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RESEARCH ARTICLE

The long-run and short-run influence of environmental pollution, energy consumption, and economic activities on health quality in emerging countries

Muhammad Khalid Anser[1] · Imran Hanif[2,3] · Xuan Vinh Vo[3] · Majed Alharthi[4]

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Abstract

This study investigates the effect of energy utilization, greenhouses gasses emissions, and economic activities on health risks such as mortality rate and incidence of respiratory diseases in emerging Asian economies. The study analyzes a panel data from 1995 to 2018 to examine the long-run and short-run influence of environmental pollution on health issues. The empirical findings highlight that greenhouse gasses emissions, fossil fuel consumption, and natural resources depletion in the region are key factors to increasing health risks in the long-run period, while the use of clean energy and improvement in per capita economic growth is helping to improve the health status of the households. In a short period, greenhouse gasses emission is the only significant factor responsible for the high mortality rate and occurrence of respiratory diseases in the emerging economies of Asia. According to the results, there is a need for government intervention programs to rescue the region from the negative effects of environmental pollution and the utilization of nonrenewable energy. In emerging Asian countries, the combustion of fossil fuels, environmental pollution, and limited access to clean energy are such factors responsible for high mortality rate and stimulating incidence of respiratory diseases in the individuals. The study suggests that alternative green energy can prove helpful to control greenhouse gasses emissions and to control health issues by improving environmental quality. The study further suggests that the use of clean energy from water, wind, and sunlight may prove helpful to meet the energy requirement at the domestic level and improve the health status of the individuals by reducing the incidence of respiratory diseases in emerging countries of Asia.

Keywords Energy consumption · Emerging economies · Greenhouse gasses · Mortality rate · Respiratory diseases

JEL classification Q5 · Q52 · R1 · R11

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✉ Imran Hanif
ihanif@gsu.edu

Muhammad Khalid Anser
khalidsnnu@yahoo.com

Xuan Vinh Vo
vxvinh@yahoo.com

Majed Alharthi
mdalharthi@kau.edu.sa

1 School of Public Administration, Xi'an University of Architecture and Technology, Xi'an, China

2 Department of Economics, University of Management and Technology, Lahore, Pakistan

3 Institute of Business Research, University of Economics Ho Chi Minh City, 59 C Nguyen Dinh Chieu Street, Ward 6, District 3, Ho Chi Minh City, Vietnam

4 Finance Department, College of Business, King Abdulaziz University, P.O. Box. 344, Rabigh 21911, Saudi Arabia

Introduction

In recent years, developing countries are facing the challenges of stagnant economic development, huge gap in energy demand and supply, high mortality rate, and increase in the incidence of respiratory diseases due to poor environment quality. To produce more goods and meet the rising energy demand at domestic level have increased the combustion of fossil fuels such as oil, coal, and gas at the industrial level and solid fuels combustion at the household level. Undoubtedly, the utilization of such fossil fuels is contributing to per capita income but generating greenhouse gasses which are affecting human health (Bailis et al. 2005; Alcock et al. 2017). Like developing countries in the different regions, the emerging countries in Asia are also consuming fossil fuels' and solid fuels' resources and overseeing the antagonistic influence of greenhouse gasses emissions on environment and health risks in human and other biological lives. Globally, there are approximately 2.8 billion individuals, which are almost 41% of the world population, are consuming solid fuels to meet energy requirements to perform the day to day tasks (WHO 2015). It is also expected that in future, enormous carbon dioxide emissions and other greenhouse gasses may deplete natural environment that can trigger health risks in the form of lung cancer, cardiovascular diseases, and respiratory diseases particularly in emerging economies all over the globe (Bailis et al. 2005; Barnes 2014). Therefore, it is frightening that at global level, due to air pollution every year, about 3.4 million deaths attribute to environmental degradation, and it is more alarming that about two-third are reported alone from the Asian region (WHO 2019). Therefore, the emissions of greenhouse gasses in developing countries are not only increasing health issues, but it is also increasing the burden of health expenditures and shortage of medicine. Globally, air pollution is a serious concern and considered a primary cause of respiratory diseases in humans. According to the World Health Organization, about 65 million individuals suffering from chronic obstructive pulmonary disease, about 334 million individuals suffering from asthma, and 1.6 million people have lung cancer, and these statistics are growing rapidly (WHO 2019). In 2015, about 1.4 million individuals died with tuberculosis, and 1.6 billion deaths attribute to lung cancer. More alarmingly, about 3 million individuals are dying each year as a result of obstructive pulmonary disease, and the number of causalities may further increase. Thus, the present study is highlighting how greenhouse gasses emission and fossil fuel consumption are fostering health risks in the Asian region.

No doubt, the utilization of fossil and solid fuels is not only helping to meet the energy requirements but also manifesting challenges in the form of health problems such as respiratory diseases, lungs cancer, and other pulmonary diseases (Beatty and Shimshack 2014; Brunekreef and Holgate 2002). Till the time, fossil and solid fuels are considered cheapest sources for energy generation and used massively at the domestic level to produce energy at macro- and micro-levels (Barnes 2014; Chafe et al. 2014). Thus, low prices of fossil fuels are key attractions for emerging economies to rely extensively on nonrenewable energy sources to manufacture goods. In addition, economic progress is also essential for the survival of emerging nations to fight with numerous socioeconomic challenges such as poverty and health issues (Etchie et al. 2017; Faivre et al. 2017; Williams et al. 2015; Collier et al. 2008; Harpham and Stephens 1991). Thus in developing countries, the utilization of solid fuels seems a primary contributor to greenhouse gasses emissions and an indirect source that manifests health and environmental issues in developing countries (Chaabouni and Saidi 2017; Destek and Aslan 2017). Therefore, emerging economies seems to be moving away from the trajectory of sustainable development targets. Thus, the findings of this study may be helpful to propose a policy for emerging economies to cope with health and environmental issues. Mostly, socially consistent and more open economies are following the sustainable development pattern and less exposed to environmental led health issues. However, the rise in greenhouse gasses emission has a substantial effect on rising health issues in the developing Asian nations.

