(\alpha_i')} \quad (9.1)$$

$$G_a = \frac{1}{N} \sum_{i=1}^N \frac{T \alpha_i'}{\alpha_i'(1)} \quad (9.2)$$

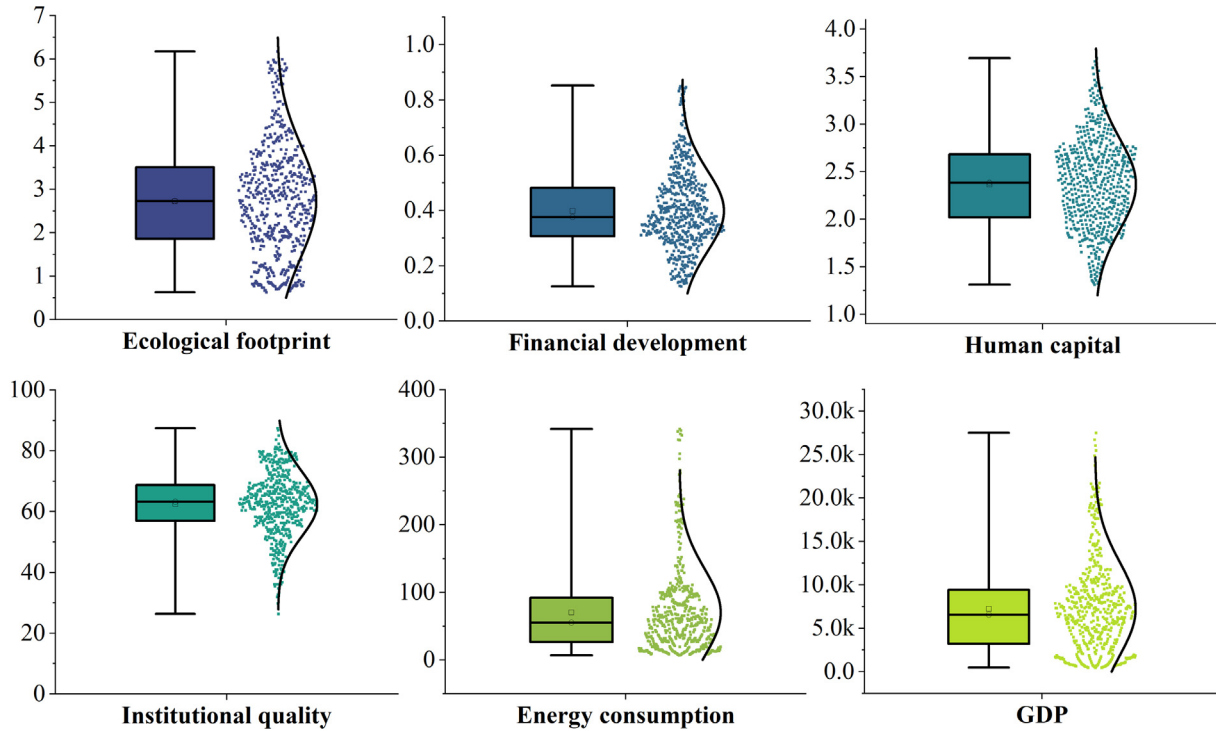


Fig. 2. Box chart of variables with scatterplot and distribution.

$$P_t = \frac{\alpha'}{SE(\alpha')} \quad (9.3)$$

$$\alpha' = \frac{P_a}{T} \quad (9.4)$$

where $\alpha' = \frac{P_a}{T}$ indicates the proportion of the error to be corrected yearly, in case of short-term disequilibrium.

3.2.5. Short-run and long-run analysis

Economists proposed various econometric techniques for empirical analysis of the panel data. However, the first-generation cointegration estimation techniques, such as Dynamic Ordinary Least Squares (DOLS), Fully modified ordinary least squares (FMOLS), etc., may provide biased results in the presence of cross-sectional dependence and heterogeneity in panel data. The cross- cross-sectional autoregressive distributed lags (CS-

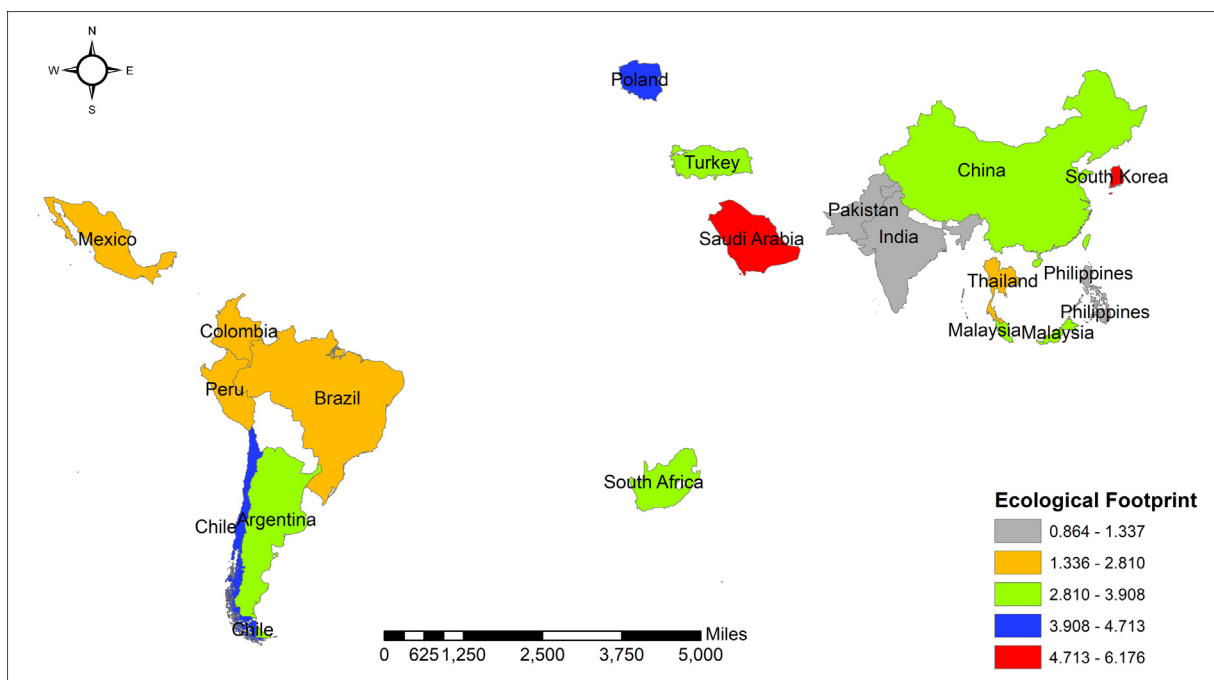


Fig. 3. Spatial distributions of ecological footprint (per capita) for the 17 selected emerging countries in 2017. Data Source: GFN (2020).

