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**Does financial development reinforce environmental footprints? Evidence from emerging Asian countries**

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# **Does financial development reinforce environmental footprints? Evidence from emerging Asian countries**

## **Abstract**

In the preceding two decades, the expansion of financial services has played a vital role in pursuing economic growth agendas in the developing Asian nations. However, its harmful effect on environmental quality cannot be denied. In this backdrop, in the present study, we investigated whether the financial sector development moderated the ecological footprint, carbon footprint, and land footprint in the eight developing nations of South and Southeast Asia from 1990-2015. In doing so, we included the per capita income, energy solutions, and trade expansions as determinants of the ecological indicators. The results of the second-generation unit root tests and Westerlund's cointegration test reported the long-run stability and cointegration, respectively. To navigate the possible cross-country dependency, we employed the cross-sectional augmented autoregressive distributed lag approach (CS-ARDL). The results confirmed that per capita income, energy solutions, trade expansion, and financial sector development invigorated the ecological footprint, carbon footprint, and land footprint in the long run. Further, it is reported that the development in the financial sector has a significant moderating impact on the nexus between energy and environmental footprints. In other words, the financial sector development drove the association between the overall environmental quality and energy solutions in the long run. Similarly, we observed that the financial sector development worked as a significant mediator between environmental proxies and trade expansion. By including the ecological footprint, carbon footprint, and land footprint as environmental proxies, the study provides the wider environmental spectrum. Based on the outcomes of the study, we proposed a novel scheme, which may help to address the harmful environmental impacts of the financial sector development in the selected developing nations.

**Keywords:** Ecological footprint; carbon footprint; land footprint, South Asian countries; Southeast Asian countries; per capita income, energy.

**JEL Classification:** Q56, C31, D12, O13

# Does financial development reinforce environmental footprints? Evidence from emerging Asian countries

## 1. Introduction

The literature suggests that the liberal trade policies (Shahbaz et al. 2013) and financial sector development (Sharma and Kautish, 2020) have strengthened the economic growth process in the developing countries of South and Southeast. In support of this notion, the OECD (2018), in its report ascertained that the emerging Southeast Asian economies have witnessed an annual per capita growth of 7.1% during 2012-2016; and in the coming five years, it is expected to grow at an annual rate of 6.3%. Similarly, the IMF (2017) in its report mentioned that the South Asian countries have recorded a GDP growth of 6.7%, whereas the overall economic growth of the world was merely 3.2% in the same year. Due to the profound population base and growing convergence between local and international markets, the high GDP growth is expected to be continued in both regions (OECD, 2019). In this pursuit, the expansion of financial markets and the availability of cheap factor inputs have made emerging economies more attractive to foreign investors (IMF, 2003). At the same time, liberal trade policies have facilitated the free movements of factor inputs such as labor, energy, technology, and financial resources across countries (Yeo and Deng, 2019). As a result, the demand for imported-energy resources has continuously increased in most of the developing countries of South and Southeast Asia. Despite having scarcity of domestic energy resources, the persistent increase in the demand for oil, coal, and natural gases indicates that these regions are involved in uplifting their domestic production. As per the report of IEA (2019), in comparison to the year 2000, the demand for energy in Southeast Asian countries has increased by 80%. Furthermore, compared to the global energy demand, the average energy demand in South Asia is expected to be doubled in the coming years; which in turn may lead to an increase in the demand for fossil fuel by 6% (Hou et al., 2019). In the exchange process of productive resources, the expansion of financial instruments and services has facilitated the cointegration in the local and international markets, which in turn, has allowed the excessive consumption of imported energy resources (UNCTAD, 2018).

These developments, undeniably, are necessary for the economic growth of an economy. However, more than 90% usage of nonrenewable energy resources to meet the commercial energy demand in the South (Rahman et al., 2011) and Southeast Asian countries (Munir et al., 2020) discloses the actual success story of the economic growth, as these nations are net buyers of fossil fuel. Furthermore, the excessive dependency on fossil fuel and external energy resources may have seriously harmful environmental consequences in the long run. The incessant consumption of nonrenewable solutions may soon deplete the available energy reserves, which in turn, may increase the dependency on the other countries. At the same time, the combustion of nonrenewable energy solutions may continue to intensify environmental pollution, which in turn, may reduce the net benefits of economic growth. Therefore, these regions may likely witness the *Limits to Growth* phenomenon and the economic growth process may be impeded by the scarcity of natural resources (Meadow et al., 1974). The ongoing pollution havoc appears to be the result of the casual approach towards environmental aspects in these regions. This is evident from the fact that the largest numbers of most polluted cities in the

world are situated in the South (The Economics Times, 2019) and Southeast Asian countries (The Jakarta Post, 2019). Henceforth, to navigate the economic growth led to environmental challenges; the South and Southeast Asian countries have to reengineer their future strategy where endogenous renewable energy resources can work as a catalyst to sustainable economic growth.

In this regard, the sustainable development goals like climate action (SDG-13), affordable & clean energy (SDG-7), and responsible consumption & production (SDG-11) are supportive in framing the sustainable growth strategy for both developed and developing nations. In the case of developing countries, a sustainable growth approach becomes even more necessary, as the long-term growth strategies in the developing regions are generally woven around the agriculture or allied industries where the possibility of environmental damages are more pronounced (Todaro and Smith, 2017). Thus, these regions seriously need to promote environmentally viable endogenous energy resources. At the same time, the production processes and other necessary economic sectors such as the financial markets and international trade need to be aligned with the SDGs. Once the key sectors are mandated to follow the sustainability approach, the other associated sectors may automatically be aligned in the same direction; because the inherent interdependency among these sectors may bring forth a common approach of environmental consciousness. Therefore, to develop a sustainable growth framework, it requires investigating the long-run association between these variables.

Prompted from the above discussion, we intended to establish our study's objectives where three distinct representations for the environmental qualities are being considered. Our first objective is to assess the impacts of per capita income, energy consumption, financial development, and trade expansion on the ecological footprint in the emerging economies of South (India, Pakistan, Sri Lanka, Nepal, and Bangladesh) and Southeast Asia (Malaysia, Philippines, and Thailand) from 1990 to 2015. Thereafter, to get a better understanding of the air quality and land quality, we investigated the impacts of these variables on the carbon footprint and land footprint, respectively. Lastly, we investigated whether the financial sector development has reinforced the environmental footprints through energy consumption and trade expansion. Because, the development in the financial sector may tend to invigorate the trade expansion and energy consumption, which in turn, may lead to the ecological footprint. In doing so, we investigated whether the association between energy consumption and environmental proxies (i.e. ecological, carbon, and land footprint) is influenced by the financial sector development. Similarly, we searched whether the association between trade expansion and environmental proxies is invigorated by the financial sector development. Here, by using the multiplicative interaction, we followed the conditional hypothesis procedure. By doing so, we reported the moderating effect of the financial sector development on the nexus between environmental indicators and energy consumption and environmental indicators and trade expansion. To simplify it, we examined the direct effects of the per capita income, trade expansion, and energy solutions on the various environmental footprints. Secondly, we investigated whether the development of the financial market worked as a significant mediator between environmental footprints and energy solutions, and environmental footprints, and trade expansion.