Energy utilization and environmental pollution in emerging economies are connected with health-related issues; the subject of investigation highlighted the miserable picture of the ecological disorder. Instantly, it highlights the cost of economic benefits in the form of the poor health status of individual and other biological life. It is not astonishing that energy is a significant input in the lives of human and this input is also facilitating to produce other goods and services (Beatty and Shimshack 2014; Epstein et al. 2013). Although, in low-income countries, the role of energy usage may help to improve life, the net benefit of energy to promoting life quality depends on the types of energy sources consumed to produce energy. Thus, the problem is that what aspect of energy production can improve quality of life with minimum negative externalities. However, it can be argued that the solution to the puzzle is missing in contemporary research. It is also important to mention that the notion of energy production by utilizing such resources which are cheaper in terms of nominal price may appear expensive in the long run, and such low price energy resources could appear to be expensive in the form of low life expectancy and poor health status of the individuals and depletion of natural resources (Destek and Aslan 2017; Lobell et al. 2008). Therefore, rising challenges in the form of low life expectancy, climate change, and inrcreasing temperature are such indications demanding an urgent inquiry and appropriate solutions.

The present energy misery fueled by coal and gas has continued to dominate the power generation mix. This is apparent since the source has proven to be flexible and economically competitive when compared with alternative power generation methods. The challenge is that coal and natural gas are both associated with greenhouse gasses emission properties which are not only the drivers of environmental degradation but also a network of heat which continued threatening the survival of the human race and unborn generation (Machol and Rizk 2013; Martin et al. 2011). Realizing such dividends cannot be achieved given the present state of health of the people in the developing nations of Asia and other regions of the world. A recent report of the World Health Organization (WHO) has confirmed that essential health facilities needed to preserve and extend human life expectancy are lacking in the developing nations (Kishore and Ramana 2002; Mead and Brajer 2005). Undoubtedly, mushrooming health challenges in developing countries is demanding urgent attention and inclusion in public policy initiatives to control such environment-led issues on a priority basis (Helbich 2018; Kurt 2015; Martin et al. 2011; Menyah & Wolde-Rufael 2010;

López et al. 2008; Muysken et al. 2003). For different regions, the prior studies have highlighted that the leading cause of higher mortality rate is the exposure to environmental pollution which emerges due to the utilization of nonrenewable energy resources such as fossil fuels at macro- and micro-level, (Hanif 2018a, b; Hanif 2017; Gao et al. 2015; Pereira et al. 2015; Vineis et al. 2014; Singh and Sachs 2013; Pope et al. 2010). In developing countries, for nearly a decade, the energy sector has passed through multiple transitions; still, the efficient production of energy is challenging, and energy shortfall is growing over time. Thus the priority of the governments was to overcome energy shortfall, and they want to produce energy by any sources. As a result, environmental challenges have been increased; therefore, the present study aims to highlight those emerging environmental and health challenges due to the utilization of nonrenewable energy resources like oil, coal, and gas (Hanif 2018a, b; Sulemana et al. 2017; Nadal et al. 2015; Odubunmi et al. 2012; Narayan and Narayan 2010; Janke et al. 2009). Our study contributes to the literature by examining the impact of energy utilization, per capita income, and environmental pollution on health issues in emerging economies. In contrast to the work of Dumat et al. (2019), Hanif (2018a, b), and Zou et al. (2016), this study contributes to the literature by testing linearity between per capita income and health issues in emerging Asian economies. Following the EKC hypothesis, the quadratic term of per capita income (PCI) is introduced to test linearity. Though PCI in emerging economies is usually associated with a greater level of pollution, it may also facilitate environmental breakthroughs, for instance, improving technology and stimulating the switching pace from nonrenewable to clean energy. This study hypothesized that environmental pollution is based on economic activities, and once the economy grows, the health status of individuals may have to improve. Therefore, the growth pattern is a significant factor to highlighting the health status of individuals in emerging economies. To the best of our knowledge, this is the first inclusive study considering a different set of dependent and independent variables. Therefore, the findings of this study will help the policymakers and practitioners of emerging economies to design policies in reducing pollution, making a softer transition from fossil fuels to clean energy sources to mitigate health issues. The primary emphasis of the present research is to answer the following questions: (1) Does solid fuels utilization is a source of respiratory diseases and mortality rate in developing Asian countries? (2) Does environmental degradation increases the occurrence of respiratory diseases and mortality rate in developing Asian countries? Besides, we also mitigate endogeneity and heterogeneity to control the robustness of the results and reported robust and reliable results with an efficient policy design to overcome the health challenges such as high mortality rate and incidence of respiratory diseases in developing Asian countries.

Thus, the rest of the paper organized as follows: Pollution and energy relationship in emerging Asian countries is presented in "Pollution and energy relations in emerging Asian countries" section. In "Data and methodology" section, data and methodological framework is constructed. Empirical results are reported and discussed in "Estimation of results" section, and the conclusion is given in the "Conclusion" section.

Pollution and energy relationship in emerging Asian countries

Environmental pollution in developing countries is not only a major health risk but also has adverse impact on economic conditions. Although different policy measures are adopted in developing economies, there is still a demand for further actions to bring air quality to safe levels. Figure 1 shows the average score of the emerging Asian economies in pollution index.

Figure 1 shows the alarming condition of the environment quality in Mongolia, Bangladesh, and Myanmar, and it can be observed that these countries have high average score above 90% in pollution index. While China, Iran, Nepal, Pakistan, Maldives, Vietnam, Jordan, and Yemen also have high average score in pollution index (80 to 89.99%) highlighting the poor air quality in majority of emerging Asian countries, Kazakhstan, India, Cambodia, Indonesia, Thailand, Philippines, and Turkey have average score between 70 and 79.99%. In general, the majority of the emerging Asian countries are facing poor environment quality, and it would be meaningful to examine the influence of current environment condition on human health. In Fig. 2, the share of renewable energy in total energy consumption in emerging Asian economies is presented.

Figure 2 highlights the reliance on renewable energy to fulfil the energy requirements in the selected emerging economies of Asia. It can be observed that only four out of twenty-four countries have more than 60% share of renewable energy in total energy consumption. Moreover, 11 countries have less than 10% share of renewable energy in total energy consumption; this shows the high reliance of Asian emerging economies on nonrenewable energy resources.

Figure 3 highlights that Uzbekistan, China, Sri Lanka, Myanmar, Indonesia, Jordan, and Turkey have fossil fuel energy consumption of more than one thousand (Kg of oil equivalent per capita). The excessive use of fossil fuels highlighted that if emerging economies in Asia maintain such pattern, the consumption of such nonrenewable energy sources with similar pace may increase air pollution in the future.

