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RESEARCH ARTICLE

Striving towards sustainable development: how environmental degradation and energy efficiency interact with health expenditures in SAARC countries

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Abstract

The previous studies focused on environmental issues, identifying their root causes, urging prompt action to reduce environmental degradation. In this context, the current article extends the literature by incorporating the ecological impacts on the health sector and the role of sustainable development. The present study adds to the body of knowledge by examining the relationship between CO_2 emissions, sustainable development, energy efficiency, energy intensity, and health expenditures for SAARC countries from 2000 to 2020. Fully modified OLS (FMOLS) and dynamic OLS (DOLS) are used and diagnostic tests to check the association between the variables. The empirical analysis validated the long-run impact of the examined factors on health expenditures. The results show that energy efficiency and sustainable development have a statistically significant negative effect on health expenditures, vice-versa for CO_2 emission. Energy efficiency, energy intensity, and CO_2 emissions have been shown to have a one-way causative relationship with health expenditures, but sustainable development and economic growth have a two-way causation relationship. The better health status of the SAARC economies necessitates the establishment of long-term development strategies, environmental sustainability, and an examination of the energy sector. This work's conceptual and empirical advances have significant policy ramifications for this part of the globe and its efforts to improve sustainability.

Keywords Energy efficiency · Energy intensity · Environmental degradation · Health expenditures · SAARC countries · Sustainable development

Introduction

Health is a crucial element for a dynamic workforce, and work productivity relies mainly on the general health condition of the community (Akbar et al. 2020). Sustainable development aims to address humanity's self-development needs while preserving the natural environment's capacity to protect the habitats and services upon which human economies and populations depend. The assurance of improved health services for all citizens to create a safer world has become a significant global policy target. The United Nations (UN) proposed the Sustainable Development Goals (SDGs) in 2015, with health and welfare as primary priorities. The outlined SDGs in the 2030 Agenda for Sustainable Development provide a collective proposal for ensuring that we all will work and flourish in a prosperous and more sustainable environment (Ranjbari et al. 2021). The priorities are broad in scope, encompassing opportunities and obstacles for growth ranging from water, electricity to the environment, ecology, food, employment, creativity, wellness, and hunger. At national, regional, and local levels, efforts are required in all sectors to achieve these 17 goals and 169 objectives. SDG 3 puts health at the core of the agenda, and it is closely tied to more than a dozen other goals, including urban health, fair access to treatments, and noncommunicable diseases.

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Indeed, the SDGs provide a once-in-a-lifetime opportunity to enhance public health via an integrated approach to public policy across many sectors (Hák et al. 2016). Better education for girls (goal 4.1) improves maternal health (goal 3.1); combating child malnutrition (goal 2.2) has a significant impact on child health (goal 3.2), and ensuring access to safe water (6.1) or combating ambient air pollution (11.6) has a direct effect on several SDG 3 targets. However, using coal to enhance energy availability (goal 7) would harm one's health. Consequently, to enhance synergies between particular SDGs and minimize trade-offs, attaining the health goals would require policy consistency (Hussain et al. 2020). The "Sustainable Development" paradigm outlined in Agenda 21 is based on three philosophical pillars: social sustainability, economic sustainability, and environmental sustainability (Aye and Edoja 2017). Ecological sustainability is contingent upon the ecosystem's stability and the carrying capacity of the natural environment. So, it is essential to use natural resources at the rate they can be recovered. Simultaneously, waste should not be emitted at a pace more remarkable than that at which the environment absorbs it because the earth's systems are bounded and constrained (United Nations 2017; Haller 2018).

Moreover, environmental degradation is likely to stifle development and progress, raise vulnerability, harm people's health, and force them back into poverty (Fankhauser and Stern 2016). According to the WHO, 250,000 deaths are expected per year between 2030 and 2050 caused by climate change, from malnutrition, malaria, diarrhea, and heat stress. As global temperatures rise, the number of deaths and heat stress illnesses such as heat stroke and cardiovascular and kidney disease also increase. In addition, respiratory health is negatively affected by worsened air quality, mainly for the 300 million people living with asthma globally. In the absence of proper and significant global climate change mitigation actions, distractive and extreme events are expected to increase. Emerging nations and lower-income people would be affected extremely hard. According to Cutler et al. (2006), growing urbanization in the USA has a negative impact on health. Urbanization exacerbates sanitary issues and allows more illnesses to spread among people. CO_2 emissions do contribute to climate change and global warming. Pollutants are released into the atmosphere as a result of human activity. It has a significant impact on human health, causing illnesses ranging from respiratory difficulties to lung cancer. Furthermore, the production of goods emits significant amounts of CO_2 that last for a long period of time. All of these elements have significantly degraded our environment and produced dangerous threats. One of the most serious consequences of pollution is a health risk. On the one hand, technology has revealed a solution for many ailments, yet on the other hand, it has contaminated our air with pollutants that cause unique and distinct diseases (Naeem et al. 2021).