Rationality in doing so lays with the fact that besides GDP growth, these factors have also witnessed an upward trend and appear to be complementary to economic growth. By using the ecological footprint, carbon footprint, and land footprint as proxies for the environmental quality, we intended to generate a wider environmental spectrum; as a single environmental proxy may not be sufficient to scale the overall environment-related damages. Moreover, the included drivers of environmental pollution may have differentiated impacts on ecological footprint, carbon footprint, and land footprint. Thus, in terms of policy formulation, this kind of understanding may become vital and governments can put more effort to improve the quality of worst-hit indicators. Owing to the scarcity of environment-related budgets, such kinds of tradeoffs are essential to managing the available financial resources. The data unavailability forced us to exclude some of the countries in the present study. The selection of the countries and study period appears just as the pooling of high GDP growth registering Asian countries in terms of ecological footprint, carbon footprint, and land footprint has not been addressed in the past.

Our findings manifest that the ongoing production processes, financial developments, and trade expansions have intensified the ecological footprint, carbon footprint, and land footprint in the long run. Except for the land footprint, the other two footprints (i.e., ecological and carbon) have been damaged by the usage of energy resources in the eight developing economies of South and Southeast Asia. We also confirmed that the interaction of the financial sector with energy consumption and trade expansion has reinforced the environmental pollution in the long run. Based on the outcomes, we tried to develop an appropriate and sustainable long-term growth strategy where solutions to achieve the SDG-11, SDG-13, and SDG-7 are intended.

The study contributes to the literature in many ways; firstly, a parallel analysis of the ecological footprint, carbon footprint, and land footprint enables us to comprehend whether a common environmental policy will be sufficient to fortify the overall quality of the established ecosystem in these regions. Secondly, the study proposes the need for low pollution-intense techniques and energy resources where the role of the financial sector and trade policy is judicially established. Thirdly, we observed that the financial sector development could damage the environmental quality not only directly but also indirectly. Lastly, in terms of methodology or econometric techniques, we have adopted a relatively new and robust approach. The adopted augmented cross-sectional distributed lag (CS-DL) approach is advantageous than traditional approaches, as it is efficient in handling the cross-sectional dependency which is a common problem in the pooled data. Due to the distinct features of the financial sector growth in the selected countries, a single proxy for the financial sector growth was not sufficient. Therefore, by using the principal component method, we constructed an index for it where four different proxies for the financial sector growth are used.

The second section allows us to understand the existing state of the literature; thereafter, the third section is dedicated to the research methodology. In the end, the fourth and fifth sections are exhibiting the calculated results and conclusions & policy framework, respectively.

## **2. The literature survey**

As we know, economic activities tend to influence the environmental quality of a region. However, certain activities may be more harmful in terms of air pollution, whereas others may have a severe impact on the land or water quality. Therefore, the examination of merely one environmental aspect is not sufficient. Saying this, the selection of the right proxy for depicting the environmental quality of a region is the most important aspect. In this regard, environmental proxies such as CO<sub>2</sub> emission, NO<sub>2</sub> emissions, and ecological footprint are often been tested in the past. However, to widen the scope for the literature examination, we have thrown light on those studies where not only CO<sub>2</sub> emissions but also other environmental proxies are being considered. To keep the literature examination systematic, we have divided it into sub-parts where the association of different environmental proxies with domestic production, energy consumption, financial sector development, and trade expansion has been examined.

#### *Nexus between economic growth and environmental quality*

The association between economic growth and environmental quality is not at the standstill. Starting from Kuznets (1955) to date, it is well established that their association may vary across times and regions. When an underdeveloped country starts expanding its economic growth horizons, the investment in growth-oriented programs may overtake the investment in environment and scale-effect may get operative; as a result, the quality of the environment may get worsened. However, in the second stage of development, the consistently growing income level allows industries to invest in advanced and energy-efficient techniques of production, which in turn may reduce the marginal pollution level significantly (Hettige et al., 2000). About the second stage, Shahbaz et al. (2019) in his study confirmed that the operation of the second stage (i.e., the composite-effect) has intensified the growth of strategic importance industries in the Middle East and North African countries, which has a positive impact on the per capita income level and environmental quality in the long run. In the third stage, once again, the applicability of the technology-effect may significantly lead to environmental distortion. Here, the over-utilization of the obsolete production techniques operated with the carbon-intense energy resources may lead to an increase in marginal pollution (Álvarez et al., 2017).

In the majority of studies, the nonlinear impact of per capita income is tested through CO<sub>2</sub> (Iwata et al., 2012; Mazur et al., 2015) or SO<sub>2</sub> (Llorca and Meunié, 2009; Fosten et al., 2012) emissions, whereas other proxies for the environment quality such as ecological footprint and land footprint are ignored. This shows that the positive impacts of the increasing per capita income on the ecological or land footprint are yet to witness, which is a matter of concern for the policymakers. As merely improving the air quality through development programs is not sufficient. The preservation of the overall biodiversity should be aimed through economic and environmental policies. However, by taking a sample of 93 countries, Al-mulali (2015) in their study confirmed an inverse U-shaped association between the ecological footprint and domestic production. The timely introductions of energy-saving and low-carbon intense energy resources are observed as responsible factors to reduce the ecological footprint in these countries. Similarly, the outcomes of Ulucak and Bilgili's (2018) study established an inverted U-shaped association between per capita income and ecological footprint among high, middle, and low-income countries that are considered for examination.