Therefore, it is essential to highlight and investigate the influence of fossil fuel consumption and air pollution on the health status of individuals by using the latest data. Overall, it can be observed from the graphical presentation of data that the majority of the emerging economies in Asia are experiencing poor air quality due to high reliance on fossil fuel

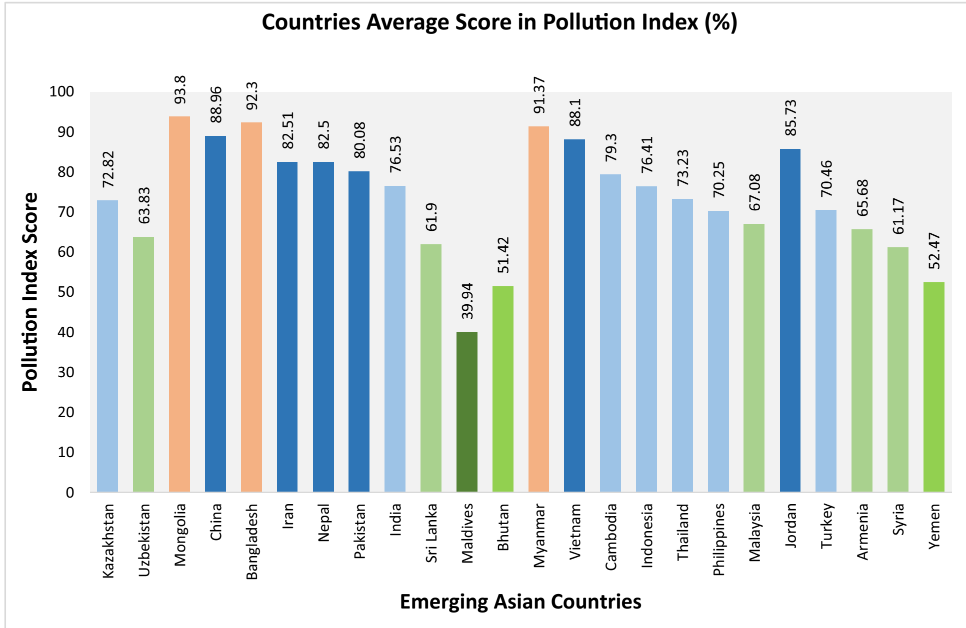

Fig. 1 Countries' average score in pollution index (%)

consumption and the low share of renewable energy in total energy consumption. Therefore, it can be argued that air pollution can appear as the most lethal environmental health threat in developing Asian economics because polluted air penetrates deep into the lungs of individuals and causes damage of lungs and cardiovascular system. In the year 2016, about 2.2 million deaths are attributed to air pollution, and 29% deaths were due to cardiovascular diseases, 27% due to heart failure, 22% as a result of chronic obstructive pulmonary diseases, 14% due to lung cancer, and about 8% due to pneumonia. Thus, according to the new data, air pollution is alarmingly high in many parts of Asia. Therefore, to depict a more precise picture, an econometric method is adopted to investigate the impact of air pollution on respiratory diseases and mortality rate in emerging Asian economies.

Data and methodology

The study takes into consideration a simple model to explain the interaction of energy utilization, greenhouse gasses emissions on life expectancy, and the occurrence of respiratory diseases in developing Asian countries. Our empirical strategy follows the work of Hanif (2018a, b) and Hanif and Gago-de-Santos (2017) to investigate the effect of energy utilization and greenhouse gasses emissions on health risks. For

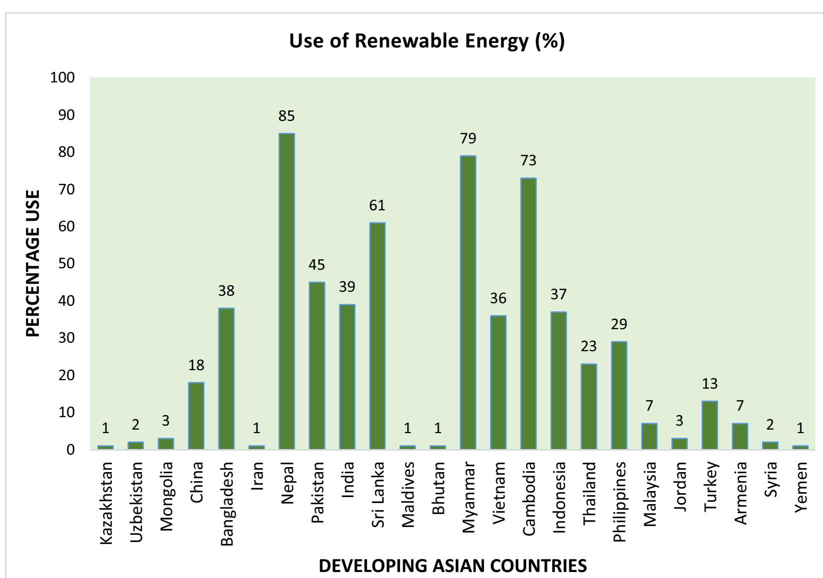

Fig. 2 Use of renewable energy (%)

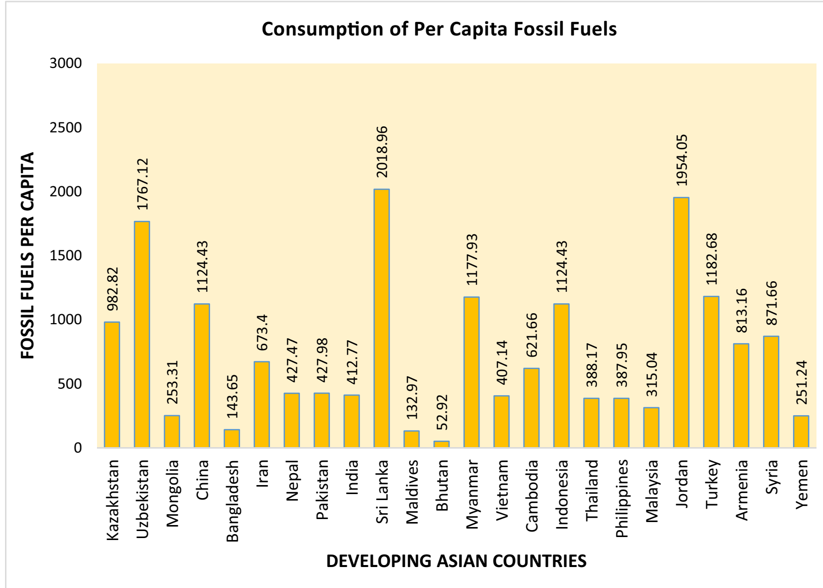

Fig. 3 Consumption of per capita fossil fuels

this purpose, panel data from 1995 to 2018 is collected form Millennium Development Goals (MDGs) published by the World Bank. The proposed model is given as follows.

$$logMOR_{it}\backslash logRPD_{it} = \gamma_0 + \gamma_1 logGHG_{it} + \gamma_2 logFFC_{it} + \gamma_3 logCLE_{it} + \gamma_4 logGDP_{it} + \gamma_5 logNRD_{it} + \mu_{it} \quad (1)$$

