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Examining the impacts of economic and demographic aspects on the ecological footprint in South and Southeast Asian countries

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2020

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Abstract

The reexamination of the existing economic and environmental policies in the South and Southeast Asian countries seems to be necessary, as these countries are struggling to achieve the goals of sustainable development. For suggesting a long-term environmental policy, we intend to examine whether the selected economic and demographic indicators have influenced the ecological footprint in the eight developing countries of Asia for the period of 1990-2015. The use of pooled mean group (PMG) approach allowed driving the long-run common coefficients, which may facilitate us to develop a common policy framework to fortify the environmental quality. The computed results confirmed that the selected variable are cointegrated in the long run; and, per capita income, nonrenewable energy usage, urbanization, fertility rate, and population density are observed as the significant drivers of the environmental pollution. On the other hand, renewable energy consumption restored the environmental quality in these countries. Based on the results, we recommend the need for the diversification of the energy-basket where the use of renewable energy resources to be enhanced. Further, by sensitizing the necessity of environmental conservation, governments should promote less carbon-intense economic and demographic practices across the industries and sectors.

JEL classification: Q56, C31, D12, O13
Keywords: Ecological footprint; South and Southeast Asia; Energy; Urbanization

1. Introduction

It is a well-established fact that economic growth endeavors have damaged environmental quality across the regions (Birdsall, 1992; Holtz-Eakin and Selden, 1995; Wackernagel and Rees, 1996). Considering the need for environmental conservation, the Kyoto protocol, and later on, the Paris Agreement has been initiated. The philosophy of both agreements is to control environmental degradation and to achieve sustainable economic growth. Even the United Nations Development Committee has recognized the need for sustainable economic growth, which is evident from the recommendations of the sustainable development goals (SDGs) (UNDP, 2019). In this regard, despite registering the phenomenal GDP growth rate, the emerging economies of Asia have preferred economic interests over the environmental purification. It is evident from the increasing social-cost bill caused by the increasing pollution level in the region (Yorifuji, 2015). As per the report of the World Bank, the social cost of 4% per annum in terms of GDP growth has been borne by Bangladesh's economy, which is caused by environmental degradation (Khwaja et al., 2012). Similarly, the annual social-cost caused by electricity plants and other production activities in India has been estimated at $210 billion (PTI, 2018). In a report submitted to Nepal health research council, Khanal and Shrestha (2005) observed that the pollution-led diseases had caused approximately 8% deaths in 2004. Here it can be perceived that the rapid mobilization of economic resources may have a direct or indirect negative impact on the established eco-system (Godfray and Garnetl, 2014; Alola, 2019). Nevertheless, for mitigating the direct negative effects of the economic expansions, the governments of the Asian countries have initiated certain long-term plans. For example, in January 2019, the Indian government has launched an air-pollution abatement plan named as National Clean Air Program, which aims to reduce the pollution level by 30% in the coming five years (PTI, 2019). Similarly, to safeguard the quality of water, the Philippines government has passed an Act in 2004, which is termed as the Clean Water Act (CWA).[1] Considering the need for environmental conservation, the Malaysian government has also issued the guidelines, which are part of the Environmental Quality (Clean Air) Regulation-2014. Nevertheless, the governments of these countries have not made serious efforts to mitigate the negative spillover impacts of economic expansions and human activities.

In this regard, environmentalists and policymakers have started measuring the level of ecosystem contamination, which is caused by socio-economic developments across the world. The assessment of such kind of indirect ecological cost or ecological footprint is termed as ecological accounting, which is introduced by Wackernagel and Rees (1996). In comparison to CO_2 emissions measurement, the ecological footprint (hereon EFP) is a broader concept. The EFP concept examines the overall impact of human activities on various natural resources such as water, air, forest system, cultivated and non-cultivated land. The EPF also accounts the carbon emissions while estimating the damage caused by human endeavors. Notably, the various social activities, whether economic or non-economic, may have an adverse impact on these natural resources (Nasir et al., 2019; Destek and Sinha, 2020). Reportedly, the overall ecosystem's quality in the Asian region has deteriorated significantly, especially in the preceding decades (Squires, 2013; Hasnat et al., 2018). The market-oriented economic policies adopted by the Asian emerging economies have enlarged the opportunities for economic development and resource exploitation (OECD, 2018). But at the same time, the reckless exploitation of water,

[1] Details available at: http://ap.fftc.org.tw/ap_db.php?id=281

forests, and other natural resources has posed a serious concern to the established ecosystem. It is evident from the budget allocations that the emerging Asian economies have focussed on pursuing their long-term growth targets over ecosystem or biodiversity conservation (Squires, 2013). However, the policymakers are well aware of the negative consequences of the overutilization of natural resources, which is evident from the fact that the Asian governments have accepted the membership of the Paris Agreement.