In contrast, some of the study unable to find out the inverted U-shaped association while considering the ecological footprint as a variable to be explained, which indicates that all regions are not able to reap the economic growth led ecological improvements. For example, by taking the sample of 27 highest pollution emitter nations, Uddin et al. (2017) in their study revealed that the selected countries have witnessed a significant increase in ecological footprint caused by the increased per capita income during the study period (1991-2012). Therefore, the study recommended inculcating the healthy lifestyle and production processes to reduce the negative impacts of consumption and production, respectively. Similarly, Alola et al. (2019) in their study confirmed that the increase in per capita income in European countries has increased the level of the ecological footprint in the long run. The rejection or ignorance of the U-shaped EKC in both studies indicates that until now some of the countries or regions have not achieved the development stage where economic growth enabled to reduce the ecological footprint. To comprehend the impact of technological innovation on environmental quality, Sinha et al (2020) in their study developed an environmental index where four different gases are used to exhibit the environmental quality in the MENA countries. This approach allowed assessing whether technological advancement has significantly led to an increase in greenhouse gas emissions (i.e., CO<sub>2</sub>, NO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O) in the long run. Instead of segregation, they have developed a composite index where the principal component method is used. Considering the need for a comprehensive examination of the environmental quality, Bello et al. (2018) in their study analyzed the impact of per capita income on carbon, water, and ecological footprint by using the time series (1971-2016) data for Malaysia. The study confirmed that the per capita income increase has a significant impact on the ecological footprint, whereas the impact of the squared term is found insignificant. Therefore, it can be contemplated that the increased per capita income is unable to reduce the ecological footprint in the long run. However, in terms of the carbon footprint, the study established an inverse U-shaped EKC. Based on the results, we can assert that the increased per capita income may have different impacts on the various environmental indicators. Therefore, in the present study, we established the three different environmental functions where ecological footprint, carbon footprint, and land footprint are examined through a panel data set.

#### *Nexus between energy consumption and environmental pollution*

Besides supplementing the economic growth, the excessive dependency on nonrenewable energy resources has imposed certain economic and environmental challenges. As far as the economic challenges are concerned, net energy-importer countries have to spend a gigantic amount on the procurement of energy resources. And, in terms of environment-related challenges, the excessive consumption of fossil fuel has intensified the level of environmental pollution in the long run. To support this notion, Shahbaz et al. (2016), Shahbaz et al. (2017), Munir et al. (2020), Sharma and Kautish (2020a), and Ike et al. (2020) in their respective studies ascertained that the increased consumption of energy resources have contributed to increasing CO<sub>2</sub> emissions in the long run. At the same time, the results of Alola et al. (2019), Destek and Sinha (2020), and Sharif et al. (2020) ascertained that the nonrenewable energy consumption has played a significant role in raising the ecological footprint in 16-EU, OECD countries, and Turkey, respectively. Contrarily,



the literature support that the increased consumption of renewable energy resources may help to fortify the environmental quality in the long run (Sharif et al., 2019; Destek et al., 2020).

Here it needs to mention that besides industries, other sectors such as transportation, agriculture & allied industries, financial activities, and household-level energy requirements have also contributed to raising the consumption of nonrenewable energy resources, which in turn might have led to pollution increase across countries (Sharvini et al., 2018). In the given situation, the increased consumption of renewable energy resources may help to reduce imported energy dependency and pollution intensity, which is an urgent need for developing regions like South and Southeast Asia. Studies in the past confirmed that renewable energy can serve as a substitute for nonrenewable energy. Secondly, in comparison to the latter, the negative environmental impacts of renewable energy consumption are less. For mitigating the negative impacts of energy consumption, the SDG-17 underlines the need for clean and affordable energy resources. However, with the existing basket of energy resources, it is doubtful to achieve the goal of sustainable development by 2030. Therefore, it is high time to introduce the mixed energy basket where a combination of both types of energy resources to be introduced to safeguard the planet earth.

#### *Nexus between financial sector development and environmental pollution*

With the economic expansion, the associated growth channels such as energy consumption, market size, demand for inputs, and financial services tend to improve (Ebohon, 1996; Faisal et al., 2016; Sharma et al., 2019). In the developing and open economies, the economic contribution of financial sector development cannot be ignored. By integrating the local and international markets, it facilitates the smooth exchange of goods and services (World Bank, 2012). However, in terms of improving environmental quality, its role can be positive (Gill et al., 2019) or negative (Moghadam and Lotfalipour, 2014) in the long run. Saying this, the results of Sadorsky's (2010) study confirmed that the improvement in financial services has led to an increase in the demand for energy in the developing countries, which in turn, has intensified the level of CO<sub>2</sub> emissions in the long run. Similarly, by taking the panel of Gulf Cooperation Council nations, Bekhet et al. (2017) in their study revealed that the growth of financial sector development has a significant and negative impact on the environmental quality. Contrarily, the outcomes of Riti et al.'s (2017) and Baloch et al.'s (2018) studies revealed that the development of financial markets has fortified the air quality in the sample of 90 countries, and Saudi Arabia, respectively. In contrast to the above, the results of Ozturk and Acaravci's (2013) study denied the role of the financial sector development in altering the environmental quality in Turkey.

Owing to the wide range of proxies for the financial sector development, its representation has remained a debatable topic in past studies. For example, Ang (2008) and Ozturk and Acaravci (2013) used domestic credit to the private sector as a proxy for the financial sector development in China and Turkey, respectively. On the other hand, overall credit by the financial sector (Jenkins and Katircioglu, 2010) and stock market capitalization (Beck et al., 1999) are considered appropriate proxies by other studies. Given the availability of the various proxies, some of the studies have constructed the financial development index where various

possible proxies for financial development are considered (Ang, 2008; Katircioğlu and Taşpınar, 2017).

### *Nexus between trade expansion and environmental pollution*

Economic openness allowed developing countries to procure necessary inputs for economic growth (Zhang and London, 2011). While addressing their growth targets, the developing countries witnessed a sharp increase in the demand for imported technology and energy resources (Shahbaz and Sinha, 2019). However, the increased energy demand, especially nonrenewable energy widened the scope for greenhouse gas emissions. In support of this notion, the outcomes of Shahbaz et al. (2012) and Tiwari et al. (2013) confirmed that trade expansion has led to a significant increase in CO<sub>2</sub> emissions in Pakistan and India, respectively. Similarly, other studies also reported that the trade expansion can be a significant driver of CO<sub>2</sub> emissions (Kanjilal and Ghosh, 2013; Wang et al., 2019; Sharma et al., 2020), ecological footprint (Ghita et al., 2018; Sabir and Gorus, 2019), and carbon footprint (Herrmann and Hauschild, 2009) in the long run. While examining the association between trade expansion and ecological footprint, Sharif et al. (2019) ascertained that the level of ecological footprint changed significantly at the different levels of trade expansion. Interestingly, the results of Dogan and Seker's (2016) study ascertained that trade expansion has fortified the environmental quality in the top ten renewable energy-consuming countries. In support of this, Dogan and Sekar (2016) ascertained that trade expansion has allowed countries to adopt energy-efficient and advanced techniques of production. This technology spillover, in turn, helped these countries to reduce carbon emissions in the long run. Studies of Shahbaz et al. (2013) and Sulaiman et al. (2013) also confirmed the positive impact of trade openness on environmental quality in Indonesia and Malaysia, respectively.