Some studies have shown a link between CO_2 emissions and health expenditures, such as Zhang et al. (2018) in China who found that air pollution is the world's fourth most serious hazard to human health, the environment, and the economy. Furthermore, Abdullah et al. (2016) discovered a positive effect of CO_2 emissions on health expenditures and economic development. Chaabouni et al. (2016), Siti Khalijah (2015), and Toplicianu and Toplicianu (2014) have also investigated the influence of environmental degradation on health expenses and discovered a substantial association. Similarly, Bedir (2016) and Ke et al. (2011) explored a positive and substantial association between economic growth and health expenses. According to Saida and Kais (2018), environmental challenges, notably CO_2 emissions, have had major effects in recent decades, particularly for health. In their research of 30 Chinese provinces, Lu et al. (2017) discovered a detrimental influence of CO_2 emissions and other environmental contaminants on public health; nevertheless, health and medical conditions were documented bearing considerable involvement in growth and health promotion. Previous panel studies of health spending and CO_2 emissions corroborated the positive and causal link (Chaabouni and Saidi 2017; Chaabouni et al. 2016). According to the results of Wang et al. (2019), environmental deterioration and economic expansion have a considerable impact on health costs.

According to our best knowledge, there is little literature on the association between CO_2 emissions and health spending since academics have paid less attention to this area, particularly in South Asian Association for Regional Cooperation (SAARC) nations. Furthermore, the growing threats posed by CO_2 to human health and economic growth motivate us to consider the links between carbon emissions, economic growth, and health expenditures and to quantify how CO_2 emissions, energy efficiency, and economic growth in the SAARC region affect health expenditures.

A substantial percentage of the world's population has been affected by health concerns and is experiencing a significant increase in health expenditures and global health issues (Akbar et al. 2020). Countries like SAARC (Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka) are rich in natural and human resources (Rafay and Farid 2017). But they are more reliant on climate-sensitive economic sectors, and their ability to adapt is insufficient. Poor people are much more likely to live in danger zones, such as flood-prone areas, and their properties are at risk of being damaged by severe weather conditions. They are also more vulnerable to insects and illnesses brought on by heatwaves, flooding, and dehydration (Losos et al. 2019). However, with a total land area of 4,771,604 km^2 and a population of 1,835.3 million, approximately 20% of the population lives in poverty (United Nations 2019). According to World Development Indicators, in 2019, the average life expectancy was 71.4 in this region, where the highest was (79 years) which belongs to the Maldives and the lowest (65 years) belongs to Afghanistan. On average, the infant mortality rate in the region is 27.3 per thousand; in this, Pakistan is leading with 55.7 per thousand, and Sri Lanka has a minimum number of deaths of 6.1 per thousand. Moreover, the average current health expenditures in 2019 were (5.07% of GDP). However, various health-related factors such as environment, energy, public, personal health budgets, cleanliness, and sanitary considerations are not adequately considered (Rahman and Khanam 2018).

Figure 1 demonstrates the health expenditures in the SAARC region from 2000 to 2019. As seen in the figure, health expenditures are increasing in all countries. In the Maldives, there was a downward turn in 2008. However, overall, the health expenditures in the Maldives are higher than in other countries.

No one can deny the fact that these disasters are the consequences of environmental damage. Different indicators have been used to measure environmental degradation in prior research, such as NOx, CO_2 emissions, and SO_2. Moreover, according to the Intergovernmental Panel on Climate Change (IPCC), CO_2 emissions are the leading contributor to global climate change. Amounts of it in the atmosphere have increased quicker than in pre-industrial eras (IPCC 2019). CO_2 emissions can cause health problems and respiratory sickness in people, placing pressure on governments to devote more money to public health initiatives. The sustainability and stability of climatic conditions directly affect national health expenditures (Apergis et al. 2020). According to the Energy Information Administration (EIA), CO_2 emission was 5,140 mt in 2019, and developing countries are predicted to increase CO_2 emissions by 127% by 2020 compared to the developed countries. Figure 2 shows the levels of CO_2 emissions in SAARC countries. We can see that the emission level in the Maldives is surpassing all the other countries in the region. Thus, overall there is an increasing trend of CO_2 emission in the region.

Various researchers concluded that fossil fuel consumption has a positive association with pollution levels, whereas non-fossil fuel usage have been shown to reduce carbon footprint levels, especially in developing countries (Rehman et al. 2021a, b, c; Chishti et al. 2021; Murshed et al. 2021; Weimin et al. 2021). Rehman et al. (2021a, b, c) found that negative GDP per capita growth shocks indicate a significant increase in economic advancement, whereas positive shocks indicate an undesirable impact on economic growth in China. The findings suggest that fossil fuel energy consumption has a positive influence on economic growth, and that variable CO_2 emissions have also shown positive shocks that have a major impact on economic growth. Furthermore, the results of the long-run study show that energy use has both negative and positive shocks, exposing China's detrimental impact on economic advancement. In both shocks, GDP per capita growth revealed a positive impact on economic growth. In the case of Pakistan, CO_2 emissions from the transportation industry have a negative influence on Pakistan's long-term development. The findings of Rehman et al. (2021a) show that CO_2 emissions from Pakistan's transportation sector have an impact on the country's economic development. Positive shocks to such CO_2 emissions have been shown