Merely agreeing to safeguard the ecosystem does not solve the looming problem. The most critical challenge is to identify the factors/activities/resources that are seriously posing environmental challenges in these countries. Owing to the geographical conditions, socio-economic environment, and government policies, the significant drivers of the ecological footprint may vary significantly across countries. The Asian region is bestowed with natural resources, which is desirable for economic growth. In the preceding years, the region has become one of the most sought after places for fresh investment. As, the massive population growth in Asia ensures the effective demand in the long run (Sahoo, 2006). However, excessive pressure on the ecosystem has posed certain new challenges such as air-pollution driven diseases. In terms of population density and air pollution, cities like Delhi, Jakarta, and Faisalabad have reached an alarming level. Overpopulation, excessive traffic, household wastage, and industrial concentration are the main reasons for deteriorating air quality in the region (The Economic Times, 2019; Greenpeace Southeast Asia, 2019).

Considering the sustainable development perspective of the Asian countries, it is evident that the problem of ecological sustainability is more prevalent in the South and Southeast Asian nations, as reported in the "Asia and the Pacific SDG Progress Report 2020" (UNESCAP, 2020). Therefore, it is necessary to assess the economic growth pattern in these nations, so that its impact on the ecological sustainability can be analyzed, and consequential policies can be suggested. Now, while analyzing the ecological impact of the economic growth pattern, the drivers of economic growth need to be considered. As the South and Southeast Asian nations are traversing a high growth trajectory, these nations are characterized by high energy consumption, which is majorly sourced by fossil fuel. Now, in the background of elevated economic growth, these nations are also characterized by growth in job opportunities, which causes a rural-urban migration. Owing to this migration, the urban centers encounter a pressure on the existing urban infrastructure and ecological balance. In order to commensurate the rise in consumption, not only the energy consumption goes up, but also this rise in consumption catalyzes the other economic activities, which in turn is translated into trade and other manufacturing activities. Rise in the level of disposable income further catalyzes the consumption pattern, and thereby, putting further pressure on the ecological balance. Hence, in order to ascertain ecological sustainability in these nations, it is necessary to realign the economic and allied policies, while bringing forth new energy and trade policies. This aspect of comprehensive policy redesigning from environmental sustainability perspective has never been addressed in the literature, and there lies the focus of the study. The study outcome helps in designing a comprehensive policy framework for the South and Southeast Asian nations in safeguarding the ecological balance by analyzing the impact of human and economic activities on ecological footprint, and this aspect is the policy level contribution of the study in the literature.

While saying this, it is also needed to be remembered that designing the suitable policies for these nations also calls for appropriate methodological adaptation. Now, it is practical to assume that every policy parameter might not have an impact on the target policy variable at the same time, as the nature of the impacts differ from one policy parameter to another. Therefore, the adapted methodology should be able to take care of this aspect. In this pursuit, the present study employs the autoregressive distributed lag (ARDL) based pooled mean group (PMG) approach. This method allows the individual parameters to have different lag specifications, which is relevant to the study. Now, from the policymaking perspective, this methodological application complements the policy-level contribution. As policy parameters might have differential impacts at different phases of an economic cycle, therefore the long-run coefficients measured through the PMG method can encapsulate that aspect. Therefore, the application of PMG complements the contextual development, and thereby contributing to the literature of environmental economics from the contextually-driven methodological perspective.

The sections second and third provide insight into the existing literature and research methodology, respectively. The computed PMG results and discussion is placed in the fourth section. Based on the results, the conclusions and recommendations for various stakeholders are exhibited in the fifth section of the study.