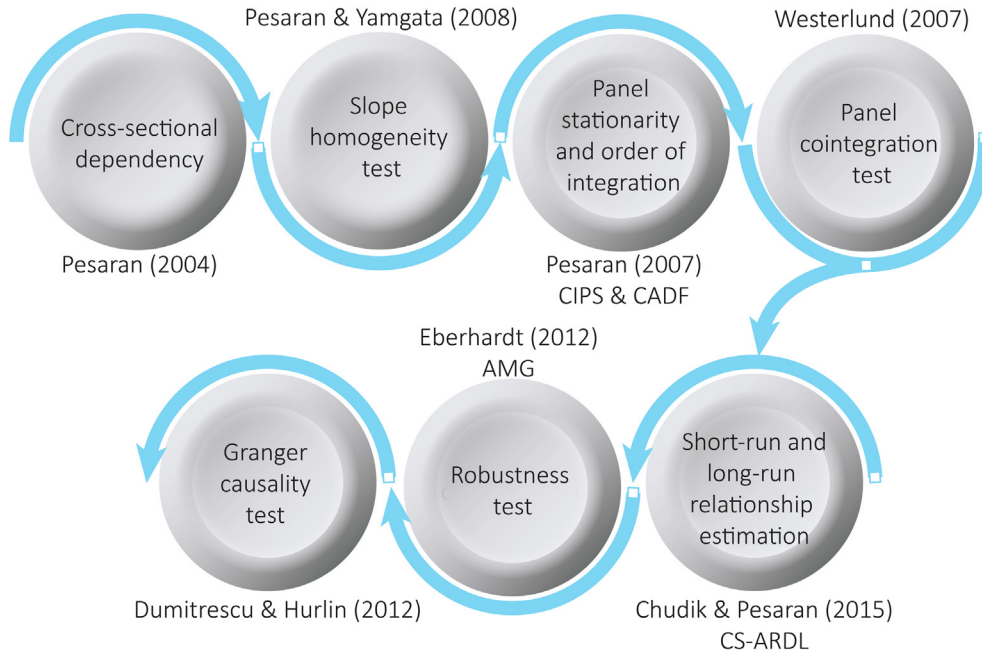


Fig. 4. Estimation strategy.

ARDL) model proposed by Chudik and Pesaran (2015) is robust not merely for cross-sectional dependency and heterogeneity but also non-stationarity and endogeneity problems. Therefore, the short-run and long-run relationship between FD, human capital, institutional quality, economic growth, energy consumption, and EF are examined by using the CS-ARDL method. The test equation of CS-ARDL is given as:

$$\Delta EF_{i,t} = \varphi_i + \sum_{j=1}^p \varphi_{it} \Delta EF_{i,t-j} + \sum_{j=0}^p \varphi'_{ij} AEV_{i,t-j} + \sum_{j=0}^p \varphi'_{it} \bar{Z}_{t-j} + \varepsilon_{i,t} \quad (10)$$

The cross-sections averages are represented by $\bar{Z}_t = (\Delta \bar{EF}_t, \bar{AEV}'_t)'$, while AEV represents the set of explanatory variables.

3.2.6. Robustness test (AMG)

The results of CS-ARDL are reconfirmed by using the Augmented Mean Group (AMG) method. This test has more power compared to many traditional methods because it deals with cross-sectional dependence, heterogeneity, and endogeneity problems (Eberhardt, 2012).

3.2.7. Granger causality test

Although the results from the AMG and CS-ARDL estimator offer a crucial insight, they do not gauge the causal relationships between the variables, which are imperative for policy suggestions. Therefore, for this purpose, this research uses the recent second-generation Dumitrescu and Hurlin (2012) test. The model is represented as follows.

$$z_{i,t} = \alpha_i + \sum_{j=1}^p \beta_i^j z_{i,t-j} + \sum_{j=1}^p \gamma_i^j T_{i,t-j} \quad (11)$$

where β_i^j postulates the parameters of autoregressive and lag length denoted by j .

4. Results and discussion

The outcome of the CD test, calculated by estimating equation (4), shown in Table 3 depicts the presence of CD in panel data by rejecting the null hypothesis at the 1% significance level. Hence, high dependence exists in countries, which indicates that shock in one of the emerging countries will have consequences for other regions and countries.

The slope homogeneity test outcomes are summarized in Table 4. The empirical findings revealed that all three models have a heterogeneous slope, which is proved by the value of delta ($\tilde{\Delta}$) and adjusted delta ($\tilde{\Delta}_{adjusted}$). The unit root test results are given in Table 5, demonstrating that FD and institutional quality constitute the unit root problems at the level. However, all the variables became stationary at the first difference.

The results derived from Eq. (9.1) to Eq. (9.4) of Westerlund cointegration assessment are presented in Table 6, indicating the cointegration relationship between FD, human capital, institutional quality, economic growth, energy consumption, and EF. Besides, the error correction parameter (α') is represented by $-25.928/34 = -0.76$ in model-I, -0.55 in Model-II, and -0.60 in model-III. It suggests that on average >64% errors between ecological footprint and its explanatory variables are corrected each year, and short-run non-equilibrium is adjusted in the model of long-run.

The regression estimates of CS-ARDL are shown in Table 7, depicting that FD is positively associated with the EF in the short-run as well as in the long run. The positive coefficient of FD portrays that the financial institutions and markets impede the environmental quality by increasing the EF. FD increases economic activities, which in turn stimulate environmental pressure as a result of the high usage of fossil fuel energy. In other words, financial sectors and markets in emerging economies are allotting resources to polluting industries and investing in environmentally unsustainable projects. Another reason could be the weak financial system and tight regulation, which hamper the ability of financial institutions to fund environmentally friendly projects in emerging

Table 3
CD test results.