Here, the short-run dynamics based on the ARDL model can be written as

$$\Delta \log MOR_{it}\backslash \Delta \log RPD_{it} = A + \sum_{j=1}^{k} \beta_1 \Delta logGHG_{it} + \sum_{j=0}^{k} \beta_2 \Delta logFFC_{it} + \sum_{j=0}^{k} \beta_3 \Delta logCLE_{it} + \sum_{j=0}^{k} \beta_4 \Delta logGDP_{it} + \sum_{j=0}^{k} \beta_5 \Delta logNRD_{it} + \pi_1 logGHG_{it-1} + \pi_2 logFFC_{it-1} + \pi_3 logCLE_{it-1} + \pi_4 logGDP_{it-1} + \pi_5 logNRD_{it-1} + \varepsilon_{it} \quad (2)$$

Further, the null hypothesis of no-cointegration interlinks between the right-hand side variables with mortality rate or the occurrence of respiratory diseases can be presented as

$$H_0: \quad \pi_1 = 0; \pi_2 = 0; \quad \pi_3 = 0; \pi_4 = 0; \pi_5 = 0;$$

After verification of cointegration among the regressors, an error correction mechanism is developed and presented as

$$\Delta \log MOR_{it}\backslash \Delta \log RPD_{it} = A + \sum_{i=1}^{n} \beta_1 \Delta logGHG_{it} + \sum_{i=1}^{n} \beta_2 \Delta logFFC_{it} + \sum_{i=1}^{n} \beta_3 \Delta logCLE_{it} + \sum_{i=1}^{n} \beta_4 \Delta logGDP_{it} + \sum_{i=1}^{n} \beta_5 \Delta logNRD_{it} + \pi_1 logGHG_{it-1} + \pi_2 logFFC_{it-1} + \pi_3 logCLE_{it-1} + \pi_4 logGDP_{it-1} + \pi_5 logNRD_{it-1} + \varphi EC_{it-1} + u_{it} \quad (3)$$

Here, 'φ' indicates error correction term (EC_{t-1}). The coefficient of the error correction term shows the speed of adjustment and convergence of the model to attain the

Table 1 Summary statistics of variables

Variables	Mean	Median	Maximum	Minimum	Std. dev.
RPD	274.23	275.11	276.01	270.00	1.91
MOR	84.71	83.61	106.4	64.61	12.67
GHG	62.58	53.16	126.89	9.95	40.13
FUL	123.81	127.94	134.37	105.86	8.79
CLE	25.42	26.01	42.13	7.42	10.53
GDP	8.12	7.81	9.44	7.44	0.61
NRD	97.41	97.39	98.09	96.72	0.42

Table 3 Results of cross-sectional dependence tests

	I		I&T	
	Statistics	*p* value	Statistics	*p* value
CD adjusted	0.834	1.426	1.984	0.368
CDLM1	12.114	0.190	17.139	0.113
CDLM2	0.4635	0.132	1.025	0.101

Here I indicates intercept, and I&T is used for intercept and trend. Null hypothesis: There is no cross-sectional dependence, and if the *p* value is less than 5% significance level, the null hypothesis will be rejected

equilibrium state. Here, mortality rate (MOR) per thousand individuals and annually reported cases of respiratory diseases (RPD) are used as dependent variables, while the total greenhouse gasses emissions (GHG) kiloton of carbon dioxide equivalent is used as an independent variable. Fossil fuel energy use (FFC) and clean energy use (CLE) kilogram of oil equivalent (Rehfuess et al. 2014; Mehrara et al. 2012) are employed to examine the impact of nonrenewable and renewable energy on the occurrence of respiratory diseases and mortality rate in emerging Asian countries. Here, GDP per capita (Lim et al. 2012; Gao et al. 2015) is used to highlight the role of per capita income on health risks. In addition, GDP per capita square is also introduced to test the EKC hypothesis for health indicators. Finally, natural resource depletion (NRD) is measured in terms of total deforestation percentage of total land area in square kilometers used to examine the impact of natural resources depletion on health risks in emerging Asian countries.

Estimation of results

The summary statistics are given in Table 1.

To identify the problem of multicollinearity in the models, Table 2 shows the results of correlation matrix.

Here, correlation matrix revealed that the dependent variables, i.e., incidence of respiratory diseases (RPD) and mortality rate (MOR), have a weak correlation with greenhouse gasses emissions (GHG), fossil fuel energy utilization (FUL), clean energy utilization (CLE), per capita GDP (GDP), and natural resources depletion (NRD). Thus, the low value of correlation coefficients reflects the absence of multicollinearity in the variables.

To examine the cross-sectional dependence when cross-sectional size is less that time dimension ($N < T$), Lagrange multiplier (LM) CDLM1 is used (Breusch-Pagan 1980). However, when N is larger than T, CDLM test is used, and in the case where both T and N are large, CDLM2 is employed to test the cross-sectional dependence (Pesaran 2004). In CDLM1 test, the group average is zero and biased because individual average differs from zero; however, this issue was resolved by Pesaran et al. (2008) by adding the variance and average into test statistics. The corrected version of CDLM1 is known as deviation-corrected LM test (LM adjusted). The results of cross-sectional dependence diagnostic tests are given in Table 3.

The results in Table 3 indicate the acceptance of null hypothesis; this finding suggests that the cross-sectional dependence is not an issue, and unit root in data series can be determined by applying first-generation unit root tests. In the next step, to deal with unit root, the results of ADF test are given in Table 4.

The results show that incidence of respiratory diseases (RPD), the mortality rate (MOR), greenhouse gasses

Table 2 Result of pair-wise correlation matrix

	LogRPD	*LogMOR*	*LogGHG*	*LogFUL*	*LogCLE*	*LogGDP*	*LogNRD*
LogRPD	1.00						
LogMOR	0.13	1.00					
LogGHG	0.52	0.10	1.00				
LogFUL	0.33	0.37	0.16	1.00			
LogCLE	− 0.21	− 0.18	− 0.07	0.02	1.00		
LogGDP	− 0.36	− 0.38	0.27	0.29	0.06	1.00	
LogNRD	0.31	0.53	0.09	0.44	0.18	0.47	1.00

Table 4 Result of unit root test

Unit root test		*LogRPD*	*LogMOR*	*LogGHG*	*LogFUL*	*LogCLE*	*LogGDP*	*LogNRD*
At level	T	0.68	− 2.81	− 1.36	− 3.13	− 2.48	–	− 1.45
	T&I	− 1.69	− 0.02	− 1.54	− 0.64	− 5.18	–	− 2.89
At first difference	T	− 5.41	− 6.37	− 6.14	− 5.16	–	− 3.96	− 4.89
	T&I	− 5.32	− 7.12	− 6.31	− 6.25	–	− 4.02	− 4.97
Conclusion		1(I)	1(I)	1(I)	1(I)	1(0)	1(0)	1(I)

emissions (GHG), fossil fuels energy utilization (FUL), and natural resources depletion (NRD) are having level stationary with an order I(0), while the variables such as clean energy utilization (CLE) and per capita GDP (GDP) are stationary at first difference with an order I(1). Here the mix stationary order of variables advocates the application of autoregressive distributed lag (ARDL) model to estimate the proposed model. In the present study, the bound testing is also performed to determine the cointegration among the regressors (Table 5).