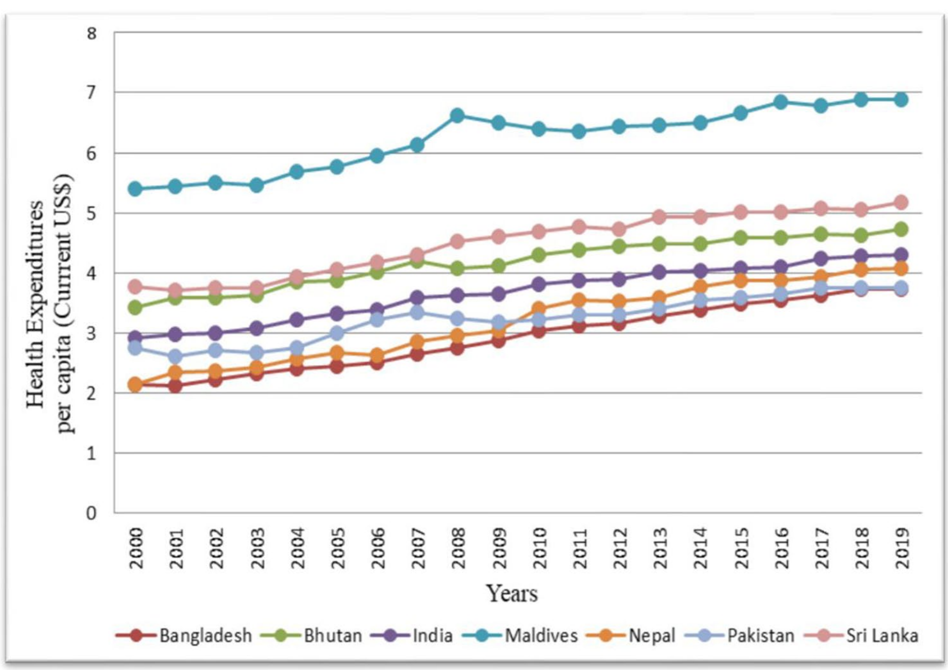

Fig. 1 Trends of health expenditures in SAARC region (Source: WDI)

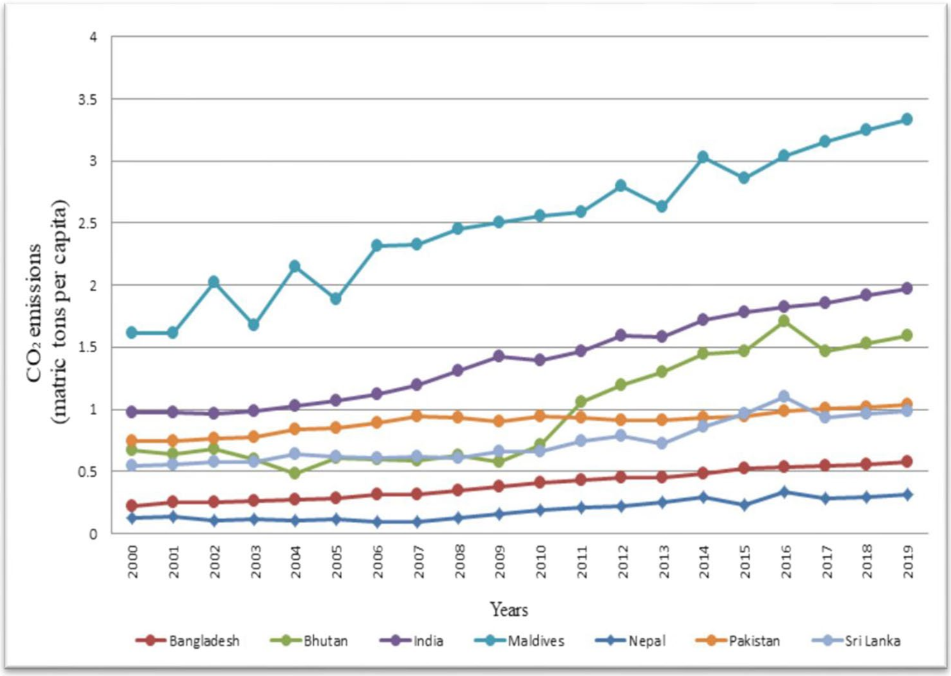

Fig. 2 Trends of CO_2 emission in SAARC region (Source: WDI)

to hinder economic development in the long run, whereas negative shocks have been shown to promote growth in the short and long term.

In addition, the main reasons for CO_2 emissions are excessive energy use (Khan et al. 2019; Xinmin et al. 2020). Akbar et al. (2021b), Hafeez et al. (2019), and Yuelan et al. (2019) have shown that energy utilization has been increasing for many years as economic growth is expanding and found a significantly positive and bidirectional causal association between CO_2 emission and energy use. When local manufacturing businesses extend their operations to achieve economies of scale via mass production, they use more energy, leading to more health problems (Sethi et al. 2020). The manufacturing industry not only pollutes the air but also causes water and land pollution. In return, agriculture sectors also get affected, directly affecting a person's health. Furthermore, an increase in a country's economic activity creates an increase in energy demand and increases its energy consumption.

Moreover, some studies (such as Weimin et al. 2021; Hussain and Rehman 2021; Chishti et al. 2021) have found a negative relationship between renewable energy consumption and environmental pollution levels and concluded that renewable energy consumption improves environmental quality. They also discovered a positive and significant relation between FDI and CO_2 emissions, while in the case of PIC nations (Pakistan, India, and China), Ozturk et al. (2021a, b) estimated that energy structure raises CO_2 emissions, but energy intensity can lower CO_2 emissions. Various researchers found a positive relationship between energy usage and pollution levels and concluded that increased energy usage have an adverse impact on carbon emissions (Rehman et al. 2021a, b, c; Ozturk et al. 2021a, b; Murshed et al. 2021; Ahmad et al. 2020).

The primary indicators for resolving climate change are likely to be energy efficiency and renewable energy. According to many studies, energy efficiency may decrease CO2 emissions (Liobikien and Butkus 2017). According to Özbuğday and Erbas (2015) and Shahbaz et al. (2013), nuclear energy use reduces CO_2 emissions. The conversion of the energy mix to renewable energy is crucial in a worldwide environmental acknowledgment of green energy sources and ecologically friendly surroundings. It may play a vital role in protecting the environment and human health. As per the International Energy Agency (IEA), energy demand in Southeast Asia is expected to surge by 80% between 2013 and 2035. Conventional energy is one of the leading causes of environmental degradation and climate change (Akbar et al. 2021a, b).