2. Examining the existing literature

In the existing literature, GDP growth (Selden and Song, 1994), energy utilization (Danish and Wang, 2017), FDI (Acharyya, 2009), trade expansions (Friedl and Getzner, 2003), financial sector development (Nasir et al., 2019), urbanization (Liang et al., 2019) have commonly been carried to determine the function of the CO_2 emissions. However, the estimation of merely CO_2 emissions unable to capture the spillover effects of human activities on water, land, and other ecological indicators (Shahbaz and Sinha, 2019). Therefore, in the recent past, economists and environmentalists have started following a broader spectrum, i.e. ecological footprint.

In this regard, Liu et al. (2003) observed that with the increasing trend in economic prosperity, the consumption pattern, and magnitude has changed substantially, which in turn has contributed to intensifying the economic bads. Furthermore, the study found that the increasing size of the family has remained more harmful to biodiversity than population growth, as with the declining population growth rate, the consumption pattern may continue to deteriorate environmental quality. Further, Dietz et al.'s (2007) analyses confirmed that the increasing economic prosperity and size of the population affected environmental quality in the long run. The study highlighted that the age pattern and economic settings such as urbanization and industrialization have a direct but mild impact on the ecological system. Contrarily, the study approved that the improvement in the level of education and life expectancy can be achieved with minimal EFP. Using the sample of Chines provinces, Feng and Wu (2011) observed that the relationship between the EFP and per capita income has remained nonlinear and established an inverted U-type shape in the long run. However, for some reason, it has not reached the threshold level. Stating differently, in the Shanghai region, the direct impact of per capita income on EFP has become mild but yet to achieve the inverse relationship.

Using a sample of 93 countries, Al-mulali et al.'s (2015) study confirmed the inverted U-type association between per capita income and ecological footprint. However, this association has not remained common across the regions. In other words, the impact of increasing income level in upper-middle and high-income countries on ecological footprint has turned from direct to negative, whereas in the lower-income countries it has continued to deteriorate the environmental quality. Further, the study confirmed that in all the chosen countries, trade expansion, urbanization, and energy utilization has a negative impact on ecological indicators in the long run. Remuzgo and Sarabia (2015) in their study found that CO_2 emissions inequality in the sampled countries has widened across the countries during the study period (i.e. 1999-2010). GDP growth pattern has been found as the main cause of the widening CO_2 inequality in the long run. Contrarily, the population growth rate has contributed to reducing emissions differences. By employing the ARDL approach, Nguyen et al. (2017) in their study observed that investment endeavors have significantly contributed to establishing the relationship between energy utilization, GDP, and CO_2 emissions in China. Contrarily, its role in India is found insignificant in the long run. Similarly, Uddin et al. (2017) in their panel of 27 countries found that per capita income increase leads to an increase in ecological footprint in the long run. On the other hand, the impact of trade expansion on ecological footprint is found negative and insignificant. The study tested the results using the group mean and VECM approach. Further, the results of Charfeddine's (2017) study carried in Qatar confirmed that the expansion in trade activities and urban spread has contributed to increasing the EFP during the study period (i.e., 1990-2015). Furthermore, the study confirmed the inverse U-type of association between EFP and domestic income in the long run. The outcomes of the study are calculated using the Markov-Switching approach. Similarly, by using the longer study period (i.e. 1882 to 2010) for Uruguay, Piaggio et al. (2017) in their study intended to establish the long-run relationship of CO_2 emissions and its possible determinants (i.e., per capita income, renewable energy, and trade expansion). Besides, the study explored the possibility of the long-run relationship between CO_2 emissions and structural transitions. The results of the study found that with the increased income level, the level of CO_2 emissions has increased but at a decreasing pace. Furthermore, the results confirmed that trade expansion has strengthened the environment quality in the long run. Instead of decreasing the consumption of energy, the study proposed to develop cleaner energy resources in the country, which are less carbon-intense.

Considering the case of East Asian countries, Rodríguez and Pena-Boquete (2017), in their study, exhibited that for reducing the carbon intensity, the level of labor productivity has remained a crucial factor. Further, the increased use of energy at domestic and industrial fronts has led to more carbon emissions in the region. Stating differently, the increased use of energy by workers and households has led to an increase in carbon footprint in the long run. Based on the consumer expenditure survey in Norway, Isaksen and Narbel (2017), in their study, found that due to the increased per capita expenditure, the carbon footprint has increased significantly in 2007. Further, the study revealed that even increased import-led consumption has led to an increase in carbon footprint in the region. In terms of carbon emissions, the impact of power plants is found insignificant, which may due to the implementation of modern and energy-efficient techniques of electricity generation. Considering the panel data of 183 countries, Kolcava et al., (2019) in their study confirmed that trade expansion has partially shifted the burden of environmental pollution from developed to developing countries. In comparison to international trade agreements, the impact of domestic trade policies is found sharper on