The results of bound test show that F statistics are greater than critical upper bound value; therefore, we reject the null hypothesis and confirm the cointegration interlink between dependent and a set of independent variables.

Results and discussion

The estimated long-run coefficients based on ARDL are given in Table 6.

Results show that the coefficient of greenhouse gasses emissions has a positive sign and statistically significant at 1%. The results depict that 1% increment in greenhouse gasses emission can improve the incidence of respiratory diseases by about 0.67%. Similarly, the results depict a positive association of greenhouse gasses emissions with mortality rate. More precisely, a 1% increase in greenhouse gasses emissions is stimulating the mortality rate by about 0.39% in emerging Asian countries. From the results, it is clear that addition to greenhouse gasses emission is increasing the incidence of respiratory diseases and mortality rate in emerging Asian countries if all other factors are considered constant. Thus the findings of present study endorsed the results of Hanif (2018a, b), Sapkota et al. (2013), Sumpter and Chandramohan (2013), Bonjour et al. (2013), Clark et al. (2013), and Baltagi and Moscone (2010). Moreover, the results indicate that greenhouse gasses emission has major contribution to the occurrence of respiratory diseases in the long run in countries under question. The empirical results highlight that air pollution in the form of greenhouse gasses emission is a serious concern and considered a primary cause of respiratory diseases in humans such as chronic obstructive pulmonary disease, asthma, and lung cancer, and these statistics are growing rapidly with high emissions of toxic gasses in the atmosphere. As the results of this study showed that greenhouse gasses emissions variable has significant positive influence on death rates in emerging Asian countries. Therefore, it can be concluded from the empirical results of this study that the current pace of greenhouse gasses emission in Asian emerging countries may lead the occurrence of aforementioned pulmonary disease, and the number of causalities may further increase at the regional level.

The combustion of fossil fuels also has a positive correlation with the incidence of respiratory diseases, and this interlink is also significant at 1%. It can be observed that a 1 % increase in the combustion of fossil fuels to produce energy is leading to an increase in the reported cases of respiratory diseases by about 0.35%. In a similar way, a 1 % increase in the use of fossil fuels increases the mortality rate by about 0.17%. It shows that increase in the utilization of nonrenewable energy sources is increasing the health risks significantly in emerging Asian countries by increasing the mortality rate and increasing probability of the respiratory diseases in the individuals (Bailis et al. 2005; Barnes 2014). The results depict that the coefficient of access to clean energy has a negative sign and significant at 10%. It reflects that 1% improvement in access to clean energy has the potential to decrease the incidence of respiratory diseases by about 0.21%. The results spotlight that accesses to clean energy also have

Table 5 Bound testing results

Dependent variable	*LogGHG, LogFUL, LogCLE, LogGDP, LogNRD*		
	F and W statistic	95% lower bound	95% upper bound
LogRPD	4.218/37.654	2.266	3.655
LogMOR	6.739/89.346	18.132	29.238

Table 6 Long-run estimates

A dependent variable is *LogRPD*			A dependent variable is *LogMOR*	
Variables	Specification 1	Specification 2	Specification 1	Specification 2
LogGHG	0.67*** (0.22)	0.48** (0.24)	0.39*** (0.17)	0.34*** (0.14)
LogFUL	0.35*** (0.15)	0.29*** (0.13)	0.17*** (0.09)	0.24** (0.11)
LogCLE	− 0.21* (0.12)	− 0.26** (0.14)	− 0.11** (0.06)	− 0.28*** (0.12)
LogGDP	− 0.84*** (0.34)	− 0.67** (0.37)	− 0.91** (0.47)	− 0.58*** (0.25)
Log GDP^2	–	− 0.89** (0.45)	–	− 0.68*** (0.27)
LogNRD	0.17** (0.08)	0.21* (0.12)	0.26** (0.14)	0.32* (0.19)

Significance levels are specified at 10, 5, and 1% and presented with *, **, and ***. Standard errors are in parentheses.

a negative interlink with mortality rate; it reflects that 1 % improvement in the access to clean energy has the potential to reduce mortality rate by about 0.11%. These results are highlighting the importance of access to clean energy resources, because the improvement in the provision of clean energy resources at domestic level may prove helpful to lower the health risks by controlling the prevalence of respiratory diseases and reducing the mortality rate in the emerging Asian countries (Barnes 2014; Beatty and Shimshack 2014).

The results also demonstrate a statistically significant and negative coefficient of per capita income that reflects the negative influence of improvement in per capita income and the incidence of respiratory diseases. According to the findings, 1% improvement in per capita income reduces the prevalence of respiratory diseases by about 0.84%. In a similar way, the results depict that a 1% increase in per capita income has the potential to reduce mortality by about 0.91%. The empirical results highlight the importance of the financial status of the individuals, and it can be argued that the countries with low per capita income have more health risks due to high mortality rate and incidence of respiratory diseases. Therefore, improvement in financial development and improvement in the access to clean energy are important factors to reducing health risks in emerging Asian countries (Brunekreef and Holgate 2002; Destek and Aslan 2017). In addition, by following the environmental Kuznets curve (EKC) hypothesis, a GDP square is introduced in Eq. (2) to test the nonlinear relationship between per capita income and the dependent variables, i.e., respiratory diseases and mortality rate. Under specification 2, the results show