An in-depth examination of the literature suggests that the selected variables can be crucial drivers of CO<sub>2</sub> emissions. However, there is a dearth of studies where the impacts of these drivers on the ecological footprint and land footprint are examined. This research gap motivated us to carry this research where a pool of the developing nations is considered.

### **3. Research approach and data interpretation**

#### *Data definition and sources*

From the close observation of the environmental series, it appears that the economic expansion and its associated channels have contributed to disturbing the established ecosystem in the developing countries. Therefore, by using the annual data series (i.e., 1989-2015), we intended to assess the impact of per capita income, total energy consumption, financial development, and trade expansion on the ecological footprint, carbon footprint, and land footprint where eight developing countries of South and Southeast Asia are being considered for this examination. Except for the ecological footprint, carbon footprint, and land footprints, other annual series are retrieved from the World Bank's data repository. The series related to environmental indicators are collected from the website of the global footprint network. Both GDP (US\$ 2010) and energy (kiloton per capita) series are measured in the per capita forms, whereas trade expansion is the

ratio of the sum of the export and import to GDP. All the environmental footprints are measured into the area to a hectare. The data related to the financial indicators are assessed from the World Bank's repository. After that, to establish the data uniformity, the series are converted into the natural logarithm form.

### *Financial development index*

The assigned role of a financial indicator may depend on the monetary policy of a country; therefore, across countries, a financial indicator may have a different role to play (Ang, 2008). The availability of the various proxies for financial development motivated us to construct the financial development index. By doing so, we reduced the possibility of omitted variable bias and provided a comprehensive representation of the financial sector development, which can be a significant driver of environmental pollution. The broad money supply (MS), an offering by the private sector (PL), domestic offering to the private sector (DL), and government's liquid liabilities (LL) are considered to construct the financial development index (Katircioğlu and Taşpinar, 2017). The liquid liabilities are in percentage of broad money, whereas other indicators are the percentage of GDP. By using the principal component method, equation (1) is used to construct the index:

$$FI = f(MS, PL, DL, LL) \quad (1)$$

Money supply and liquid liabilities are considered important instruments of financial sector development (Beck et al., 1999). However, Levin et al. (2000) ascertained that the credit supply by the private sector development may have a long-lasting impact on an economy. Also, Jenkins and Katircioğlu (2010) earmarked the role of lending to the private sector in a developing economy, as it helps to intensify the fresh investments in the long run. Further, the growing trade through stock markets signifies the need for a developed stock market mechanism in recent years (Sharma and Kautish, 2020). However, while calculating the financial development index in the present study, we ignored its role. As the financial markets are more vulnerable to international fluctuations; and can be put as a drawback of the present study. Based on the variables carried in equation (1), we performed the principal component analysis, which facilitated us to reduce the more familiar variables into reduced unassociated but expressive variables. The varimax rotation procedure of the principal component approach enabled us to generate the financial development index where the above-mentioned variables are duly weighted. Based on the Eigenvalues, we retrieved the cumulative percentage of variations led by the respective principal components. Table (1) revealed that the Eigenvalue of only one variable approved the statistically desired criteria (i.e.,  $3.800 > 1.000$ ), contrarily other Eigenvalues are found less than one (Beck et al., 1999). The first principal component is considered better than others because about 95.100% variation in the dependent variable is explained by it. Thus, to derive the financial development, the first principal component is employed; however, based on the respective factor scores, the weights of the other components are used to develop the final financial development index. Katircioğlu and Taşpinar (2017) in their study also followed the same procedure where 73.622% variation was explained by only one component; and, the values of the other four components were found less than one.

The numerical procedure to develop the index is mentioned in equation (2):

$$FI = \sum_{i=1}^n Wi . IFSi \quad (2)$$

Here, the financial index ( $FI$ ) is constructed by multiplying the weight/load ( $Wi$ ) (i.e., the ratio of changes made by each considered indicator to the total variation made by all indicators) to individual factor scores ( $IFS_i$ ) of each proxy. The procedure to derive the  $Wi$  is mentioned in (3):

$$Wi = \frac{VEi}{\sum_{i=1}^n VEi} \times 100 \quad (3)$$

In equation (3),  $Wi$  and  $VE_i$  are used to represent the weight and explained variance of each component (i), respectively.

**<Insert Table 1 here>**

After constructing the financial index, the ecological footprint, carbon footprint, and land footprint based equations (4), (5), and (6), respectively can be introduced where per capita GDP (PCY), energy (EN), financial index (FI), and trade expansion (TR) are carried as the independent variables.

$$EFOOT_{it} = \beta_0 + \beta_1 PCY_{it} + \beta_2 EN_{it} + \beta_3 FI_{it} + \beta_4 TR_{it} + \mu_{it} \quad (4)$$

$$CFOOT_{it} = \alpha_0 + \alpha_1 PCY_{it} + \alpha_2 EN_{it} + \alpha_3 FI_{it} + \alpha_4 TR_{it} + \mu_{it} \quad (5)$$

$$LFOOT_{it} = \gamma_0 + \gamma_1 PCY_{it} + \gamma_2 EN_{it} + \gamma_3 FI_{it} + \gamma_4 TR_{it} + \mu_{it} \quad (6)$$

Thereafter, for each function, we introduced the moderating effect of financial development because the availability of the financial resources with diversified financial instruments may likely to damage the environmental quality by intensifying the energy consumption and international trade in a free market place.

$$EFOOT_{it} = \beta_0 + \beta_1 PCY_{it} + \beta_2 EN_{it} + \beta_3 FI_{it} + \beta_4 TR_{it} + \beta_5 TR * FI_{it} + \mu_{it} + \varepsilon_{it} \quad (7)$$

$$EFOOT_{it} = \beta_0 + \beta_1 PCY_{it} + \beta_2 EN_{it} + \beta_3 FI_{it} + \beta_4 TR_{it} + \beta_5 EN * FI_{it} + \mu_{it} + \varepsilon_{it} \quad (8)$$

$$CFOOT_{it} = \alpha_0 + \alpha_1 PCY_{it} + \alpha_2 EN_{it} + \alpha_3 FI_{it} + \alpha_4 TR_{it} + \alpha_5 TR * FI_{it} + \mu_{it} + \varepsilon_{it} \quad (9)$$

$$CFOOT_{it} = \alpha_0 + \alpha_1 PCY_{it} + \alpha_2 EN_{it} + \alpha_3 FI_{it} + \alpha_4 TR_{it} + \alpha_5 EN * FI_{it} + \mu_{it} + \varepsilon_{it} \quad (10)$$

$$LFOOT_{it} = \gamma_0 + \gamma_1 PCY_{it} + \gamma_2 EN_{it} + \gamma_3 FI_{it} + \gamma_4 TR_{it} + \gamma_5 TR * FI_{it} + \mu_{it} + \varepsilon_{it} \quad (11)$$

$$LFOOT_{it} = \gamma_0 + \gamma_1 PCY_{it} + \gamma_2 EN_{it} + \gamma_3 FI_{it} + \gamma_4 TR_{it} + \gamma_5 EN * FI_{it} + \mu_{it} + \varepsilon_{it} \quad (12)$$