ecological indicators in the long run. Further, while determining the ecological footprint in four developing countries, Dogan et al. (2019) observed that urban and banking sector expansion and the increased export bill has led to an increase in ecological degradation in the long run. For computing the results, the study has employed the ARDL approach. Further, the results confirmed that import expansion has helped in improving the quality of the environment in the selected countries. Using the partial least square approach, the results of Dong et al.'s (2019) study found that in Hainan Province (China), the EFP has increased at a rate of 3.57% per annum during the study period (2005-2016). Further, the results confirmed that to fulfill the growth-targets, the north and northeast regions have utilized the natural capital flow. In terms of maintaining the natural capital flow, the water bodies have played a crucial role in the Hainan Province. In terms of ecological footprint, energy's impact on crop and forestland is found sharper than other ecological indicators.
Further, in socially bonded and culturally rich countries like South and Southeast Asia, it is necessary to investigate whether the demographic attributes can influence the ecosystem significantly. Past studies have confirmed that social obligations such as having children, marriage, and fertility rate may have a significant effect on biodiversity. For example, Alola et al., (2019) in their study confirmed that the increased fertility rate in the USA and Canada has intensified the environmental pollution; however, the interaction between fertility and marriage has fortified the environmental quality in the long run. Similarly, Downey and Hawkins (2008) in their study recommended assessing the impact of unconventional variables such as family size, male or female headed family on the ecological quality. Because the results of their study confirmed that the single-mother led houses and houses with younger children have emitted more hazardous pollutants in the US. Thus, here it can be ascertained that for addressing the environmental issues, both economic and demographic indicators to be handled judicially where volunteer and ethical efforts are much needed (Cafaro, 2012).

3. Research approach and data

On economic and demographic fronts, these countries have gone through major transitions. For example, from 2000 to 2010, the urban land in Malaysia had grown by 1.5% annually. Besides, the urban population reached 53% in 2010, which was 43% in 2010 (The World Bank, 2015). Similarly, India has also witnessed an upward trend in the urban population (Ritchie and Roser, 2019). In terms of demographic features, all the developing countries have witnessed transitions such as population density, fertility, and migration. Now, it poses a question whether these economic and demographic changes have enabled to alter the air, water, and land quality in the long run. Therefore, the study has intended to examine the impact of per capita income (constant $US), renewable energy (percentage of total energy utilization), nonrenewable energy (% of total energy utilization), population density (people p. /sq.km. of land area), the fertility rate (births per woman), and urbanization (% of the total population) on the ecological footprint. Except for the ecological footprint, all the other series are retrieved from the development indicators, which are maintained by the World Bank (2019). The data for the ecological indicators are retrieved from the website of the footprint network (https://www.footprintnetwork.org/).

In comparison to traditional CO_2 emissions, the prospective of ecological footprint is wider, as it measures the quality of water, air, forest, and land. For the period of 1990-2015, the eight developing economies of South and Southeast Asia (i.e. India, Sri Lanka, Nepal, Bangladesh, Pakistan, Malaysia, Philippines, and Thailand) have been examined using the pooled mean group approach. To generate the commonality in data series, the natural log values are used for the simulations. Notably, the study has included economic and demographic variables to examine their impact on environmental quality. The selection of the variables is based on the past studies (Hubacek et al., 2009; Marquart-Pyatt, 2015; Alola et al., 2019), which may have a possible impact on environmental pollution. In past studies, the comprehensive range of economic and demographic variables is ignored. Furthermore, the PMG approach enables to provide common coefficients, which may help in developing a common policy framework across the selected countries. In the context of the selected Asian countries, the present type of setting is considerably ignored in past studies.

3.1. Research approach

After examining the basic attributes of the incorporated series, the possibility of cross-section dependence needs to be tested. Its rejection allows employing the PMG estimation. After that, the common and individual panel unit root tests for the data stability are carried. For establishing the long-run equilibrium and integration, Pedroni's (1999) and Kao's tests are employed. The long-run common coefficients are calculated using the PMG approach. Stability of the model is validated through CUSUM and CUSUM square tests.