Variable	Pesaran scaled LM		Pesaran CD		
	Test stat.	Prob.	test stat.	Prob.	Abs(corr)
<i>lnEF</i>	82.031***	0.000	13.048***	0.000	0.483
<i>lnFD</i>	123.167***	0.000	34.046***	0.000	0.614
<i>lnGDP</i>	200.329***	0.000	58.93***	0.000	0.817
<i>lnEC</i>	170.607***	0.000	33.896***	0.000	0.739
<i>lnHC</i>	268.533***	0.000	69.708***	0.000	0.966
<i>lnIQ</i>	65.172***	0.000	23.478***	0.000	0.428

Note: P < 0.01, 0.05, 0.10 indicate ***, ** and *, respectively.

Table 4
Results of slope Homogeneity test.

Test	Model-1		Model-2		Model-3	
	Test stat.	Prob.	Test stat.	Prob.	Test stat.	Prob.
$\tilde{\Delta}$	17.648***	0.000	16.496***	0.000	15.418***	0.000
$\tilde{\Delta}_{adjusted}$	18.290***	0.000	17.119***	0.000	16.000***	0.000

Note: P < 0.01, 0.05, 0.10 indicate ***, ** and *, respectively.

Table 5
Unit root test.

	Level		First-difference		Decision
	Intercept	Intercept & Trend	Intercept	Intercept & Trend	
Cross-Sectionally Augmented Dickey-Fuller (CADF)					
<i>lnEF</i>	-1.950	-2.011	-3.648***	-3.756***	I(1)
<i>lnFD</i>	-2.309***	-2.560	-	-	I(0)
<i>lnGDP</i>	-1.868	-2.361	-2.917***	-3.238***	I(1)
<i>lnEC</i>	-1.655	-1.663	-2.928***	-3.310***	I(1)
<i>lnHC</i>	-1.879	-2.436	-2.971***	-3.252***	I(1)
<i>lnIQ</i>	-1.965	-2.293	-4.156***	-4.448***	I(1)
Cross-Sectionally Augmented IPS (CIPS)					
<i>lnEF</i>	-2.037	-2.426	-5.580***	-5.686***	I(1)
<i>lnFD</i>	-2.690***	-2.871***	-	-	I(0)
<i>lnGDP</i>	-1.861	-1.974	-3.900***	-4.281***	I(1)
<i>lnEC</i>	-1.671	-1.714	-4.682***	-5.109***	I(1)
<i>lnHC</i>	-1.009	-1.752	-3.206***	-3.725***	I(1)
<i>lnIQ</i>	-2.471***	-2.830***	-	-	I(0)

Note: P < 0.01, 0.05, 0.10 indicate ***, ** and *, respectively.

countries. These findings are similar to the outcome of [Ahmad et al. \(2020\)](#) for Belt and Road countries, and [Ahmed et al. \(2021\)](#) for Japan. However, the current results are not similar to the findings of [Shahbaz et al. \(2018\)](#) who conclude that FD improves ecological quality.

The regression outcomes further indicate that economic growth affects the EF positively and significantly in the short-run and long-run, implying that GDP impedes environmental sustainability by raising EF. These results depict that economic activities in emerging economies are not environmentally friendly. In pursuit of rapid economic growth, these emerging economies are compromising on their ecological quality over artificial luxury. Economic activities lead to more energy consumption and more serious environmental degradation ([Sharma et al., 2020](#); [Khan and Hou, 2021a](#)). Our find-

ings coincide with the findings of [Ozcan et al. \(2018\)](#), ([Khan and Hou, 2021b](#)), and [Zhang et al. \(2021\)](#).

Energy consumption is positively associated with EF. On average, a 1% rise in energy consumption increases EF by 0.124% in the short-run and by 0.255% in the long-run. Energy consumption is the ultimate factor in increasing environmental degradation in emerging countries. The devastating effect of energy consumption on the environment is justifiable on the ground that the share of fossil fuel energy consumption in the total energy mix is more than 75% which deteriorates the environmental quality ([BP, 2020](#)). Hence, due to the high share of fossil fuels in the energy mix, the environmental quality of these countries deteriorates. These results are supported by the findings of [Destek and Sarkodie \(2019\)](#), [Khan and Hou \(2021c\)](#), and [Destek and Sinha \(2020\)](#).

Table 6
Westerlund cointegration.

	G_t	G_a	P_t	P_a
Model-1	-4.695*** [-10.410]	-22.959*** [-6.208]	-15.745*** [-6.352]	-25.928*** [-9.548]
Model-2	-4.679*** [-9.399]	-16.479* [-1.333]	-13.122*** [-3.438]	-18.818*** [-4.269]
Model-3	-5.089*** [-8.034]	-18.039** [-2.126]	-13.956*** [-4.137]	-20.372*** [-5.022]

Note: P < 0.01, 0.05, 0.10 indicate ***, ** and *, respectively. [] contain the Z-value.

Table 7
Results of CS-ARDL.

Variables	Model-1	Model-2	Model-3
Short-run results			
<i>lnFD</i>	0.028*** [0.011]	0.035*** [0.013]	0.055** [0.023]
<i>lnGDP</i>	0.437*** [0.147]	0.492*** [0.162]	0.534*** [0.175]
<i>lnEC</i>	0.494*** [0.117]	0.429*** [0.125]	0.415*** [0.131]
<i>lnHC</i>	-0.915** [0.373]	-0.949** [0.395]	-1.067*** [0.398]
<i>lnIQ</i>	-0.062** [0.025]	-0.046** [0.018]	-0.086** [0.021]
<i>ln(FD*HC)</i>	-	-0.056** [0.026]	-
<i>ln(FD*IQ)</i>	-	-	-0.016* [0.009]
<i>ECM(-1)</i>	-0.863*** [0.072]	-0.910*** [0.074]	-0.937*** [0.064]
Long-run results			
<i>lnFD</i>	0.015** [0.006]	0.019*** [0.007]	0.030** [0.013]
<i>lnGDP</i>	0.241*** [0.077]	0.269*** [0.090]	0.284*** [0.094]
<i>lnEC</i>	0.255*** [0.062]	0.214*** [0.067]	0.206*** [0.066]
<i>lnHC</i>	-0.433** [0.198]	-0.462** [0.215]	-0.507** [0.199]
<i>lnIQ</i>	-0.035** [0.017]	-0.032** [0.014]	-0.044*** [0.016]
<i>ln(FD*HC)</i>	-	-0.037** [0.018]	-
<i>ln(FD*IQ)</i>	-	-	-0.009* [0.005]

Note: P < 0.01, 0.05, 0.10 indicate ***, ** and *, respectively. [] contain the standard error.