If we apply the partial differentiation with respect to  $TR_{it}$  (trade expansion) and  $EN_{it}$  (energy consumption) in equations (7) and (8) respectively, the actual impact of  $FI_{it}$  can be calculated through equation (13).

$$\frac{\partial EFOOT_{it}}{\partial TR_{it}} = \beta_4 + \beta_5 * FI_{it} \quad \text{and} \quad \frac{\partial EFOOT_{it}}{\partial EN_{it}} = \beta_2 + \beta_5 * FI_{it} \quad (13)$$

By following the same procedure in other equations, we can estimate the impact of  $FI_{it}$  on the carbon and land footprint. If the coefficients  $\alpha_4 + \alpha_5*FI$ ,  $\alpha_2 + \alpha_5*FI$ ,  $\gamma_4 + \gamma_5*FI$ , and  $\gamma_2 + \gamma_5*FI$  are statistically significant, it will confirm the role of financial development in improving/deteriorating the environmental quality. Stating differently, the long-run marginal effects of  $TR_{it}$  and  $EN_{it}$  on ecological footprint, carbon footprint, and land footprint depend on the financial sector development ( $FI_{it}$ ) if the calculated values are statistically significant. However, in doing so, we need to consider the sign and strength of  $\beta_4$ ,  $\beta_2$ ,  $\alpha_4$ ,  $\alpha_2$ ,  $\gamma_4$ , and  $\gamma_2$  also. These constant values are integral parts of these equations and may change the overall impact in a different direction. Further, the differentiation of equation (13) with respect to  $FI_{it}$  will enable us to get the mediating effect of  $FI_{it}$ , which serves as a mediator between an environmental proxy and independent variables (i.e.,  $TR_{it}$  and  $EN_{it}$ ). This is given in equation (14) hereunder:

$$\frac{\partial^2_{EF_{it}}}{\partial TR_{it} \partial FI_{it}} = \beta_5 \text{ and } \frac{\partial^2_{EF_{it}}}{\partial EN_{it} \partial FI_{it}} = \beta_5 \quad (14)$$

It means, even before interaction, the coefficient  $\beta_5$  was carrying moderating effect; that is, the ecological footprint is influenced by  $FI_{it}$  through  $TR_{it}$  and  $EN_{it}$ . When  $FI_{it}$  is kept constant, the intensity of influence of  $TR_{it}$  and  $EN_{it}$  on the ecological footprint depends on  $\beta_4 + \beta_5$  and  $\beta_2 + \beta_5$ , respectively. The same econometric treatment allows us to extract the moderating impact of  $FI_{it}$  on the carbon and land footprint.

### Data description

The basic attributes of the data series are mentioned in Table 1A (Appendix). Among all the variables, the land footprint reports the maximum deviation, whereas the minimum standard deviation is shown by trade expansion in the panel model. In the case of per capita income, India's per capita income has shown maximum deviation, whereas the per capita income in Bangladesh has reported minimum deviation in the considered countries. Further, the energy consumption in Sri Lanka has observed maximum deviation in the given country list.

### Panel unit root test

The stationarity of the series is a prerequisite to establishing reliable and consistent results. Therefore, we employed the common panel unit root test proposed by Levin et al. (2002) and abbreviated as LLC in the present study. Thereafter, by using the augmented Dickey-Fuller (ADF) test, we established the individual stationarity of the series. The series stability is checked at intercept and intercept & trend; however, to manage the space, the results with the constant are mentioned in Table 2A (Appendix).

Due to the possibility of the inter-country convergence, we cannot rely on the traditional stability tests; because the traditional stationarity tests may give inconsistent results if countries possess interdependency in the long run. To navigate this possible error, we employed the stationarity tests that are efficient in handling cross-sectional dependence and provide reliable results. In Table (2), we reported results of cross-sectional augmented Dickey-Fuller, and cross-sectional augmented Im-Pesaran-Shin tests, which are termed as CADF and CIPS, respectively.

<Insert Table 2 here>

The results of the panel stationarity tests given in Table (2) reveal that all the variables are either stationary at the level or the first difference. In other words, the series are of I(0) or I(1) types. Therefore, we need to adopt an approach where the cointegration of such kind of variables is possible. As mentioned earlier, in the panel data model where variables such as per capita income, energy, financial development, and trade expansion are included, the cross-sectional dependency is likely to emerge because these variables tend to generate international economic shocks (Liu, 2013; Bello et al., 2018). Thus, before proceeding further, it requires to examine whether the variables are really influenced by the cross-border shocks. For doing so, we employed the cross-sectional dependency tests, which may confirm the relevance of the CADF and CIPS procedures in the present study.

*Cross-sectional dependency test*

To address this issue, Pesaran (2004) cross-section unit root test and Pesaran Lagrange multiplier tests are performed. The former is more suitable for a large number of countries and a short study period, whereas the latter is recommended where the numbers of countries are less but the study period is long. Besides Pesaran’s CD and LM tests, we have employed Breusch and Pagan’s (1980) test to confirm the possibility of the cross-sectional dependency. The computational procedure for the cross-sectional dependency is given in equation (15) where the independence of the variables is considered as the null hypothesis provided the size of the population (SP) goes up to infinity and study time (ST) is sufficiently large.

$$CST = \frac{\sqrt{2ST}}{SP(SP-1)} \left( \sum_{i=1}^{SP-1} \sum_{r=l+1}^{SP} p_{ir} \right) \tag{15}$$

A modified form of equation (15) can provide the cross-sectional dependency test result if the study carries the unbalanced data set. However, in this study, the procedure for that is not mentioned because our data set is perfectly balanced. The results related to the above-mentioned cross-sectional dependence tests are shown in Table (3).

**<Insert Table 3 here>**

The results of Table 3 reported the need for an estimation technique that can provide reliable results after considering the cross-sectional dependency because all the mentioned tests have rejected the possibility of cross-sectional independence at the 1% level of significance. In the given situation, the traditional approaches such as the panel-ARDL, FMOLS, and DOLS may provide misleading results.