3.2. The PMG estimation approach

By including economic and demographic variables, the study substantially contributes to the literature. As we expect that the conceded variables may influence the ecological system in the long run. The given equation (1) establishes the functional relationship between ecological footprint and its possible determinants.

$$LFOOT = f\,(LGDP, LNONRE, LRENE, LURB, LFER, LDENS) \qquad (1)$$

The adopted panel approach is based on both, i.e. time and cross-section dimensions, which may enable us to provide a better understanding of the existing problem of ecological footprint in Asian countries. The expected impact of GDP and nonrenewable energy on the EFP is positive. Contrarily, the impact of renewable energy on the ecological footprint is expected to be negative. As in comparison to nonrenewable energy, it is less-carbon intense (Alola et al., 2019). Furthermore, the quality of the ecological system is expected to be got deteriorated due to the increasing trend in urbanization and population density. Similarly, the association between fertility rate and ecological footprint is expected to be direct in the long run. The working mechanism for this association is mentioned in equation (2):

$$LFOOT_{i,t} = \lambda + \alpha_1 LGDP_{i,t} + \alpha_2 LNONRE_{i,t} + \alpha_3 LRENE_{i,t} + \alpha_4 LURB_{i,t} + \alpha_5 LFER_{i,t} + \alpha_6 LDENS_{i,t} + \mu_{i,t} \qquad (2)$$

For the computation purpose, the natural logarithm form is adopted, since it generates the homogeneity in the system. Besides, it enables us to compute the elasticity coefficients for each variable. Respectively, the constant term and elasticity coefficients are represented by the symbols λ and α. The study period (1990-2015) and countries are represented by the subscript (t) and (i), respectively. The error term, which is supposed to be carrying the desired properties, is mentioned by (μ) in equation (2).

The proposed group of countries has some common characteristics such as increasing levels of per capita income, high population density, and increasing urbanization. Therefore, it generates the case of the panel data examination (Baltagi et al., 2005). The study has tried to examine the impact of economic and demographic characteristics on land, forest, air, and water quality. The aggregated degradation of them is termed as the ecological footprint. For achieving the homoscedastic results, the study has used a linear log form. The panel autoregressive distributed lag approach (*q*, *r*) enabled to determine the ecological footprint function where optimum lags for the dependent and independent variables are considered (Pesaran et al., 1999).

$$LFOOT_{i,t} = \lambda + \sum_{k-1}^{q} \delta i,j\ LFOOT_{i,t-k} + \sum_{k-0}^{r} \theta_{\ i,k} D_{i,t-k} + \mu_{i,t} \qquad (3)$$

In equation (3), $D_{i,t} = (LGDP, LNONRE, LRENE, LURB, LFER, LDENS)$

As per equation (2), time and countries are mentioned by t and i subscripts, respectively. The fixed effect is mentioned by λ, and δ is placed for the lagged value of the ecological footprint. The symbol θ is carried for the lagged values of the independent variables. The panel ARDL approach enables us to generate both types of coefficients (i.e. the common log run and differentiated short coefficients). Moreover, it handles the endogeneity issue efficiently. Further, it allows the use of I(0) and I(1) or both types of integrals. However, this approach is not appropriate for the I(2) level integrals. In the present study, the pooled mean group approach is adapted, as the coefficients calculated by this approach even controls the outliers and lags efficiently (Pesaran et al., 1999). Based on the PMG simulation, the error correction mechanism is mentioned in equation (4).

$$\Delta\ LFOOT_{i,t} = \eta_i\ LFOOT_{i,t-1} - \Psi_i D_{i,t} + \sum_{k-1}^{q-1} \delta_{i,j} \Delta\ LFOOT_{i,t-k} + \sum_{k-0}^{r-1} \rho_{\ i,k} \Delta D_{i,t-k} + \mu_{i,t} \quad (4)$$

Where,

$$\eta i = -\left(1 - \sum_{k-1}^{q} \delta_{i,k}\right),\ \Psi_i = -\frac{\sum_{k-0}^{r} \rho i,k}{\left(1 - \sum_{k-1}^{q} \delta i,k\right)} = -\frac{\sum_{k-0}^{r} \rho i,k}{\eta i},\ \delta_{ik} = -\sum_{d-k+1}^{q} \delta_{i,d},\ \rho_{i,k} = \sum_{d-k-1}^{r} \rho_{i,d} \qquad (5)$$

In equation (5), the correction speed ηi (i.e., $LFOOT_{i,t-1} - \psi_i D_{i,t}$) automatically enables to achieve the equilibrium if disequilibrium happens. The remaining part of the equation is given for the short-run equilibrium process. For the long-run coefficients of the independent variables, ψ_{it} is carried in equation (5). The coefficient ηi in equation (5) is also known as the ECM term.