In Fig. 3, we can see that the use of energy-efficient technologies in the region is shallow. Apart from Sri Lanka, energy-efficient techniques are the same throughout other countries. In fact, in Bhutan and Maldives, there is a decline in the trends from 2007. Energy efficiency can be shown by GDP per unit of energy use in the SAARC region. Most countries consume 95% of non-renewable energy, causing environmental damage in the SAARC region.

In light of the above discussion, it is clear that different factors are depleting the environmental quality and there are also some ways to save our environment. With the fact

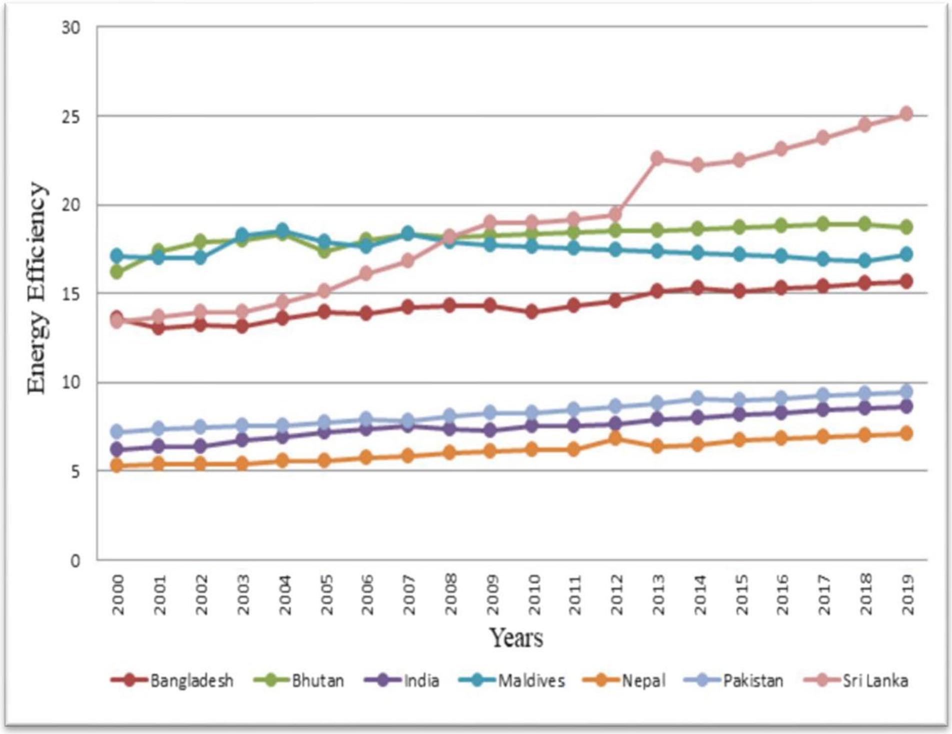

Fig. 3 Trends of energy efficiency in SAARC region (Source: WDI)

that our environment is degrading at a very fast speed as the countries move towards industrialization, so it is also very important to know the effects on human health in the SAARC region. The previous pieces of research do not ponder to evaluate the nexus among sustainable development, energy efficiency, environmental degradation, and health expenditures for SAARC countries. Sustainable development and environmental degradation play a substantial effect in the health sector. Therefore, the main aim of the present study is to explore the relationship between health expenditures, energy efficacy, energy intensity, environmental deterioration, and sustainable development. In contrast with previous studies, the present study's uniqueness is as follows. The study develops a sustainable development index for SAARC countries. The current research uncovered the nexus between sustainable development, energy intensity, energy efficiency, environmental degradation, economic growth, FDI, and health expenditures for SAARC countries. The rest of the paper has been structured as follows: the "Data and methodology" section explains the data and econometric model specification of the study. The "Empirical results" section elucidates the results and analysis. The "Discussion" section includes discussions on research findings. The "Conclusions, Policy implications, and limitations" section concludes the study and offers policy recommendations. Finally, the "Limitations" section discusses research limitations and future work.

Data and methodology

Data and variables description

Data for CO_2 emission, energy efficiency, energy intensity, health expenditures, FDI, and GDPc has been extracted from the World Development Indicators (2021) from 2000 to 2020 for the selected participants based on data availability, i.e., Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka. Afghanistan is not in the data set due to the unavailability of data. CO_2 emissions metric tons per capita have been taken as a proxy for environmental degradation because, in contrast to NOx and SO_2 impacts, CO_2 emissions pave the way for global-scale issues. Compared to others, CO_2 emissions have a significantly greater atmospheric half-life (Yang et al. 2015). The atmospheric half-life of NOx is 3 to 5 h (Boon and Marletta 2006), SO_2 is 6 to 1 day (Brimblecombe1996), and almost 27 years of CO_2. Also, CO_2 emissions are widely used by previous researchers (Akbar et al. 2021a, b; Khan et al. 2020a, b; Xinmin et al. 2020) (Akbar et al. 2021b; Hafeez et al. 2018; Khan et al. 2020a, b; Xinmin et al. 2020). GDP per unit of energy use has been used for energy efficiency (Akbar et al. 2021b; Malinauskaite et al. 2019; Nasir et al. 2021). Gross domestic product has been considered a variable for economic growth in GDP per capita growth annual percentage as many scholars like