Human capital is negatively related to EF in the long-run and short-run. Statistically speaking, a 1% rise in human capital decreases EF by 0.977% in the short-run and by 0.467% in the

Table 8
Robustness check (AMG).

Variables	Model-1	Model-2	Model-3
<i>lnFD</i>	0.013*** [0.004]	0.012*** [0.005]	0.024*** [0.007]
<i>lnGDP</i>	0.421*** [0.103]	0.414*** [0.096]	0.441*** [0.107]
<i>lnEC</i>	0.511*** [0.142]	0.566*** [0.137]	0.583*** [0.142]
<i>lnHC</i>	-0.247*** [0.064]	-0.249*** [0.073]	-0.243*** [0.059]
<i>lnIQ</i>	-0.038*** [0.009]	-0.033*** [0.010]	-0.044*** [0.014]
<i>ln(FD*HC)</i>	-	-0.070*** [0.023]	-
<i>ln(FD*IQ)</i>	-	-	-0.013** [0.005]
Constant	-4.737*** [0.651]	-5.277*** [0.618]	-5.230*** [0.722]

Note: P < 0.01, 0.05, 0.10 indicate ***, ** and *, respectively. [] is for standard error.

Table 9
Results of panel causality test.

Variables	<i>lnEF</i>	<i>lnFD</i>	<i>lnGDP</i>	<i>lnEC</i>	<i>lnHC</i>	<i>lnIQ</i>
<i>lnEF</i>	-	3.660*** [2.720] (0.007)	4.233*** [3.758] (0.000)	6.250*** [7.415] (0.000)	4.270*** [3.825] (0.000)	3.079* [1.666] (0.096)
<i>lnFD</i>	2.580 [0.762] (0.446)	-	4.573*** [4.251] (0.000)	7.006*** [5.144] (0.000)	5.611*** [6.080] (0.000)	3.706*** [2.724] (0.006)
<i>lnGDP</i>	5.384*** [5.845] (0.000)	4.614*** [4.325] (0.000)	-	5.776*** [3.455] (0.000)	6.977*** [8.488] (0.000)	5.119** [2.548] (0.010)
<i>lnEC</i>	3.203* [1.890] (0.059)	5.431*** [4.092] (0.002)	2.096*** [2.640] (0.008)	-	4.824*** [4.694] (0.000)	2.558*** [3.831] (0.000)
<i>lnHC</i>	2.839 [1.230] (0.219)	4.466*** [4.064] (0.000)	6.257** [2.082] (0.037)	4.297 [1.414] (0.157)	-	9.187*** [3.370] (0.000)
<i>lnIQ</i>	2.512 [0.638] (0.523)	2.889 [1.284] (0.199)	5.471 [0.614] (0.538)	2.892 [1.290] (0.197)	4.348*** [3.854] (0.000)	-

Note: P < 0.01, 0.05, 0.10 indicate ***, ** and *, respectively. [] contains the Z-bar tilde, and () contains P-values.

long-run. The findings portray that with the development of human capital, countries can impede environmental degradation because the existence of educated human capital nurtures environmental quality and positively contribute to the preservation of natural resources, energy conservation, and efficient utilization of resources. The results are consistent with the findings of Ahmed et al. (2020). Furthermore, the joint effect of FD and human capital is also evaluated by using the interaction term. The negative coefficient of the interaction term explains that FD reduces ecological degradation when it combines with human capital. This is sensible since FD promotes human capital development, which implies that FD promotes sustainability through the channel of human capital. An upsurge in financial development can improve the quality of human capital, which can play a mitigating role in environmental degradation.

Institutional quality is also negatively correlated to EF in both the short and long-run. Strong institutions pave the way toward decreasing corruption and smoothen the path for the implementation of strict environmental law. Thus, institutional quality makes an enormous difference in alleviating climate change and its effects via social, governance, and economic readiness. Therefore, quality political institutions need strict social, governance, and economic reforms and policies before adaptation options can be enforced. The joint impact of FD and institutional quality gauged by the interaction term of these two variables is shown in Model 3. The negative coefficient of interaction term depicts that moderating influence of institutional quality positively contributes to mitigating environmental degradation. Strong institutions enable countries to implement strict laws related to financial institutions and ease the way for green projects. Therefore, IQ lessens the harmful effects of FD and environmental quality improves when IQ interacts with the FD.

The robustness analysis with AMG also confirms the CS-ARDL outcomes. Results in Table 8 indicate that GDP, FD, energy consumption increases the EF, while human capital and institutional quality help to enhance the environmental quality. The human capital and institutional significantly moderate the relationship between FD and EF.

Table 9 provides the outcomes of the panel Granger causality test. The results demonstrate that there is a single-way linkage from FD, human capital, and institutional quality to EF but not the reverse. Whereas, bidirectional causalities between GDP, energy consumption, and EF are proved by the tests. The outcome indicates a bidirectional causal linkage among financial development, energy consumption, and economic growth. A unidirectional link is found from institutional quality to financial development, energy consumption, and human capital. A one-way causality is found from human capital to energy consumption (see Fig. 5).

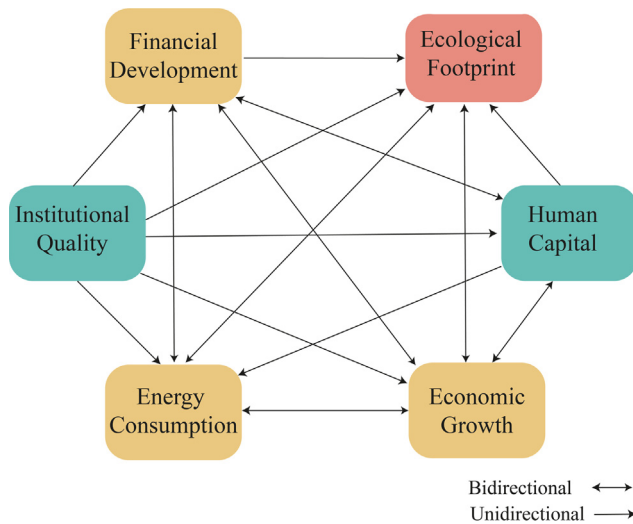


Fig. 5. Representation of causality results among variables.