4. Results and discussion

In order to initiate the analysis, it is necessary to validate the selection of parameters, and this is achieved by carrying out the CUSUM parameter stability test (see Appendix 1). For all the countries, the model parameters demonstrate stability. Once the stability of the model parameters is conformed, it is necessary to check the applicability of first or second generation series of methodological approach and in this pursuit, Chudik and Pesaran, (2015) weak cross sectional dependence has been performed. The test outcomes reported in Appendix 2 demonstrate the absence of cross sectional dependence in the data, and thereby, validating the applicability of the first generation methodological approach.

Table (1) provides a detailed summary of the comprised variables. The Jarque-Bera test results highlight the distribution pattern. All the mean values and standard deviations are found positive. Notably, the standard deviation value of the ecological footprint is most volatile among all the series. As expected, the mean value of the per capita GDP has remained larger than other variables. Except for urbanization, all other series are abnormally scattered. The lower panel of Table (1) establishes the correlation among the comprised series. Except for renewable energy, the ecological footprint's correlation with other variables is found positive. Besides, the correlation between per capita income and renewable energy usage has been observed negative. A high correlation between per capita income and nonrenewable energy indicates that with economic expansion, the Asian countries have intensified the consumption of nonrenewable energy resources.

INSERT TABLE 1 HERE

Before proceeding further, it is required to examine whether the selected series are stationary. If the variables are stationary at level 2 then the PMG approach is not an apt option. The results of the common and individual stationarity tests are mentioned in Table (2). The stationarity property is examined with intercept and trend and intercept. However, for saving the space, the results with intercept are given in Table (2).

INSERT TABLE 2 HERE

Individual (i.e., ADF and IPS) and common (LLC) panel stationarity tests results given in Table (2) reveal that all the series are stationary either at the level or at first difference. In other words, the variables belong to the mixed ordering of I(0) or I(1), which is desirable for the PMG estimation. Owing to the confirmation of the data stability, the long-run cointegration among the comprised variables can be examined. In this regard, the study has used Pedroni's (1999) and Kao's tests. The results of both tests given in Table (3) confirm that the given set of variables is cointegrated. In other words, the relationship between ecological footprint and its determinants is meaningful and it may be able to provide reliable results.

INSERT TABLE 3 HERE

The significant p-values of both the tests confirm the rejection of the null hypothesis. Stating differently, the comprised variables are cointegrated in the long run. Once stationarity and cointegration are confirmed, the PMG estimation can be employed.

INSERT TABLE 4 HERE

The results of PMG estimation test are documented in Table 4, while the model stability diagnostics are reported in Appendix 3. The statistically significant value (1% level) of the error correction term given in the lower panel of Table (4) confirms that per capita income, nonrenewable and renewable energy consumption, urbanization, fertility, and density converge to the long-run equilibrium with a speed of (-0.808) if disequilibrium occurs. Stating differently, the deviation caused by the independent variables converges towards equilibrium with a speed of 80%. The results of Table (4) reveal that per capita income increase has contributed to deteriorating the ecological system significantly in the long run. In other words, the environmental quality is worsened by 0.103% if per capita income increases by 1% in the long run. The studies in the past have also confirmed such kind of linear association between per capita income and ecological footprint (Ulucak and Bilgili, 2018; Alola, et al., 2019). The present study has not exhibited the impact of the squared-term of per capita income on ecological footprint. When the results with the linear and squared-term of per capita income were tested, the impact of linear term turned into insignificant but indirect, whereas the impact of the squared-term remained significant and direct. It indicates that the selected countries need to generate environmentally sustainable production processes, as the present modes of production are significantly contributing to increasing environmental pollution in the long run. The association between CO_2 emissions and per capita income in the Asian countries has been found inverted U-type or N-type in the past studies (Dong et al., 2018; Sharma, et al., 2019). However, the studies in the past have ignored the association between the ecological footprint and per capita income, especially in the considered region. The results of the present study may be important for various stakeholders. As, in terms of carbon emissions control, these countries have achieved the threshold level (Tjoek and Wu, 2018). As far as ecological damage is concerned, the region is still unable to generate environment-friendly methods of production. Consequently, the impact of the square-term has also remained positive on the ecological footprint. Here it can be inferred that the region is unable to develop a sustainable economic environment and may be tolerating the tradeoff between ecological system and economic growth.