Ike et al. (2020), Khan et al. (2021), and Sun et al. (2021). FDI, net inflows used as FDI as previously researchers used in their studies (Akbar et al. 2021a) (Charfeddine and Kahia 2019). Health expenditures per capita current US dollars have been taken in the study (Akbar et al. 2020; Rahman and Khanam 2018; Ullah et al. 2020). Energy intensity level primary energy has also been taken (Bekun et al. 2019; Chang et al. 2018; Emir and Bekun 2019; Lin and Raza 2019). We measured sustainable development by incorporating social, economic, and environmental factors. Life expectancy, labor force participation, and education have been taken as social factors. GDP, employment, and FDI as economic and energy intensity as an environmental factor have been taken in the study following Li et al. (2021). To obtain the index for sustainable development, we use principal component analysis (PCA) (Mahmoudi et al. 2021; Odhiambo et al. 2021; Schreiber 2021). The variable description is given in Table 1, and the results of the principal component analysis are given in Table 2. The first component's eigenvalue is 38.67, showing 38.67% variation is explained by this variable, and then the other components (Hafeez et al. 2019). Equation 1 depicts the computation of the sustainable development index.

$$SD = \sum_{i=1}^{7}, w_i \times SD_i \quad (1)$$

In Eq. 1, "i" shows the 7 sub-dimensions; SD1 = GDP per capita, SD2 = FDI, SD3 = education, SD4 = employment, SD5 = labor force participation, SD6 = life expectancy, and SD7 = energy intensity. The weight of each indicator is shown with W_i and calculated as follows:

$$Wi = \left(\frac{Vi}{\sum_{i=1}^{7} Vi} \right) \quad (2)$$

where V_i is the ratio of variation explained by each indicator.

Econometric model specification

In the age of globalization, residual interdependence and common factor omitting cross-sectional dependence are common issues in the panel data studies. So we begin our analysis with the cross-sectional dependency test because unobserved factors and shocks that form part of the error term are likely to generate significant cross-sectional dependency in panel data models and give misleading and spurious results. The null hypothesis of the cross-sectional dependency test is that there is no cross-sectional dependency, whereas the alternative hypothesis is that cross-sectional dependence does exist. Afterward, unit root tests were used to confirm the variables' integration level because the existence of unit root can cause issues like false results. Different unit roots are used to validate the findings and to ensure their robustness. Therefore, Levin, Lin and Chu

Table 2 Principal component analysis results

Component (C)	Eigenvalue	Difference	Proportion	Cumulative %
C1	2.707	1.168	0.387	38.67
C2	1.539	0.502	0.220	60.65
C3	1.037	0.162	0.148	75.46
C4	0.875	0.875	0.125	87.96
C5	0.381	0.117	0.054	93.4
C6	0.264	0.067	0.038	97.17
C7	0.197	0	0.028	100
SD Indicators	Variation explained by indicators			
SD1	0.972			
SD2	0.828			
SD3	0.825			
SD4	0.768			
SD5	0.591			
SD6	0.829			
SD7	0.470			

C1 to C7 are the components of PCA. SD1 = GDP per capita, SD2 = FDI, SD3 = education, SD4 = employment, SD5 = labor force participation, SD6 = life expectancy, and SD7 = energy intensity.

Table 1 Description of variables

Considered variables	Variable description	Abbreviations	Source of data
Sustainable development	Extracted by using PCA (employment, life expectancy at birth, education, labor force participation, FDI, energy intensity, and GDP)	SD	WDI
CO_2 emission	Metric tons/pc	CO_2	WDI
Economic growth	GDP per capita annual growth %	GDP_C	WDI
Energy efficiency	Gross domestic product per unit of energy (PPP constant 2017 per kg oil equivalent)	EE	WDI
Foreign direct investment	Foreign direct investment, inflows percentage of GDP	FDI	WDI
Health expenditures	Health expenditures per capita current US dollars	HE	WDI
Energy intensity	Energy intensity level primary energy	EI	WDI

Source: World Development Indicator

(LLC) (Levin et al. 2002), Pesaran and Shin (IPS) (Im et al. 2003), ADF Fisher (Maddala and Ã 1999), and Philips Peron unit root tests were utilized in this research. The long-run connections identifications among considered variables are essential before estimating the econometric model. Therefore, we used the cointegration test proposed by Pedroni (Pedroni 1999), Johanson, and Fisher combined cointegration test developed by Maddala (Maddala and Wu 1999), and Kao residual test (Mouelhi 2021). Dynamic ordinary least squares (DOLS) and fully modified ordinary least square (FMOLS) are used for the cointegration regression analysis to evaluate the long-run sensitivities. FMOLS is helpful to address the issue of autocorrelation and endogeneity (Marimuthu et al. 2021). For unbiased estimators, FMOLS and DOLS perform better than OLS (Akbar et al. 2021a, b; Marimuthu et al. 2021).

We aim to find the nexus between health expenditures, environmental degradation, energy efficiency, sustainable development, and energy intensity for SAARC countries. In the panel data analysis, it is essential to consider the time and country effects so by following existing literature (Akbar et al. 2021a, b; Xinmin et al. 2020), the following functional form of the model is used in this study:

$$HE_{it} = f\left(CO_{2it}, EI_{it,}EE_{it}, FDI_{it}, GDPc_{it}, SD_{it}, U_{it}\right) \quad (3)$$

The estimated model's econometric form is given below:

$$HE_{it} = \delta i + \lambda i + \beta 1_i CO_{2it} + \beta 2_i EI_{it} + \beta 3_i EE_{it} + \beta 4_i FDI_{it} + \beta 5_i GDPc_{it} + \beta 6_i SDc_{it} + \mu_{it} \quad (4)$$

The above-written equation, "i" shows the explicit SAARC country, and "t" specifies time. In the given model, λ_i and δ_i state the trends and specific country effects, while β_1 *to* β_6 are the impact magnitude of CO_2 emission, energy intensity, energy efficiency, FDI, GDPc, and sustainable development, respectively.