Table 7 Short-run estimates

A dependent variable is *LogRPD*			A dependent variable is *LogMOR*	
Regressor	Specification 1	Specification 2	Specification 2	Specification 2
LogRPD(− 1)	0.73*** (0.28)	0.64*** (0.25)	–	–
LogMOR(− 1)	–	–	0.81** (0.41)	0.72** (0.36)
LogGHG	0.19* (0.11)	0.17** (0.09)	0.48** (0.26)	0.42* (0.24)
LogGHG(− 1)	0.08* (0.05)	0.07* (0.04)	0.81** (0.43)	0.67** (0.36)
LogFUL	0.51 (0.37)	0.48 (0.31)	0.71** (0.38)	0.52** (0.25)
LogFUL(− 1)	0.38 (0.22)	0.29 (0.18)	0.66** (0.35)	0.49* (0.28)
LogCLE	− 0.23 (0.16)	− 0.26 (0.18)	− 0.53* (0.30)	− 0.47* (0.27)
LogCLE(− 1)	− 0.12 (0.08)	− 0.14 (0.09)	− 0.49* (0.29)	− 0.38 (0.24)
LogGDP	− 0.71* (0.42)	− 0.53 (0.37)	− 0.98** (0.47)	− 0.62* (0.33)
LogGDP(− 1)	− 0.35* (0.21)	− 0.41 (0.29)	− 0.56** (0.26)	− 0.39 (0.24)
$LogGDP^2$	–	− 0.61* (0.36)	–	− 0.74*** (0.31)
$LogGDP^2(-1)$	–	− 0.43* (0.25)	–	− 0.37* (0.22)
LogNRD	0.41 (0.32)	0.39 (0.28)	0.21 (0.16)	0.26 (0.18)
LogNRD(− 1)	0.22 (0.18)	0.19 (0.13)	0.15 (0.11)	0.17 (0.12)
Intercept	− 3.82** (1.33)	− 2.37** (1.27)	− 4.35*** (1.77)	− 3.88*** (1.29)

Significance levels are specified at 10, 5, and 1% and presented with *, **, and ***. Standard errors are in parentheses.

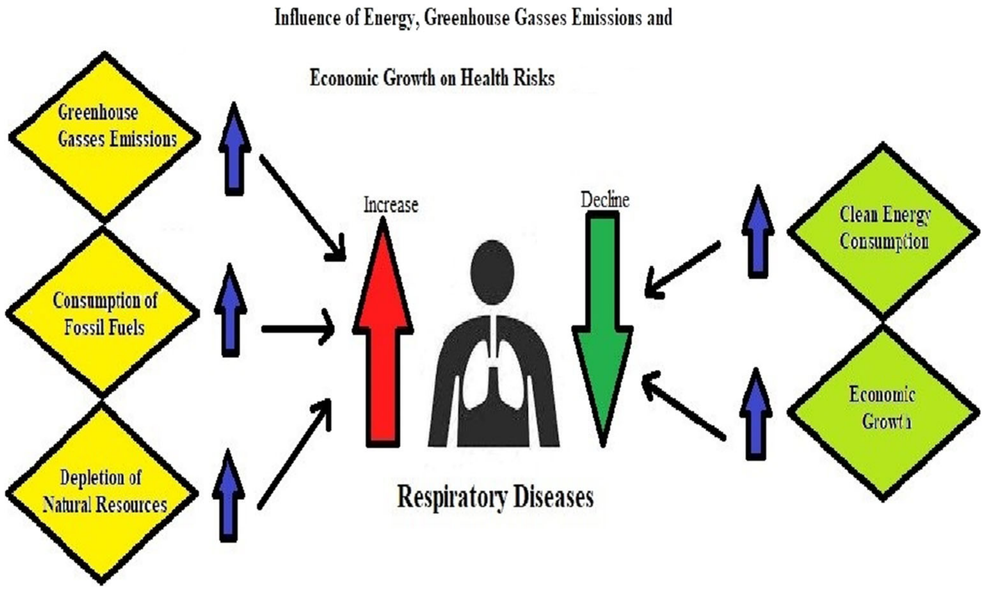

Fig. 4 Influence of energy, greenhouse gasses emissions and economic growth on health risks

that both models per capita growth square *(GDP^2)* have a negative and statistically significant relationship with respiratory diseases and mortality rate. Thus, it can be concluded that there exists a linear relationship between per capita income and the dependent variables. The results show that a further increase in per capita income could be helping to control the spread of respiratory diseases and lower mortality rate in emerging Asian economies.

The results demonstrate that coefficient of natural resources depletion has a statistically significant and positive sign. This reflects that a 1% increase in natural resources depletion leads to an increase in the incidence of respiratory diseases by about 0.17%. According to the results, a 1% increase in natural resources depletion contributes to mortality rate by about 0.26%. The present study highlights the importance of natural resources preservation for healthy living with low health risks in emerging Asian countries. In short, the factors which are directly or indirectly involved in environmental degradation are responsible for high health risks by increasing the incidence of respiratory diseases and health risks (Esso and Keho 2016; Hanif 2018a, b (Table 7).

The short-run results show that greenhouse gasses emissions are the only factor increasing the occurrence of respiratory diseases (Sanchez and Egea 2018; Bailis et al. 2005). For instance, a 1% increase in greenhouse gasses emissions is contributing to the prevalence of

Table 8 Results of error correction model

A dependent variable is *LogRPD*			A dependent variable is *LogMOR*	
Regressor	Specification 1	Specification 2	Specification 1	Specification 2
LogGHG	0.67*** (0.22)	0.48** (0.24)	0.39*** (0.17)	0.34*** (0.14)
LogFUL	0.35*** (0.15)	0.29*** (0.13)	0.17*** (0.09)	0.24** (0.11)
LogCLE	− 0.21* (0.12)	− 0.26** (0.14)	− 0.11** (0.06)	− 0.28*** (0.12)
LogGDP	− 0.84*** (0.34)	− 0.67** (0.37)	− 0.91** (0.47)	− 0.58*** (0.25)
$LogGDP^2$	–	− 0.89** (0.45)	–	− 0.68*** (0.27)
LogNRD	0.17** (0.08)	0.21* (0.12)	0.26** (0.14)	0.32* (0.19)
Δ*LogGHG*	0.27** (0.13)	0.29** (0.14)	0.21* (0.12)	0.32** (0.17)
Δ*LogFUL*	0.18 (0.11)	0.21 (0.13)	0.58* (0.33)	0.65* (0.37)
Δ*LogCLE*	− 0.38 (0.24)	− 0.32 (0.22)	− 0.47 (0.31)	− 0.39 (0.19)
Δ*LogGDP*	− 0.91 (0.69)	− 0.58** (0.31)	− 0.23 (0.14)	− 0.18 (0.11)
$\Delta LogGDP^2$	–	−0.71** (0.38)	–	−0.69*** (0.27)
Δ*LogNRD*	0.53 (0.38)	0.41 (0.29)	0.71 (0.43)	0.54 (0.37)
$ECM_{(-1)}$	− 0.41** (0.19)	− 0.21** (0.11)	− 0.23*** (0.09)	− 0.16*** (0.07)

Significance levels are specified at 10, 5, and 1% and presented with *, **, and ***. Standard errors are in parentheses.