Due to the increased consumption of nonrenewable energy usage, the level of environmental pollution has increased considerably in the South and Southeast Asian countries in the long run, as the association between nonrenewable energy and ecological footprint has been found positive and direct. Stating differently, a 1% increase in nonrenewable energy usage has led to a 0.09% increase in ecological degradation in the long run. It means, going against the Sustainable Development Goals (SDG-7), the adopted nonrenewable energy resources are pollution-intense in the region. Therefore, the region requires adopting the energy resources which are environment-friendly or less pollution-intense. In this regard, the impact of renewable energy resources on ecological footprint has been observed as indirect and significant. In other words, the use of renewable energy resources such as wind, solar, biomass, etc. has contributed to reducing the ecological footprint in the long run. It is well justified that in comparison to nonrenewable energy resources, the negative impact of renewable resources on environmental pollution is less intense. This association refers that to fulfill the long-term growth targets, these developing countries have to intensify the usage of renewable energy. It may have twin benefits; firstly, renewable energy is more appropriate in terms of ecosystem conservation. Secondly, the widespread use of renewable energy resources may lessen the burden of the energy import bill, as most of the selected countries are net-energy importers (Sharma et al., 2018). Once the widespread use of renewable energy is initiated, the additional marginal cost production may be significantly low, which may improve the market competitiveness of these countries in the long run. The study enables to compare both types of energy resources since the utilization of renewable and nonrenewable energy is simultaneously considered for the examination. Even the results of the preceding studies confirm that the impact of renewable energy and nonrenewable energy on environmental pollution may be indirect and direct, respectively (Nazir et al., 2019; Gielen et al., 2019; Karasoy and Akçay, 2019).

While examining the association between urbanization and ecological footprint, the study found that urbanization has a positive and strong impact on the ecological system. Nonetheless, the association is rejected at a 10% significance level. From the results, it can be assumed that in comparison to the other indicators, the impact of urbanization on environmental quality is less negative. However, in any case, the negative influence of urbanization on EFP cannot be ruled out. Perhaps, the inclusion of other determinants might have diluted the impact of urbanization on EFP. The outcomes of Newman's (2006) and Hubacek et al.'s (2009) studies have confirmed that urbanization has a serious negative impact on EFP in the long run.

Further, the long-run association between fertility rate and ecological footprint is observed direct and substantial. In other words, increased fertility has a negative impact on air, water, cultivable land, and forestland quality in the long run. In comparison to developed countries, the fertility rate in the selected Asian countries is still high. More numbers of children and bigger family size may seriously widen the scope of environmental pollution in the long run. Here it can be argued that bigger family size may force to adopt a cheaper lifestyle. Contrarily, the small size of the family may encourage adopting hygiene life-standard. While comparing both, the larger family size leads to an unhealthy lifestyle and more environmental pollution in the long run (Liu, et al., 2003). However, even the improved lifestyle or less fertility may also continue to increase the ecological footprint, as it widens the scope of more consumption and energy utilization (Dietz et al., 2007). Therefore, it can be proposed that besides smaller family size, there is a need to inculcate the environmental consciousness among all the stakeholders.

Even the impact of population density on ecological footprint has been observed direct and significant in the long run. With the increased population density, the air, water, and land quality may tend to be more polluted. Notably, in comparison to the world average, the population density is eight times more in Asian countries. It means the ecological system is more exposed in the region, especially for population density (MacKinnon, 2002). The problem can be repaired if the region can control the excessive population density. Unless population growth and urbanization are controlled, it seems difficult to control the negative impact of demographic indicators on the ecological system. In this regard, governments need to generate long-term demographic and residential policies. By highlighting the benefits of small family size and hygienic living conditions, the negative impact of demographic attributes on the ecological system can be reduced. Otherwise, the prevailing economic and demographic patterns may continue to impose significant challenges for environmental quality in the region.