5. Conclusion

This study examines the dynamic association between financial development and EF in 18 emerging economies spanning from 1984 to 2017. In addition, it further explores the combined effect of human capital and FD, and institutional quality and FD on ecological footprint, controlling for economic growth and energy consumption. The findings of CS-ARDL display that financial development deteriorates the ecological quality by boosting the ecological footprint in the short term as well as in the long term. In contrast, human capital and institutional quality pose a salient improvement to the environmental quality in both the short and long-run. In addition, economic growth and energy usage have a positive effect on EF. Furthermore, we also explored the indirect effects of financial development on the ecological footprint. Interestingly, the interaction term of financial development and human capital reveals that financial development enhances ecological quality through the human capital channel. Similarly, financial development has a statistically significant positive effect on environmental quality under the moderating influence of institutional quality. The causal relationship unfolds the unilateral role of financial development, human capital, and institutional quality on the ecological footprint. It implies that the implementation of any policy pertaining to these factors will have a definite effect on ecological quality. However, any means of reducing the ecological footprint does not counteract these variables.

Based on these outcomes, we propose some policy implications. Firstly, emerging countries should improve the existing financial structure because financial development has a catalytic impact on environmental deterioration. In this regard, emerging economies should promote the innovation and improvement of financial instruments, which will help mitigate environmental problems (Cheng et al., 2021). At the same time, the flow of financial funds to polluting enterprises should be avoided and more environment-friendly projects should be supported. Besides, financial institutions must continuously adjust internal and external demands and laws and regulations to accommodate the diversification of economic development and to minimize the environmental problems associated with economic growth.

Secondly, human capital is perceived to mitigate environmental degradation, and financial development improves environmental quality through the channel of human capital. Therefore, emerging countries should allocate financial resources to the education and

health sectors as a priority in order to develop a strategy of fostering human capital that will reduce EF. Meanwhile, emerging countries should also strengthen the management tools of human resources and form a complete set of the talent supply chain to cope with the crisis of continuous environmental degradation. Finally, there is significant divergence among emerging countries in terms of the existing institutions. But the current evidence suggests a positive role of institutional quality in environmental quality. Therefore, emerging countries should improve the governance capacity of their governments and continue to establish high-quality institutions to structure and regulate sustainable development frameworks. On the other hand, strong institutions can effectively regulate transactions related to financial institutions, thereby reducing the continued advancement of polluting projects.

The scope of this study is limited to 17 emerging countries and only a limited number of variables are included. Moreover, the time dimension of this study is limited from 1998 to 2017. Future studies can extend the model by incorporating other variables.

CRediT authorship contribution statement

Mahmood Ahmad: Conceptualization, Methodology, Software, Data curation, Formal analysis, Visualization, Writing-Original Draft. **Zahoor Ahmed:** Writing-Original Draft, Writing, review & editing. **Xiyue Yang:** Visualization, Writing, review & editing. **Nazim Hussain:** Writing, review & editing. **Avik Sinha:** Writing, review & editing, Supervision, Project administration.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.gr.2021.09.012>.

References

- Abbasi, F., Riaz, K., 2016. CO2 emissions and financial development in an emerging economy: An augmented VAR approach. *Energy Policy* 90, 102–114. <https://doi.org/10.1016/j.enpol.2015.12.017>.
- Abid, M., 2016. Impact of economic, financial, and institutional factors on CO2 emissions: Evidence from Sub-Saharan Africa economies. *Util. Policy* 41, 85–94. <https://doi.org/10.1016/j.jup.2016.06.009>.
- Acheampong, A.O., 2019. Modelling for insight: Does financial development improve environmental quality? *Energy Econ.* 83, 156–179. <https://doi.org/10.1016/j.eneco.2019.06.025>.
- Adams, S., Klobodu, E.K.M., 2017. Urbanization, democracy, bureaucratic quality, and environmental degradation. *J. Policy Model.* 39 (6), 1035–1051. <https://doi.org/10.1016/j.jpolmod.2017.04.006>.
- Ahmad, M., Jiang, P., Majeed, A., Raza, M.Y., 2020. Does financial development and foreign direct investment improve environmental quality? Evidence from belt and road countries. *Environ. Sci. Pollut. Res.* 27 (19), 23586–23601. <https://doi.org/10.1007/s11356-020-08748-7>.
- Ahmad, M., Jiang, P., Mursheed, M., Shehzad, K., Akram, R., Cui, L., Khan, Z., 2021. Modelling the dynamic linkages between eco-innovation, urbanization, economic growth and ecological footprints for G7 countries: Does financial globalization matter? *Sustain. Cities Soc.* 70, 102881. <https://doi.org/10.1016/j.scs.2021.102881>.
- Ahmed, Z., Asghar, M.M., Malik, M.N., Nawaz, K., 2020. Moving towards a sustainable environment: The dynamic linkage between natural resources, human capital, urbanization, economic growth, and ecological footprint in China. *Resour. Policy* 67, 101677. <https://doi.org/10.1016/j.resourpol.2020.101677>.
- Ahmed, Z., Nathaniel, S.P., Shahbaz, M., 2021a. The criticality of information and communication technology and human capital in environmental sustainability: Evidence from Latin American and Caribbean countries. *J. Clean. Prod.* 286, 125529. <https://doi.org/10.1016/j.jclepro.2020.125529>.