Empirical results

Descriptive statistics

Table 3 represents descriptive statistics and a correlation matrix of the variables taken in the study. As a result, the statistical natures of the variables in the research are consistent with being considered for panel data estimation. Low correlation between independent variables will reduce the issue of multicollinearity. The correlation matrix shows that health expenditures strongly relate to energy efficiency, CO_2 emissions, sustainable development, and FDI. The variance inflationary factor (VIF) results are given in Table 4. The results showed no multicollinearity issue, as all the VIF values are less than 5.

The cross-sectional dependence tests are presented in Table 4, which shows that the probability value is 0.6325, i.e., greater than 0.05. Based on this *p*-value, we can

Table 4 Variance inflationary factors and cross-sectional dependence result

Variance inflation factors	
Variable	VIF
FDI	4.090
EI	1.569
EE	1.567
CO_2	2.870
GDPc	1.094
SD	2.742
No cross-sectional dependence (null hypothesis)	Rej criteria: Stats $p < 0.05$
	0.478 (0.633)

Table 3 Descriptive statistics

	HE	EE	EI	FDI	CO_2	GDPc	SD
Mean	3.992	12.975	5.875	2.009	1.013	1.296	0.820
Maximum	6.880	25.099	21.794	15.794	3.336	3.139	2.654
Minimum	2.123	5.347	1.527	−0.676	0.098	−2.813	0.001
Std. Dev	1.168	5.352	3.900	2.837	0.769	0.751	0.568
Observations	140	140	140	140	140	140	140
HE	1						
EE	−0.615***	1					
EI	0.214***	−0.060***	1				
FDI	0.750***	0.311***	−0.214***	1			
CO_2	0.833***	−0.316***	0.236***	0.795***	1		
GDPc	0.174**	0.251***	0.085***	0.062	0.043	1	
SD	−0.557***	0.488***	−0.288***	0.583***	−0.399***	0.092	1

***Significant at 1% level of significance * significant at 10% level of significance conclude that the null hypothesis of no cross-sectional dependence cannot be rejected.

Results of panel unit root

After confirming no cross-sectional dependence in the data, the results of unit root tests are given in Table 5, which confirmed that all variables are integrated of order zero, i.e., all variables are stationary at level. According to these results, we can reject all the null hypotheses of a unit root. The results show that all the variables are stationary where the *p*-value is less than 0.05, and therefore, all the variables are integrated of I(0). These results enabled us to analyze panel regression to check unexpected shocks and structural changes.

Results of panel cointegration and long-run estimates

The next step after the unit root test is to check for the long-run relationship by applying cointegration tests. These tests include the Pedroni panel cointegration test, Fisher-Johanson combined cointegration test, and Kao residual cointegration test. Pedroni panel cointegration test (1999, 2004) comprises seven statistical values to decide whether there are long-run relationships among variables or not. These statistical values include panel ADF statistics, panel v statistics, panel PP statistics, panel rho statistics, three group statistics rho, ADF, and PP. Table 6 shows the results of the Pedroni panel cointegration test. Rejection of the null hypothesis, i.e., no cointegration, based on that the most statistical values must be significant at 1%, 5%, or 10% level of significance. The findings have confirmed the long-term relationship between health expenditure, sustainable development, climate change, FDI, GDP per capita, energy efficiency, and energy intensity in the SAARC panel. The *p*-values and t-stat given in the table confirmed that six out of seven statistical values are significant.

The Fisher panel cointegration test was developed by (Maddala and Wu 1999). This test is applied to validate the Pedroni panel cointegration test results. Moreover, to authenticate the results of the above two tests (Pedroni panel and Fisher-Johanson combined cointegration test), this study also applied the Kao residual cointegration test. The Fisher panel and Kao residual cointegration test results are shown in Table 7, confirming long-term relationships among all variables. So, all three tests suggested a long-term relationship between health expenditure and all independent variables in SAARC economies.

Results of dynamic OLS and fully modified OLS

As the above tests confirm the long-term association between all the variables, we move towards the cointegration regression analysis. The nature of the cointegration test is only to ensure the presence long-rum relationship. So, to estimate the dynamics and nature of causality for the SAARC panel, this study employed DOLS and FMOLS. Results presented in Table 8 revealed that FDI positively affects health expenditure in SAARC economies. It can be inferred from results that a 1 unit increase in FDI will increase health expenditures by 5.5% according to DOLS results and 8.79% according to FMOLS results. The relationship between energy intensity and health expenditures is positive and statistically significant. It indicates that due to a 1 unit increase in energy intensity, health expenditures will increase by 25.24% according to DOLS and around 5.12% according to FMOLS, and the results are similar to A. Akbar et al. (2020) and Ullah et al. (2020). On the other hand, energy efficiency has negative and statistically significant values for DOLS and FMOLS. According to DOLS and FMOLS results, a 1 unit increase in energy efficiency will decrease the health expenditures by 10.18% and 15.55%, respectively. For economic growth, results showed that an increase in GDP per capita leads to a rise in health expenditures by 12.38% according to DOLS and 49.4% according to