*Westerlund test for the long-run cointegration*

However, before embarking further, it is required to establish whether the comprised set of variables are cointegrated in the long run. For doing so, we employed the Westerlund (2007) panel cointegration test. The econometric procedure to retrieve the results of this test is mentioned as follows:

$$\Delta z_{i,t} = \phi_i d_t + \delta_i (z_{i,t-1} - \theta y_{i,t-1}) + \sum_{m=1}^{pt} \delta_{i,m} \Delta z_{i,t-m} + \sum_{m=-qt}^{pt} \lambda_{i,m} \Delta y_{i,t-m} + \varepsilon_{i,t} \quad (16)$$

The cross-sectional ( $i = 1, \dots$ ) and time series ( $t = 1, \dots$ ) units are used together. In calculation, the deterministic components like constant and time ( $d_t$ ) and error correction terms parameters ( $\delta_i$ ) are also used. By employing the least square method on equation (16),  $\bar{\varepsilon}_{i,t}$  and  $\bar{\lambda}_{i,t}$  are to be calculated. Thereafter, the variance estimators for Newey-West are to be calculated by using the following equation (16.1).

$$\bar{u}_{i,t} = \sum_{m=-qi}^{pi} \bar{\lambda}_{i,t} \Delta y_{i,t-m} + \bar{\varepsilon}_{i,t} \quad (16.1)$$

These derived values will be used to extract  $\bar{\delta}_i = \frac{\bar{\delta}_{ui}}{\bar{\delta}_{zi}}$ , here  $\bar{\delta}_{ui}$  and  $\bar{\delta}_{zi}$  are variance estimators which are calculated from  $\bar{u}_{i,t}$  and  $\Delta z_{i,t}$ , respectively. Thereafter, by using the standard errors (SE), the group mean estimators Gt ( $\frac{1}{N} \sum_{i=1}^N \frac{\bar{\delta}_i}{SE \bar{\delta}_i}$ ) and Ga ( $(\frac{1}{N} \sum_{i=1}^N \frac{T \bar{\delta}_i}{\bar{\delta}_{i(1)}})$ ) are to be calculated. Similarly, by using the calculated standard errors, the estimators' Pt ( $\frac{\bar{\delta}}{SE \bar{\delta}}$ ) and Pa ( $T \bar{\delta}$ ) are to be calculated, which is based on  $SE(\bar{\delta}) = ((ESE_N^2)^{-1/2} \sum_{i=1}^N \sum_{t=2}^T \overline{\delta_{i,t-1}^2})^{-1/2}$ . The calculation procedure for  $ESE_N^2$  is  $\frac{1}{N} \sum_{i=1}^N \frac{\bar{\delta}_i}{\bar{\delta}_{i(1)}}$ , here  $\bar{\delta}_i$  are standard errors and calculated from equation (16). The results of this test are given in Table (4).

**<Insert Table 4 here>**

Table 4 results confirm the long-run cointegration for the selected functions. The usage of the bootstrap procedure provided a strong association among comprised variables after considering the possible cross-sectional dependency because test values in each model are statistically significant. Thereby, it can be contemplated that the selected drivers of ecological footprint, carbon footprint, and land footprint are worth examining for driving the common policy framework.

#### *The cross-sectional distributed lag estimation*

Chudik et al. (2015) introduced the CS-DL and CS-ARDL approaches to navigate the problem of cross-sectional dependency in the panel data because the inter-country economic, political, and social convergence may generate the interdependency among countries. Without addressing the inter-country dependency, the estimated results may provide misleading outcomes. Therefore, in the present study, we employed the former approach, as it has certain advantages over the latter. Firstly, the CS-DL approach is more efficient than CS-ARDL because the former may provide efficient results even with small samples and a moderate time period (Anderson and Raissi, 2018). The CS-DAL approach uses the truncated lag order; therefore, it is less sensitive to the lag selection than the CS-ARDL approach. In the CS-ARDL, the inefficiency of the lag may generate small sample errors. Another advantage of the CS-DL approach is that it reduces the

possibility of the serial correlation significantly and navigates the possibility of the structural break in the time series.

For deriving the CS-DL equation, initially, we need to introduce the basic ARDL approach through equations. Equation (17) is based on the panel ARDL approach where  $\varepsilon_{i,t} = \alpha_i c_{i,t} + \mu_i$ .

$$w_{i,t} = \sum_{l=1}^p \delta_{i,l} z_{i,t-1} + \sum_{l=0}^q \xi_{i,l} v_{i,t-1} + \varepsilon_{i,t} \quad (17)$$

In equation (17), the unobserved vectors of common factors, factor loading, countries, time, dependent, and independent variables are denoted by  $c_{i,t}$ ,  $\alpha_i$ ,  $i$ ,  $t$ ,  $w_i$ , and  $v_i$ , respectively. Further, by assuming the absence of serial correlation,  $p$  and  $q$  are used as the lag orders of the dependent and independent variables, respectively.

Further, based on the values of  $\delta_i$ , and  $\xi_{i,l}$  (i.e., the short-run coefficients), we derive the long-run coefficients, which is mention in equation (17.1).

$$\theta_i = \frac{\sum_{l=0}^r \xi_{i,l}}{1 - \sum_{l=1}^s \delta_{i,l}} \quad (17.1)$$

In the case of the CS-DL estimation, the long run coefficients can be calculated directly because this approach concentrates only on the long run relationship. This can be considered a weakness of this approach. For calculating the long run coefficients, equation (17) is to be written as follows:

$$w_{i,t} = \theta_i v_{i,t} + \alpha_i L \Delta v_{i,t} + \acute{\varepsilon}_{i,t} \quad (17.2)$$

In equation (17.2),  $\acute{\varepsilon}_{i,t} = \delta(ED)^{-1} \varepsilon_{i,t}$  and  $\delta_i(ED) = 1 - \sum_{l=1}^p \delta_{i,l} ED^l$ , similarly,  $\theta_i = \gamma(1)$ , and  $\gamma_i(ED) = \delta_i^{-1}(ED) \xi_i(ED) = \sum_{l=0}^{\infty} \gamma_{i,l} ED^l$ ,  $\xi_i(ED) = \sum_{l=0}^q \xi_{i,l} ED^l$ , and  $\alpha_i(ED) = \sum_{l=0}^{\infty} \sum_{r=l+1}^{\infty} \gamma_{i,r} ED^l$ .