- Ahmed, Z., Wang, Z., 2019. Investigating the impact of human capital on the ecological footprint in India: An empirical analysis. *Environ. Sci. Pollut. Res.* 26 (26), 26782–26796. <https://doi.org/10.1007/s11356-019-05911-7>.
- Ahmed, Z., Zhang, B., Cary, M., 2021b. Linking economic globalization, economic growth, financial development, and ecological footprint: Evidence from symmetric and asymmetric ARDL. *Ecol. Indic.* 121, 107060. <https://doi.org/10.1016/j.ecolind.2020.107060>.
- Al-Mulali, U., Weng-Wai, C., Sheau-Ting, L., Mohammed, A.H., 2015. 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>.
- Alvarado, R., Deng, Q., Tillaguango, B., Méndez, P., Bravo, D., Chamba, J., Alvarado-Lopez, M., Ahmad, M., 2021. Do economic development and human capital decrease non-renewable energy consumption? Evidence for OECD countries. *Energy* 215, 119147. <https://doi.org/10.1016/j.energy.2020.119147>.
- Anwar, A., Sinha, A., Sharif, A., Siddique, M., Irshad, S., Anwar, W., Malik, S., 2021. The nexus between urbanization, renewable energy consumption, financial development, and CO2 emissions: evidence from selected Asian countries. *Environ. Dev. Sustain.* 1–21. <https://doi.org/10.1007/s10668-021-01716-2>.
- Balaguer, J., Cantavella, M., 2018. The role of education in the Environmental Kuznets Curve. Evidence from Australian data. *Energy Econ.* 70, 289–296. <https://doi.org/10.1016/j.eneco.2018.01.021>.
- Baloch, M.A., Zhang, J., Iqbal, K., Iqbal, Z., 2019. The effect of financial development on ecological footprint in BRI countries: evidence from panel data estimation. *Environ. Sci. Pollut. Res.* 26 (6), 6199–6208. <https://doi.org/10.1007/s11356-018-3992-9>.
- Bhattacharya, M., Awaworyi Churchill, S., Paramati, S.R., 2017. The dynamic impact of renewable energy and institutions on economic output and CO2 emissions across regions. *Renew. Energy* 111, 157–167. <https://doi.org/10.1016/j.renene.2017.03.102>.
- Bilgili, F., Ulucak, R., Koçak, E., İlkay, S.Ç., 2020. Does globalization matter for environmental sustainability? Empirical investigation for Turkey by Markov regime switching models. *Environ. Sci. Pollut. Res.* 27 (1), 1087–1100. <https://doi.org/10.1007/s11356-019-06996-w>.
- Boutabba, M.A., 2014. The impact of financial development, income, energy and trade on carbon emissions: Evidence from the Indian economy. *Econ. Model.* 40, 33–41. <https://doi.org/10.1016/j.econmod.2014.03.005>.
- BP, 2020. Statistical Review of World Energy 2020. <https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy/downloads.html>.
- Charfeddine, L., Ben Khediri, K., 2016. Financial development and environmental quality in UAE: Cointegration with structural breaks. *Renew. Sustain. Energy Rev.* <https://doi.org/10.1016/j.rser.2015.07.059>.
- Cheng, Y., Sinha, A., Ghosh, V., Sengupta, T., Luo, H., 2021. Carbon tax and energy innovation at crossroads of carbon neutrality: Designing a sustainable decarbonization policy. *J. Environ. Manage.* 294, 112957. <https://doi.org/10.1016/j.jenvman.2021.112957>.
- Chudik, A., Pesaran, M.H., 2015. Common correlated effects estimation of heterogeneous dynamic panel data models with weakly exogenous regressors. *J. Econom.* 188 (2), 393–420. <https://doi.org/10.1016/j.jeconom.2015.03.007>.
- Danish, Hassan, S.T., Baloch, M.A., Mahmood, N., Zhang, JianWu, 2019. Linking economic growth and ecological footprint through human capital and biocapacity. *Sustain. Cities Soc.* 47, 101516. <https://doi.org/10.1016/j.scs.2019.101516>.
- Danish, Ulucak, R., 2020. The pathway toward pollution mitigation: Does institutional quality make a difference? *Bus. Strateg. Environ.* 29 (8), 3571–3583. <https://doi.org/10.1002/bse.v29.8.1002/bse.2597>.
- Dasgupta, S., De Cian, E., 2018. The influence of institutions, governance, and public opinion on the environment: Synthesized findings from applied econometrics studies. *Energy Res. Soc. Sci.* 43, 77–95. <https://doi.org/10.1016/j.erss.2018.05.023>.
- Destek, M.A., Sarkodie, S.A., 2019. Investigation of environmental Kuznets curve for ecological footprint: The role of energy and financial development. *Sci. Total Environ.* 650, 2483–2489. <https://doi.org/10.1016/j.scitotenv.2018.10.017>.
- Destek, M.A., Sinha, A., 2020. Renewable, non-renewable energy consumption, economic growth, trade openness and ecological footprint: Evidence from organisation for economic Co-operation and development countries. *J. Clean. Prod.* 242, 118537. <https://doi.org/10.1016/j.jclepro.2019.118537>.
- Dogan, E., Seker, F., 2016. The influence of real output, renewable and non-renewable energy, trade and financial development on carbon emissions in the top renewable energy countries. *Renew. Sustain. Energy Rev.* <https://doi.org/10.1016/j.rser.2016.02.006>.
- Dogan, E., Taspinar, N., Gokmenoglu, K.K., 2019. Determinants of ecological footprint in MINT countries. *Energy Environ.* 30 (6), 1065–1086. <https://doi.org/10.1177/0958305X19834279>.
- Dumitrescu, E.-I., Hurlin, C., 2012. Testing for Granger non-causality in heterogeneous panels. *Econ. Model.* 29 (4), 1450–1460. <https://doi.org/10.1016/j.econmod.2012.02.014>.
- GFN, 2020. GFN, Global Footprint Network. http://data.footprintnetwork.org/?_ga=2.119469760.875854760.1592913814-1106911989.1586515594#/.
- Eberhardt, M., 2012. Estimating panel time-series models with heterogeneous slopes. *Stata J.* 12 (1), 61–71. <https://doi.org/10.1177/1536867X1201200105>.
- Hashem Pesaran, M., Yamagata, T., Pesaran, M.H., Yamagata, T., 2008. Testing slope homogeneity in large panels. *J. Econom.* 142, 50–93. <https://doi.org/10.1016/j.jeconom.2007.05.010>.
- Hassan, S.T., Danish, Khan, S.-D., Xia, E., Fatima, H., 2020. Role of institutions in correcting environmental pollution: An empirical investigation. *Sustain. Cities Soc.* 53, 101901. <https://doi.org/10.1016/j.scs.2019.101901>.