Table 5 Unit roots results

Variables	LLC	IPS	ADF	PP
HE	0.000***	0.006***	0.015**	0.000***
SD	0.006***	0.069*	0.066*	0.075*
FDI	0.002***	0.027**	0.026**	0.035**
GDPc	0.000***	0.000***	0.000***	0.001***
CO_2	0.000***	0.000***	0.000***	0.000***
EE	0.001***	0.000***	0.001***	0.000***
EI	0.000***	0.000***	0.000***	0.000***

***Significant at 1% level of significance, ** significant at 5% level of significance, * significant at 10% level of significance

Table 6 Pedroni cointegration results

Within dimension		Between dimension	
Panel v-Statistic	– 1.697** (0.045)	Group rho-Statistic	2.134 (0.984)
Panel rho-Statistic	– 2.885*** (0.002)	Group PP-Statistic	– 2.134** (0.016)
Panel PP-Statistic	– 1.604* (0.054)	Group ADF-Statistic	– 4.205*** (0.000)
Panel ADF-Statistic	– 3.267*** (0.001)		

***Significant at 1% level of significance * significant at 10% level of significance

Table 7 Fisher and Johanson combined cointegration and Kao residual cointegration results

Fisher and Johanson combined cointegration results		
No cointegration: null hypothesis		Reject criteria: $p < 0.05$
Hypothesized No. of CE(s)	Fisher stat from trace test (*p*-value)	Fisher Stat from the max-Eigen test (*p*-value)
None	9.704 (0.014)**	9.704 (0.014)**
At most 1	6.931 (0.005)***	43.77 (0.000)***
At most 2	13.110 (0.074)*	128.9 (0.000)***
At most 3	128.9 (0.000)***	128.9 (0.000)***
At most 4	111.5 (0.000)***	78.13 (0.000)***
Kao Residual Cointegration Results		
No cointegration: null hypothesis		Reject criteria: $p < 0.05$
		−2.079 (0.019)**

***Significant at 1% level of significance, ** significant at 5%, and * significant at 10%

Table 8 Long-run dynamics

Variables	DOLS		FMOLS	
	Coefficients	Prob	Coefficients	Prob
FDI	0.055*	0.075	FDI	0.055*
Energy Intensity	0.252*	0.067	Energy intensity	0.252*
Energy Efficiency	−0.102*	0.097	Energy efficiency	−0.102*
SD	−0.472***	0.008	SD	−0.472***
GDPc	0.124**	0.028	GDPc	0.124**
CO_2	0.708*	0.067	CO_2	0.708*

***Significant at 1% level of significance, ** significant at 5% level of significance, and * significant at 10%

FMOLS. The effect of GDP per capita on health expenditure is statistically significant at the 5% and 10% significance level, respectively.

The coefficient value of CO_2 emission is positive and statistically significant, implying that as the CO_2 emission increases by 1 unit, health expenditure will also increase by 70.8 percent, conferring the results of DOLS and by 13.8% to FMOLS. On the other hand, the variable of sustainable development will reduce the health expenditures, as the coefficient of SD has negative and statistically significant values for both DOLS and FMOLS. Thus, according to DOLS, if there is a 1 unit increase in sustainable development, health expenditure will decrease by 47.2%, and FMOLS results show a reduction of 87% in health expenditures.

Pairwise Dumitrescu and Hurlin panel causality test

However, the above analysis confirms the long-run association among variables; still, it is not enough for establishing the causal relationship. Therefore, to figure out the causal relationship for SAARC economies, heterogeneous panel causality test is employed to deal with this problem. This test is based on the Granger causality test and was developed by Dumitrescu and Hurlin and appropriate technique to estimate causality for both short-run and long-run panel data (Dumitrescu and Hurlin 2012). It also addresses the problem of heterogeneity using W-bar and Z-bar statistics.

The results presented in Table 9 indicate that health expenditures and sustainable development have statistically significant values, which means both cause each other. The *p*-values confirm that health expenditures also change due to changes in CO2 emission, but there is no causal effect of health expenditures on CO_2 emission. According to the results, there is a bi-directional relationship as far as GDP and health expenditures are concerned. The results confirmed this bi-directional causality among sustainable development and health expenditures. In the case of energy efficiency and energy intensity, both Granger causes health expenditures, but health expenditures do not have a causal effect on EE and EI.

Results of innovative accounting approach

For this study, we used the innovative approach to accounting when examining the relationship between variables. We used variance decomposition and impulse response analysis. A more creative approach to accounting is essential for analyzing economic interactions. It provides a quantitative

Table 9 Pairwise Dumitrescu and Hurlin panel causality test results

Null hypothesis	w-bar stat	z-bar stat	*p*-value	Decision
SD ≠ cause HE	5.581	2.996	0.003***	Bidirectional causality
HE ≠ cause SD	5.632	3.044	0.002***	SD ↔ HE
EE ≠ cause HE	7.104	4.438	0.000***	Unidirectional causality
HE ≠ cause EE	2.133	0.042	0.969	EE → HE
EI ≠ cause HE	5.414	2.978	0.028**	Unidirectional causality
HE ≠ cause EI	2.514	0.140	0.888	EI → HE
CO_2 ≠ cause HE	12.10	9.068	0.000***	Unidirectional causality
HE ≠ cause CO_2	1.102	−1.175	0.240	CO_2 → HE
GDPc ≠ cause HE	4.161	1.675	0.094*	Bidirectional causality
HE ≠ cause GDPc	5.381	2.810	0.005***	GDPc ↔ HE

*Significant at 10% level of significance, **significant at 5% level of significance, ***significant at 1% level of significance

representation of the relationships and interactions between the variables compared to Granger causality analysis and is supported by the simple VAR model and cointegration theory (Athanasios et al. 2021). The results in Table 10 show that foreign direct investment described an 8.8% variation in health expenditures in 5 years and 55% in 10 years. Similarly, the variation of GDP in health expenditures is about 8.33 units in the 5-year horizon and 9.784 units in 10 years because of shocks on economic growth. Energy intensity and energy efficiency described 11.5% and 14% of the variation in health expenditures in 5 years, respectively, and in 10 years, horizon variations are 7.18% and 14.8%, respectively.