To calculate  $\theta_i$ ,  $w_{i,t}$  needs to be regressed on  $v_{i,t}$ , and  $(v_{i,t})_{l=0}^p$ . Here, the lag orders of the dependent variable are chosen after truncation, which depends on the increasing sample size. Further, to calculate the efficient  $\theta_i$ , the coefficient of  $\gamma_i(ED)$  needs to be decreased exponentially. In the CS-DL estimation, exogeneity is not a mandatory condition. The CS-DL approach based long-run coefficients ( $\ln \hat{\theta} = N^{-1} \sum_i^N \bar{\theta}_i$ ) are to be calculated by using  $\theta_i$ , and  $\theta_i$  can be calculated by using the panel-ARDL. The calculation of ( $\ln \hat{\theta} = N^{-1} \sum_i^N \bar{\theta}_i$ ) is based on the averages of the across units; and are efficient estimators where cross-sectional dependency is addressed (Chudik et al., 2015). Specifically, equation (17.3) is used to calculate the final results, which is based on the preceding observations.

$$\Delta w_{i,t} = c_i + \phi' v_{i,t} + \sum_{l=1}^{p-1} \psi'_{i,l} \Delta v_{i,t-l} + \acute{\omega}_{i,w} \overline{\Delta w}_t + \sum_{l=0}^1 \acute{\omega}'_{i,v,l} \overline{\Delta v}_{t-l} + \varepsilon_{i,t} \quad (17.3)$$



#### 4. Results and discussion

Based on the traditional unit root tests, we confirmed the stationarity in the system. Even the second-generation stationarity tests validated that the series are stable either at the level or at the first difference. Thereafter, by using the cross-sectional unit root tests, the need for an approach that can handle the cross-country dependency is confirmed. Thereafter, using the Westerlund's (2007) approach, we confirmed that all environmental proxies are associated with the comprised set of variables in the long run and each function possesses the long-run cointegration. A graphical approach mentioned in Figure 1 may help us to understand the working mechanism of the study.

<Figure 1>

The computed long run results with the ecological footprint (Model I to III), carbon footprint (Model IV to VI), and land footprint (Model VII to IX) are mentioned in Table 5.

<Insert Table 5 here>

First of all, we begin with the basic Models I, IV, and VII where direct impacts of selected variables on the ecological footprint, carbon footprint, and land footprint are tested. By doing so, we intended to explore whether the selected variables have damaged the overall quality of the environment or only a particular proxy of the environment. The long-run results indicate that the increased per capita income has intensified the ecological (coef. = 0.227, p-value = 0.013), carbon (coef. = 0.312, p-value = 0.036), and land (coef. = 0.193, p-value = 0.059) footprint in the selected South and Southeast Asia countries during the study period. However, in comparison to the other two proxies of the environment, it has a more severe impact on the carbon footprint. Such kind of association raises a question against the existing production processes. With the given production processes, it will be difficult to achieve the goal of responsible consumption & production (SDG-11) by 2030. The most important observation is that the existing mode of production exerting significant negative pressure on all indicators of environmental quality. Thus, we can contemplate that the selected developing countries by conceding the environmental responsibilities are busy in accomplishing the economic growth agendas. Alola et al. (2019), Hubacek et al. (2017), and Edoja (2017) have also detected the direct connotation between income and ecological footprint, carbon footprint, and land footprint in their studies, respectively.

While examining the impact of energy consumption, we observed that the increased use of energy led to a significant increase in the ecological and carbon footprint in the given countries. However, its impact on the land footprint is observed insignificant but direct. Here it can be mentioned that the additional combustion of energy, especially nonrenewable, exerts more air pollution, which in turn may disturb the air and ecological quality. However, its comparative impact on land quality may be less. That is why, in the present study, we found an insignificant impact of energy on land quality. But, the increased energy consumption may have an indirect and negative impact on land quality in the long run. These nations are heavily relying

on imported nonrenewable energy resources to fulfill their energy demand. Thus, it can be ascertained that the regions may continue to struggle with the environmental challenges if the nonrenewable energy-based production techniques will be continued in the coming years. In order, to avert this situation, governments have to identify alternative and endogenous energy resources, which should be less-carbon intense and cost-effective.

Further, we observed the direct and significant impact of the financial development and trade expansion on the ecological footprint, carbon footprint, and land footprint in the selected Asian countries. These kinds of outcomes indicate that not only direct production activities but also associated economic endeavors such as financial services, international trade, and exchange may exert the environmental footprint in the long run. Here it can be argued that the expansion of financial and international trade-related activities may intensify the movements of various necessary factors such as transportation, construction & manufacturing, services, and most importantly energy consumption. Due to the negative working of the multiplier-effect, these activities might have generated negative impacts such as scarcity of resources and environmental pollution in the long run. While taking the case of developing countries, the results of previous studies also confirmed the negative impact of financial development (Shahbaz et al., 2015; Javid and Sharif, 2016) and trade expansion (Tiwari et al., 2013; Shahbaz et al, 2013) on the quality of the environment in the long run. Here, Shahbaz et al. (2015) argued that the distorted socio-economic and socio-political policies of developing countries might have intensified the environmental pollution in the developing countries; because such kinds of nations are still working with the inefficient and carbon-intense production process. Consequently, these regions are unable to get the net-benefits of the economic, financial, and trade expansions.

Further, in Models II, V, and VIII, we explored the interaction effect of financial development and trade expansion on the ecological footprint, carbon footprint, and land footprint, respectively. The interaction of financial development and trade expansion has intensified the ecological footprint (Model II) and land footprint (Model VII) in the selected regions, as the interaction coefficients in both Models have exhibited a positive and significant impact on the ecological and land footprint. It means, at a given level of trade expansion, the growth in the financial instruments or resources may intensify the ecological footprint and land footprint. Similarly, at a given level of financial sector development, the improvement in the trade expansion may lead to the ecological footprint and the land footprint. In both Models, even the cross-elasticity coefficients of energy consumption, financial development, and trade expansion have shown a direct impact on both footprints. The results of Model V indicate that the interaction between financial development and trade expansion reduced the carbon footprint in the developing countries of Asia. The interaction coefficient (-0.350) and cross-elasticity coefficient (-0.019) with respect to trade expansion (keeping the financial development constant) is found negative and significant in Model V. This may be due to the better and efficient utilization of the financial resources by the international-trade oriented industries. Because to remain competitive in the international markets, the export-oriented industries may tend to utilize the financial resources to procure the energy-efficient and low carbon-intense production techniques. Here it needs to mention that cross-elasticity with respect to financial development (keeping the trade expansion constant) has remained positive. It indicates that at the given level

of trade expansion, any increase in financial development may increase the carbon footprint in the long run. The outcomes of Gill et al.'s (2019) study also revealed that the interaction between financial development and per capita income has reduced the carbon emissions in Malaysia during the study period.