Table 9 Results of diagnostic tests

Dependent Variable Log RPD				
	Specification 1		Specification 2	
Test statistics	LM version	F version	LM version	F version
Serial correlation	Chi2 (6) = 6.642 (0.00)	F(6,552) = 7.534 (0.00)	Chi2 (7) = 3.853 (0.00)	F(7,552) = 5.061 (0.00)
Functional form	Chi2 (6) = 0.365 (0.53)	F(6,552) = 0.238 (0.64)	Chi2 (7) = 0.478 (0.53)	F(7,552) = 0.205 (0.71)
Normality	Chi2 (6) = 3.566 (0.19)	—	Chi2 (7) = 4.392 (0.14)	–
Heteroscedasticity	Chi2 (6) = 0.547 (0.32)	F(6,552) = 0.218 (0.63)	Chi2 (7) = 0.738 (0.21)	F(7,552) = 0.239 (0.57)
Dependent variable log MOR				
Serial correlation	Chi2 (6) = 4.831 (0.00)	F(6,552) = 5.563 (0.00)	Chi2 (7) = 5.792 (0.00)	F(7,552) = 6.442 (0.00)
Functional form	Chi2 (6) = 0.437 (0.64)	F(6,552) = 0.227 (0.53)	Chi2 (7) = 0.362 (0.72)	F(7,552) = 0.208 (0.58)
Normality	Chi2 (6) = 4.162 (0.27)	—	Chi2 (7) = 5.128 (0.22)	–
Heteroscedasticity	Chi2 (6) = 0.801 (0.49)	F(6,552) = 0.677 (0.38)	Chi2 (7) = 0.902 (0.27)	F(7,552) = 0.576 (0.46)

respiratory diseases by about 0.8% if all other factors remained unchanged, while per capita income is the significant factor to control the incidence of respiratory diseases. According to the findings, 1% increase in precipitate income is reducing the prevalence of respiratory diseases by about 0.35%. However, in the short run, an increase in fossil fuels' utilization, improvement in access to clean energy, and depletion of natural resources are insignificant factor of the occurrence of respiratory diseases in emerging Asian countries.

Fig. 5 Model with respiratory diseases *(RPD)* as a dependent variable. **a** Plot of CUSM and CUSUM of square under specification 1; **b** Plot of CUSM and CUSUM of square under specification 2

The results depict that greenhouse gasses emissions and fossil fuels' utilization are the significant factors of high health risks by increasing the mortality rate (Bailis et al. 2005; Hanif 2018a, b. More precisely, a 1% increase in greenhouse gasses emissions and utilization of fossil fuels is contributing to the mortality rate by about 0.81 and 0.66%, respectively, while, access to clean energy and per capita income are significant factors to control health risks by reducing the incidence of respiratory diseases, in the short run. However, an increase in depletion of natural resources is an insignificant factor in the occurrence of respiratory diseases in emerging Asian countries. The summary of key findings is given in Fig. 4.

In short, the greenhouse gasses emissions and fossil fuel combustion for the sake of energy are the leading factors of high health risks in the short run and long run (Beatty and Shimshack 2014; Brunekreef and Holgate 2002; Hanif 2018a, b). Contradictory, improvement in per capita income and increase in the access to clean energy resources at domestic level are primary indicators to control health risks by monitoring the prevalence of respiratory diseases and lowering the mortality rate in emerging Asian countries.

According to the empirical results, greenhouse gasses emissions, consumption of fossil fuels, and depletion of natural resources are significant determinant stimulating the health risk in emerging Asian countries. Meanwhile, it is essential to mention that excess to clean energy and improvement in economic growth are the key determinants which can help to improve the health status of the individuals by controlling greenhouse gasses emissions in emerging Asian countries. To determine the equilibrium state in the model, the error correction model is also estimated, and results are given in Table 8 and 9.

The results in Table 8 show that in both cases, the ECM coefficients are significant and negative as well. The negative sign of $ECM_{(-1)}$ indicates the convergence of the model to attain the equilibrium state. In the model where respiratory diseases used as a dependent variable, the results show that 41% error corrected per year, while the model with a mortality rate as a dependent variable is reflecting 23% convergence rate to attain the equilibrium.