- Hatemi-J, A., Shamsuddin, M., 2016. The causal interaction between financial development and human development in Bangladesh. *Appl Econ Lett.* 23 (14), 995–998. <https://doi.org/10.1080/13504851.2015.1128066>.
- Jalil, A., Feridun, M., 2011. The impact of growth, energy and financial development on the environment in China: A cointegration analysis. *Energy Econ.* 33 (2), 284–291. <https://doi.org/10.1016/j.eneco.2010.10.003>.
- Javid, M., Sharif, F., 2016. Environmental Kuznets curve and financial development in Pakistan. *Renew. Sustain. Energy Rev.* 54, 406–414. <https://doi.org/10.1016/j.rser.2015.10.019>.
- Khan, I., Hou, F., 2021a. Does multilateral environmental diplomacy improve environmental quality? The case of the United States. *Environ. Sci. Pollut. Res.* 28 (18), 23310–23322. <https://doi.org/10.1007/s11356-020-12005-2>.
- Khan, I., Hou, F., 2021b. The Impact of Socio-economic and Environmental Sustainability on CO2 Emissions: A Novel Framework for Thirty IEA Countries. *Soc. Indic. Res.* 155 (3), 1045–1076. <https://doi.org/10.1007/s11205-021-02629-3>.
- Khan, I., Hou, F., 2021c. The dynamic links among energy consumption, tourism growth, and the ecological footprint: the role of environmental quality in 38 IEA countries. *Environ. Sci. Pollut. Res.* 28 (5), 5049–5062. <https://doi.org/10.1007/s11356-020-10861-6>.
- Khan, I., Hou, F., Irfan, M., Zakari, A., Le, H.P., 2021a. Does energy trilemma a driver of economic growth? The roles of energy use, population growth, and financial development. *Renew. Sustain. Energy Rev.* 146, 111157.
- Khan, I., Hou, F., Le, H.P., 2021b. The impact of natural resources, energy consumption, and population growth on environmental quality: Fresh evidence from the United States of America. *Sci. Total Environ.* 754, 142222. <https://doi.org/10.1016/j.scitotenv.2020.142222>.
- Khan, I., Hou, F., Le, H.P., Ali, S.A., 2021c. Do natural resources, urbanization, and value-adding manufacturing affect environmental quality? Evidence from the top ten manufacturing countries. *Resour. Policy* 72, 102109.
- Nasir, M.A., Canh, N.P., Lan Le, T.N., 2021. Environmental degradation & role of financialisation, economic development, industrialisation and trade liberalisation. *J. Environ. Manage.* 277, 111471. <https://doi.org/10.1016/j.jenvman.2020.111471>.
- Nasreen, S., Anwar, S., Ozturk, I., 2017. Financial stability, energy consumption and environmental quality: Evidence from South Asian economies. *Renew. Sustain. Energy Rev.* <https://doi.org/10.1016/j.rser.2016.09.021>.
- Nathaniel, S.P., Yalçın, K., Bekun, F.V., 2021. Assessing the environmental sustainability corridor: Linking natural resources, renewable energy, human capital, and ecological footprint in BRICS. *Resour. Policy* 70, 101924. <https://doi.org/10.1016/j.resourpol.2020.101924>.
- Ozcan, B., Apergis, N., Shahbaz, M., 2018. A revisit of the environmental Kuznets curve hypothesis for Turkey: new evidence from bootstrap rolling window causality. *Environ. Sci. Pollut. Res.* 25 (32), 32381–32394. <https://doi.org/10.1007/s11356-018-3165-x>.
- Ozturk, I., Acaravci, A., 2013. The long-run and causal analysis of energy, growth, openness and financial development on carbon emissions in Turkey. *Energy Econ.* 36, 262–267. <https://doi.org/10.1016/j.eneco.2012.08.025>.
- Pata, U.K., Aydin, M., Haouas, I., 2021. Are natural resources abundance and human development a solution for environmental pressure? Evidence from top ten countries with the largest ecological footprint. *Resour. Policy* 70, 101923. <https://doi.org/10.1016/j.resourpol.2020.101923>.
- Pata, U.K., Caglar, A.E., 2021. Investigating the EKC hypothesis with renewable energy consumption, human capital, globalization and trade openness for China: Evidence from augmented ARDL approach with a structural break. *Energy* 216, 119220. <https://doi.org/10.1016/j.energy.2020.119220>.
- Pesaran, M.H., 2007. A simple panel unit root test in the presence of cross-section dependence. *J. Appl. Econom.* 22 (2), 265–312. [https://doi.org/10.1002/\(ISSN\)1099-125510.1002/jae.v22:210.1002/jae.951](https://doi.org/10.1002/(ISSN)1099-125510.1002/jae.v22:210.1002/jae.951).
- Rizk, R., Slimane, M.B., 2018. Modelling the relationship between poverty, environment, and institutions: a panel data study. *Environ. Sci. Pollut. Res.* 25 (31), 31459–31473. <https://doi.org/10.1007/s11356-018-3051-6>.
- Salahuddin, M., Alam, K., 2015. Internet usage, electricity consumption and economic growth in Australia: A time series evidence. *Telemat. Inform.* <https://doi.org/10.1016/j.tele.2015.04.011>.
- Sarkodie, S.A., Adams, S., 2018. Renewable energy, nuclear energy, and environmental pollution: Accounting for political institutional quality in South Africa. *Sci. Total Environ.* 643, 1590–1601. <https://doi.org/10.1016/j.scitotenv.2018.06.320>.
- Saud, S., Chen, S., Danish, Haseeb, A., 2019. Impact of financial development and economic growth on environmental quality: an empirical analysis from Belt and Road Initiative (BRI) countries. *Environ. Sci. Pollut. Res.* 26, 2253–2269. <https://doi.org/10.1007/s11356-018-3688-1>.
- Saud, S., Chen, S., Haseeb, A., Sumayya, 2020. The role of financial development and globalization in the environment: Accounting ecological footprint indicators for selected one-belt-one-road initiative countries. *J. Clean. Prod.* 250, 119518. <https://doi.org/10.1016/j.jclepro.2019.119518>.
- Shahbaz, M., Nasir, M.A., Roubaud, D., 2018. Environmental degradation in France: The effects of FDI, financial development, and energy innovations. *Energy Econ.* 74, 843–857. <https://doi.org/10.1016/j.eneco.2018.07.020>.
- Shahbaz, M., Shahzad, S.J.H., Ahmad, N., Alam, S., 2016. Financial development and environmental quality: The way forward. *Energy Policy* 98, 353–364. <https://doi.org/10.1016/j.enpol.2016.09.002>.