Except for per capita income and renewable energy, the short-run impact of other economic and demographic indicators on the ecological footprint is found insignificant. In both periods, the per capita income increase has enlarged the scope for pollution emissions. Contrarily, in both periods, renewable energy utilization has contributed to improving environmental quality significantly.

In the end, it is also necessary to check for the robustness of the model. In order to assess this aspect of the model, we have applied CUSUM and CUSUM square tests on the estimated model for the individual countries. The results demonstrated in Figure 1 show that for all the countries, the estimates are within 5% critical bounds, and thereby, validating the stability of the empirical model over the study period across the sample countries.

INSERT FIGURE 1 HERE

5. Conclusions and policy implications

By far, we have analyzed the impact of economic growth and its drivers on the ecological footprint of the South and Southeast Asian countries over 1990-2015. In this pursuit, we have utilized the ARDL-based PMG modeling approach, and the study outcome suggests that the economic drivers in these nations largely have a negative impact on the ecological footprint. It can be seen that the rise in the living standard and quality of life driven by the fossil fuel based energy consumption have negatively affected the ecological balance of these nations. Hence, there lies a tradeoff between achieving economic growth and uplifting environmental quality in these countries.

Now, when we delve deeper into the study outcomes, then a number of policy implications emerge. It can be seen that the positive environmental impact of renewable energy consumption is more compared to the negative environmental impact of fossil fuel energy consumption. Apparently it might seem that nationwide implementation of renewable energy solution might solve this problem. However, the higher implementation cost of renewable energy solutions might cause harm to the economic growth pattern itself. In order to address this issue, a phase-wise solution might be implemented, so that the nation-wide implementation of renewable energy solutions can be carried out without causing harm to the economic growth pattern. As most of the job opportunities are focused at the urban centers, therefore, the first phase should focus the households in these regions. The households might be provided the renewable energy solutions at a pro-rata rate from the government, while enhancing the awareness about these solutions through people-public-private partnerships. As the quality of life indicated by fertility rate has a direct negative impact on the ecological balance, then it is necessary that the people with a standard quality of life should be targeted first for the diffusion of renewable energy solutions, as the spillover effect of their usage of these solutions will be reflected in the populace with comparatively lower quality of life. The pro-rata rate decided by the government should be discriminatively priced and it should be based on the level of income of the citizens. Now, it is obvious that the government will incur losses with this particular initiative. Hence, in the second phase, the industrial sector should be provided with the renewable energy solutions at a pro-rata rate, which will be based on the carbon footprint of the firm. In order to expedite the process, the subsidies on fossil fuel solution should be removed gradually, so that the firms are discouraged to use the fossil fuel solutions. In the third phase, the government should look into extending the breadth of the cities, so that the concentration of the population can be diluted, and the pressure on urban infrastructure and ecological balance can be released. This expansion might be possible through the revenue earned in the first two phases. In this way, the ecological footprint might be reduced, while not harming the economic growth pattern.

While these policy measures will be carried out, it will inherently help these nations to achieve the objectives of Sustainable Development Goals. The initiative of providing renewable energy solutions to households and industrial sector will help these nations to bring down the price of renewable energy solutions, and in this way, these nations will be able to achieve the objective of providing clean and affordable energy to their citizens (objective of SDG 7). When the clean energy solutions are implemented, the environmental quality will improve, ecological balance will be gradually restored (objective of SDG 13), and the natural ecosystem might start revising itself through sustenance in life (objectives of SDG 14 and SDG 15). In pursuit of city expansion and exploration of renewable energy solutions, the extent of job opportunities will rise, and the standard of living of the people will improve (objective of SDG 7). Moreover, reduced pressure on the urban infrastructure will make the cities more livable (objective of SDG 11). Gradually, the innovations in pursuit of clean energy solutions will reach the grassroots level, so that the innovations should be endogenous and can be diffused across the nation (objective of SDG 9). In this way, results obtained from this study can help designing a multipronged SDG framework, so that these nations can make improvements in achieving the objectives of SDGs by 2030. During the implementation phase, the policymakers should consider that fulfillment of the objectives in every phase in necessary to build the SDG framework, as the phases are characterized by short run economic loss and long run economic profit. Therefore, policy-level myopia should be avoided in the process of implementing this policy framework.

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