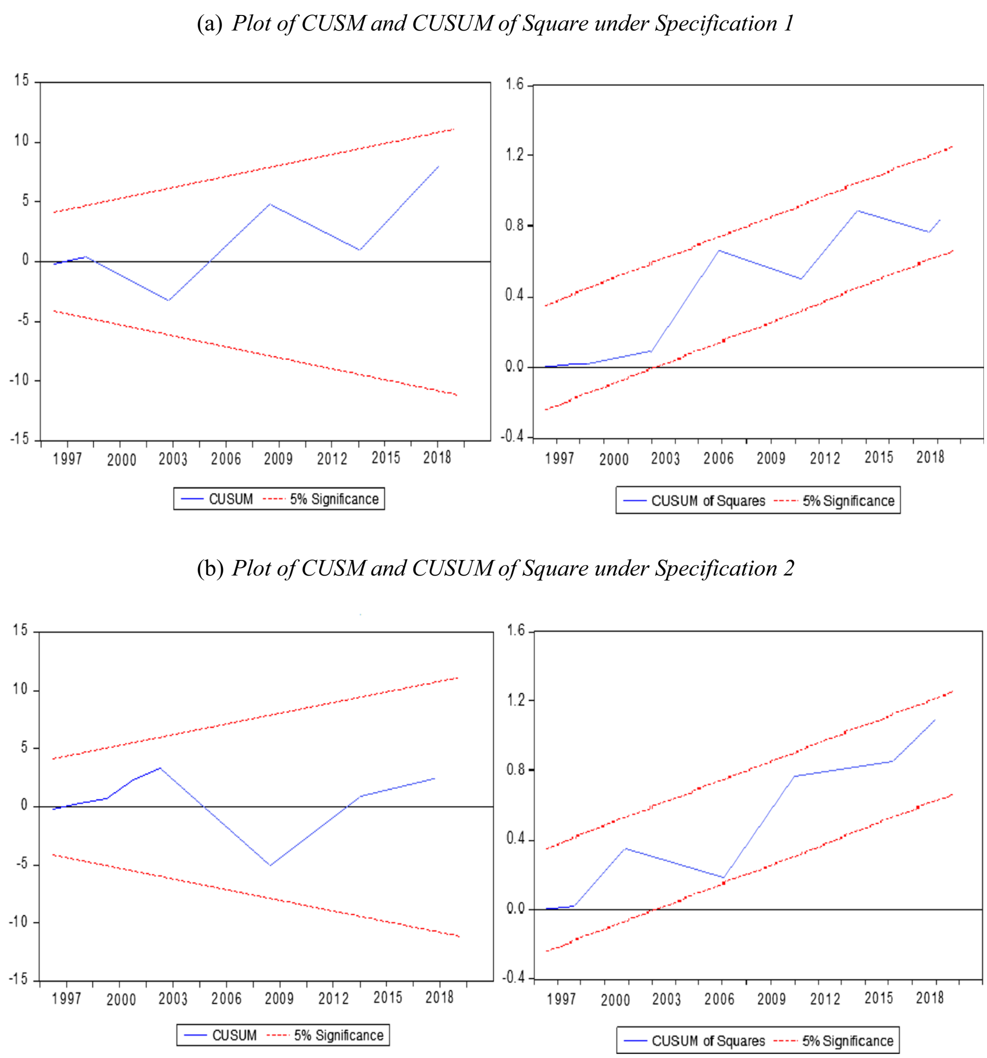

Fig. 6 Model with mortality rate *(MOR)* as a dependent variable. **a** Plot of CUSM and CUSUM of square under specification 1; **b** Plot of CUSM and CUSUM of square under specification 2

When per capita income square is introduced as an independent variable, the model with respiratory diseases as a dependent variable show that 21% error corrected per year, while the model with a mortality rate as a dependent variable is reflecting 16% convergence rate from short run to long run to attain the equilibrium.

The result of LM test for serial correlation depicts that serial correlation does not exist between the error term and health indicators. The results show that short-run models have no problem of non-normality of residual term, and error term is normally distributed with zero mean and covariance. The results of White heteroscedasticity test also show that all the models have no autoregressive conditional heteroscedasticity. Finally, the Ramsey RESET test is used to test the stability of the models by plotting graphs of the cumulative sum of recursive residual (CUSUM) and the CUSUM of squares in Figs. 5 and 6.

Conclusion

The present study determined the significant factor which is contributing to or controlling the health risks in emerging Asian countries. A panel data is analyzed by employing the ARDL estimation method to segregate the influence of economic, environmental, and energy indicators in the long- and short-run periods. Results show a positive association of greenhouse gasses emissions with mortality rate and mentioned that addition in greenhouse gasses emission is increasing the incidence of respiratory diseases and mortality rate. The combustion of fossil fuels also has a positive correlation with the incidence of respiratory diseases and mortality rate and increasing health risks significantly. The results depict that improvement in access to clean energy has the potential to decrease the incidence of respiratory diseases and to reduce mortality rate. These results highlighted the importance of access to clean energy resources, because an improvement in the provision of clean energy resources at the domestic level is capable of lowering health risks. In addition, the results demonstrate a significant role of improvement in per capita income to control respiratory diseases and mortality rate. Therefore, improvements in per capita economic growth and the access to clean energy are both critical factors to reduce health risks in emerging Asian economies. Furthermore, the empirical findings show that the depletion of natural resources is also a significant cause of high mortality rate and prevalence of respiratory diseases. The empirical results highlight the importance of economic growth, environmental preservation policies, and clean energy to get effective control over high health risks. The results depict that per capita growth square has a negative and statistically significant relationship with respiratory diseases and mortality rate, which indicate that there exists a linear relationship between per capita income and the dependent variables. These results show that a further increase in per capita income could control the spread of respiratory diseases and lower mortality rate in emerging Asian economies. However, the countries with low per capita income and high dependence on fossil fuels are more exposed to health risks due to high mortality rate and incidence of respiratory diseases. In short, this study spotlights that solid fuels and environmental degradation are both responsible for respiratory diseases and mortality rate. Thus the study suggests the promotion of clean energy production strategies to control the environment led health risks in emerging Asian countries. The promotion of clean energy production methods may also prove helpful to overcome the environmental issues by controlling greenhouse gasses emissions. Moreover, the strict compliance of natural resources preservation policies is also inevitable to control environment-related health issues. Finally, the economic, energy, and environmental policies such as carbon taxing, subsidized clean energy projects, and restricted reliance on natural resources may prove significant steps to control health risks in emerging Asian countries.

ANNEX-1

Rank	Country	Pollution Index (%)	% of renewable energy	Carbon emissions	Fossil fuel energy	Per capita GDP	Forest area (Sq. Km)
Central Asia							
1	Kazakhstan	72.82	1	5467.49	982.82	7952.67	982.82
2	Uzbekistan	–	2	96,219.54	1767.12	32,051.15	32,199.01
Eastern Asia							
1	Mongolia	93.8	3	11,973.88	253.31	569.43	253.31
2	China	88.96	18	4,751,043	1124.43	529.72	220.77
South Asia							
1	Bangladesh	92.3	38	33,269.56	143.65	14,615	143.65
2	Iran	82.51	1	381,505.4	673.4	99,560.2	673.4

3	Nepal	82.5	85	2780.57	427.47	923.55	427.47
4	Pakistan	80.08	45	108,569	427.98	1825.93	427.97
5	India	76.53	39	1,086,547	412.77	966.52	412.77
6	Sri Lanka	61.9	61	9189.51	2018.96	7553.05	2018.96
7	Maldives	–	1	501.67	132.97	3397.22	10
8	Bhutan	–	1	362.89	52.92	1537.204	26,308.24
Southeastern Asia							
1	Myanmar	91.37	79	8603.91	1177.93	2166.45	1177.94
2	Vietnam	88.1	36	71,203.83	407.14	964.17	407.14
3	Cambodia	79.3	73	2558.72	621.66	111,647.3	621.66
4	Indonesia	76.41	37	296,428.4	1124.43	1,012,323	1124.43
5	Thailand	73.23	23	190,579.8	388.17	660.98	388.17
6	Philippines	70.25	29	63,986.19	387.95	70,171.15	387.95
7	Malaysia	67.08	7	135,414.8	315.04	496.03	315.04
Western Asia							
1	Jordan	85.73	3	15,944.54	1954.05	4704.79	1954.05
2	Turkey	70.46	13	207,590.4	1182.68	8632.44	1182.68
3	Armenia	65.68	7	3366.73	813.16	2205.04	813.17
4	Syria	61.17	2	45,613.67	871.66	4430.38	871.66
5	Yemen	–	1	15,254.72	251.24	1111.543	5490

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