- Shahbaz, M., Sharma, R., Sinha, A., Jiao, Z., 2021. Analyzing nonlinear impact of economic growth drivers on CO2 emissions: Designing an SDG framework for India. *Energy Policy* 148, 111965. <https://doi.org/10.1016/j.enpol.2020.111965>.
- Shahbaz, M., Sinha, A., 2019. Environmental Kuznets curve for CO2 emissions: a literature survey. *J. Econ. Stud.* 46 (1), 106–168. <https://doi.org/10.1108/JES-09-2017-0249>.
- Shahbaz, M., Sinha, A., Raghutla, C., Vo, X.V., 2021. Decomposing Scale and Technique Effects of Financial Development and Foreign Direct Investment on Renewable Energy Consumption. *Energy* 238, 121758. <https://doi.org/10.1016/j.energy.2021.121758>.
- Sharif, A., Baris-Tuzemen, O., Uzuner, G., Ozturk, I., Sinha, A., 2020. Revisiting the role of renewable and non-renewable energy consumption on Turkey's ecological footprint: Evidence from Quantile ARDL approach. *Sustain. Cities Soc.* 57, 102138. <https://doi.org/10.1016/j.scs.2020.102138>.
- Sharif, A., Saha, S., Campbell, N., Sinha, A., Ibrahim, D.M., 2020. Tourism, environment and energy: an analysis for China. *Curr. Issues Tour.* 23 (23), 2930–2949. <https://doi.org/10.1080/13683500.2019.1703913>.
- Sharma, R., Sinha, A., Kautish, P., 2020. Examining the impacts of economic and demographic aspects on the ecological footprint in South and Southeast Asian countries. *Environ. Sci. Pollut. Res.* 27 (29), 36970–36982. <https://doi.org/10.1007/s11356-020-09659-3>.
- Sharma, R., Sinha, A., Kautish, P., 2021a. Does financial development reinforce environmental footprints? Evidence from emerging Asian countries. *Environ. Sci. Pollut. Res.* 28 (8), 9067–9083. <https://doi.org/10.1007/s11356-020-11295-w>.
- Sharma, Rajesh, Sinha, Avik, Kautish, Pradeep, 2021b. Does renewable energy consumption reduce ecological footprint? Evidence from eight developing countries of Asia. *J. Clean. Prod.* 285, 124867. <https://doi.org/10.1016/j.jclepro.2020.124867>.
- Sinha, A., Sen, S., 2016. Atmospheric consequences of trade and human development: A case of BRIC countries. *Atmos. Pollut. Res.* 7 (6), 980–989. <https://doi.org/10.1016/j.apr.2016.06.003>.
- Sinha, A., Mishra, S., Sharif, A., Yarovaya, L., 2021. Does green financing help to improve environmental & social responsibility? Designing SDG framework through advanced quantile modelling. *J. Environ. Manage.* 292, 112751. <https://doi.org/10.1016/j.jenvman.2021.112751>.
- Svirydzhenka, K., 2016. Introducing a New Broad-based Index of Financial Development. *IMF Work. Pap.* 16, 1. <https://doi.org/10.5089/9781513583709.001>.
- Tamazian, A., Bhaskara, R.B., 2010. Do economic, financial and institutional developments matter for environmental degradation? Evidence from transitional economies. *Energy Econ.* 32 (1), 137–145. <https://doi.org/10.1016/j.eneco.2009.04.004>.
- Tamazian, A., Chousa, J.P., Vadlamannati, K.C., 2009. Does higher economic and financial development lead to environmental degradation: Evidence from BRIC countries. *Energy Policy* 37 (1), 246–253. <https://doi.org/10.1016/j.enpol.2008.08.025>.
- Tawiah, V.K., Zakari, A., Khan, I., 2021. The environmental footprint of China-Africa engagement: An analysis of the effect of China – Africa partnership on carbon emissions. *Sci. Total Environ.* 756, 143603.
- Ulucak, Z.S., İlkay, S.Ç., Özcan, B., Gedikli, A., 2020. Financial globalization and environmental degradation nexus: Evidence from emerging economies. *Resour. Policy* 67, 101698. <https://doi.org/10.1016/j.resourpol.2020.101698>.
- Wang, J., Dong, K., 2019. What drives environmental degradation? Evidence from 14 Sub-Saharan African countries. *Sci. Total Environ.* 656, 165–173. <https://doi.org/10.1016/j.scitotenv.2018.11.354>.
- Yamineva, Y., Liu, Z., 2019. Cleaning the air, protecting the climate: Policy, legal and institutional nexus to reduce black carbon emissions in China. *Environ. Sci. Policy* 95, 1–10. <https://doi.org/10.1016/j.envsci.2019.01.016>.
- Zafar, M.W., Zaidi, S.A.H., Khan, N.R., Mirza, F.M., Hou, F., Kirmani, S.A.A., 2019. The impact of natural resources, human capital, and foreign direct investment on the ecological footprint: The case of the United States. *Resour. Policy* 63, 101428. <https://doi.org/10.1016/j.resourpol.2019.101428>.
- Zafar, M.W., Sinha, A., Ahmed, Z., Qin, Q., Zaidi, S.A.H., 2021. Effects of biomass energy consumption on environmental quality: the role of education and technology in Asia-Pacific Economic Cooperation countries. *Renew. Sust. Energy Rev.* 142, 110868. <https://doi.org/10.1016/j.rser.2021.110868>.
- Zhang, L., Godil, D.I., Bibi, M., Khan, M.K., Sarwat, S., Anser, M.K., 2021. Caring for the Environment: How Human Capital, Natural Resources, and Economic Growth interact with Environmental degradation in Pakistan? A Dynamic ARDL Approach. *Sci. Total Environ.* 774, 145553. <https://doi.org/10.1016/j.scitotenv.2021.145553>.