Likewise, the interaction between financial development and energy consumption is shown in Model III, VI, and IX. In the first two Models, i.e. ecological footprint and carbon footprint, the interaction between financial development and energy has enlarged the scope of environmental pollution. Even all the cross-elasticity coefficients also maintained the same sign. It shows that the separate and after interaction both energy and financial development lead to significant ecological and carbon footprint in the long run. Further, in the case of land footprint, the coefficient of cross-elasticity (0.149) shows that at the given level of energy, the impact of financial development on the land footprint has direct. Contrarily, at the given level of financial development, the impact of energy consumption on land footprint has remained negative. These results can be interpreted as, in intensifying the land footprint, the development in the financial sector has played a negative role. However, the increased energy consumption is not contributing significantly to intensifying the land footprint in the selected countries. Based on the outcomes, it can be ascertained that financial development has not only perturbed the environmental quality directly but also indirectly. Therefore, to achieve sustainable growth targets, the role of the financial sector needs to be redefined. Otherwise, it may continue to intensify environmental pollution directly and indirectly through other channels of economic growth.

## **5. Conclusion and policy framework**

In the present study, we explored the impacts of per capita income, energy consumption, financial development, and trade expansion on the ecological footprint, carbon footprint, and land footprint in the eight selected countries of South and Southeast Asia during the study period (1990-2015). By employing Westerlund's (2007) cointegration approach, we confirmed that ecological footprint, carbon footprint, and land footprint functions are associated with the comprised set of variables in the long run and each function possesses the long-run cointegration. To compute the long-run coefficients, we applied a relatively new approach, i.e., CS-DL, which navigates the possible interdependency among selected countries. Based on the common coefficients, we intended to generate a policy framework, which may help to preserve the established eco-system.

Governments in these countries are playing dual roles, i.e. the government as a producer/consumer and the government as a benefactor. Similarly, private stakeholders are working as a manufacturer/service provider and consumer. Therefore, to weave a policy framework, the synergy between both is essential to achieve sustainable development goals. Considering the interconnectedness between financial development, energy consumption, trade expansion, and environmental footprint, first of all, the government as a producer needs to reduce the nonrenewable and imported energy dependency. In doing so, the government needs to invest in endogenous and less-carbon intense energy resources such as hydroelectricity, solar, wind, and biomass. By apportioning a mandated share of bank credit to develop the endogenous

energy infrastructure, the government can resolve four problems. Firstly, it may reduce the imported energy dependency. Secondly, the renewable energy consumption may fortify the environmental quality. Thirdly, the financial sector's negative role in intensifying the environmental pollution may turn into positive; lastly, the negative impact of trade expansion may turn into positive because, with the due course of time, the industries associated with foreign trade may also start using the less-pollution intense endogenous energy resources. However, this process needs to be carried systematically without creating a production and job loss. Stating differently, in this whole process, the adaptation and diversification are crucial; otherwise, it may impede economic growth. The gradual shift from the nonrenewable to renewable energy resources may widen the new job opportunities in the less developed areas as well; because the renewable energy resources such as solar, wind, water, and biomass are easily available in the rural areas. By doing so, the government can control the job loss caused by the technology-shift; and in terms of economic growth, the country may continue to perform well. Further, if the government industries are allied according to the endogenous energy-based processes, the other industries will automatically be motivated for the same because the marginal cost of production of renewable energy resources is comparatively very less provided the basic infrastructure be developed.

As a benefactor, the government can introduce suggestive and directive approaches where clearly defined *Property Rights* are much needed. In the case of the former, the government can motivate the various stakeholders to safeguard environmental quality. *The Swachh Bharat Abhiyan* in India is a testimony of the success of suggestive programs where the Indian government motivated people to dump the household garbage at the assigned places. Similarly, to preserve the ecosystem, the government needs to adopt some stringent directive measures. If the Property Rights are well-defined, the graduated sanctions or penalties can be imposed on the basis of the severity of the violation of the environmental regulation. The even-odd vehicle number movement on the alternative days in Delhi, the capital of India, is one of the examples of Property Rights usage. However, to ensure the success of such programs, the conscious participation of all stakeholders is always needed. To establish the answerability of the private industries, the government needs to identify the more pollution-intense units. By providing tax-rebates or subsidies to such industries, the government can motivate the private industries to develop the renewable energy infrastructure where the financial sector can perform as a mediator. For example, to develop endogenous renewable energy resources, the financial sector can issue special financial instruments and services, which should be available to the renewable energy-based industries whether serving in local or international markets. The special-concessions on establishing the new and renewable energy-based industries may gradually reduce the energy import-bills, which in turn may reduce the negative impact of trade expansion as well. Furthermore, due to the reduced production cost, the increased competitiveness of such industries may compel other industries to adopt low-cost energy resources. Again, here the financial sector can come as a savior, and the negative impact of the financial sector on environmental pollution may gradually turn into positive.

At the next level, to safeguard the economic and environmental interests, a public-private-partnership based endogenous energy infrastructure can be introduced. By doing so, the

energy supply can be maintained consistently, as the government alone may not be able to serve the total energy demand in the long run. At this stage, the subsidy/concession given by the government and financial institutions can be gradually removed and the system may become self-sustaining. After this stage, the bank lending to industries those who are serving the local and international markets can be routed through the environment-related guidelines. Further, by introducing the subjects like environmental conservation at the school and University levels, governments can achieve the twin benefits; firstly, it will create environmental consciousness among people; secondly, it will promote research and development in the renewable energy field. Once again, financing by the banking sector according to the pre-determined criteria can play a complementary role in this regard. This kind of multipronged approach may help to achieve the goals of affordable & clean energy (SDG-7), responsible consumption & production (SDG-11), and most importantly climate action (SDG-13) in the coming years.

The study with a larger time-span and a larger pool of countries may be able to provide better understanding where the segregation of countries based on income level could be followed. Furthermore, the interaction of energy resources with the income and other possible proxies of development can be explored because energy can be another catalyst of environmental pollution in the long run.

### **Declaration**

**-Competing Interests:** There are no competing interests among authors/any other third party/institute.

**-Ethical Approval:** While preparing the manuscript, to the best of our knowledge, we have followed required ethical procedures. We would like to declare that there is no conflict from authors and any other party directly or indirectly.

**-Consent to Participate:** We have consent of all authors and respective institutions to communicate the manuscript for consideration in the Journal.

**-Consent to Publish:** We confirm that if the paper is accepted, could be published in this prestigious journal.

**-Authors Contributions:** The corresponding author, i.e. Dr. Rajesh Sharma has written the paper. The whole idea, novelty, and technical part is handled by Dr. Avik Sinha. Lastly, Dr. Pradeep Kautish provided support in terms of editing, proofreading, and drafting.

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