Environmental degradation had 5.12% and 4.8% of the variation in health expenditures in the coming 5 years and 10 years, respectively. Likewise, sustainable development showed around 3.86 units of deviation in 5 years and 7.15 units variation in 10 years in health expenditures. Further, we will explain the variations due to independent variables used in this study. The variation of health expenditures in FDI is 2.736 units and 3.242 units in 5 years and 10 years horizons, respectively. The energy-related variables used in this study, such as energy efficiency and energy intensity, described 0.21 and 2.87 units variation in 5 years and 0.304 and 3.315 units in 10 years in foreign direct investment. Thus, the share of CO_2 emission in FDI is about 0.95 units in 5 years and 2.13 units in 10 years.

Similarly, gross domestic product and sustainable development show a 4.86 and 5.52 units' variation in the coming 5 years, and 5.86 and 14.63 in 10 years. The discrepancy in health expenditure due to energy intensity is 32 and 97% in 5 and 10 years. FDI and energy efficiency show 15.95 and 1.58 units of variation in energy intensity in 5 years and 32.31 and 3.11 units in 10 years. Likewise, the variations described by climate change in energy intensity are 3.29 units in 5 years and 4.42 units in 10 years. The share of gross domestic product and sustainable development in energy intensity is around 28 and 41% in the 5-year horizon, and in 10 years, it is 0.64 and 5.92 units, respectively. Regarding energy efficiency, health expenditure contributed 69% in 5 years and 48% in 10 years. On the other hand, FDI adds 8.61 and 18.9 units in 5 and 10 years, respectively. Correspondingly, the energy intensity and GDP shares are 14.76 and 2.375 units in 5 years and 17.86 and 1.21 units in the 10-year horizon. Similarly, environmental degradation and sustainable development variance due to energy efficiency are 11% and 51% in 5 years and 27% and 86% in 10 years.

The variation of health expenditures in CO_2 emission is 6.43 units and 10.34 units in 5 years and 10 years, respectively. The energy-related variables used in this study, such as energy intensity and energy efficiency, described 17.04 and 1.01 units variation in 5 years and 17.95 and 1.86 units in 10 years in climate change. The share of FDI in CO_2 emission is about 4.96 units in 5 years and 5.49 units in 10 years. Similarly, gross domestic product and sustainable development show 2.61 and 2.5 unit variation in the coming 5 years and 4.28 and 5.98 units in 10 years. About 21% of the variance in health expenditure is due to sustainable development in 5 years and 65% in 10 years of the horizon.

Similarly, the variation of GDP in sustainable development is about 26% and 47% in the 5-year horizon and ten years because of shocks on economic growth. Energy intensity and energy efficiency described 1 and 0.83 units of variation in SD in 5 years and 10 years horizon variations are 60% and 81%, respectively. Environmental degradation had 1.24 and 0.76 units of variation in sustainable development in the coming 5 years and 10 years, respectively. Likewise, foreign direct investment showed around 9.19 units of variation in 5 years and 7.94 units in 10 years.

Health expenditure described 6.24 units in 5 years and 6.16 in 10 years. Similarly, the discrepancy in FDI due to GDP is 2.56 and 3.59 units in the five and 10-year horizon, respectively. Energy intensity and energy efficiency add 2.81 and 1.99 units of variation in 5 years and 2.83 and 2.04 in 10 years. Likewise, the variance of sustainable development

Table 10 Variance decomposition analysis results

Period	HE	FDI	EI	EE	CO_2	SD	GDPc
Variance decomposition of HE							
1	100.000	0.000	0.000	0.000	0.000	0.000	0.000
2	95.994	0.004	0.050	0.011	0.068	0.893	2.979
3	92.350	0.014	0.090	0.074	0.066	1.917	5.490
4	89.435	0.022	0.106	0.115	0.048	2.953	7.322
5	87.409	0.088	0.115	0.141	0.051	3.860	8.335
6	85.839	0.150	0.108	0.155	0.048	4.690	9.010
7	84.663	0.246	0.100	0.159	0.050	5.407	9.375
8	83.702	0.340	0.089	0.158	0.049	6.056	9.604
9	82.917	0.446	0.080	0.154	0.050	6.632	9.721
10	82.243	0.551	0.072	0.148	0.049	7.154	9.784
Variance decomposition of FDI							
1	2.790	97.210	0.000	0.000	0.000	0.000	0.000
2	2.502	92.580	2.303	0.041	1.065	1.374	0.136
3	2.341	88.797	2.188	0.138	0.995	2.804	2.737
4	2.650	86.006	2.611	0.171	0.890	3.695	3.976
5	2.737	82.838	2.873	0.214	0.957	5.519	4.862
6	2.840	79.911	3.007	0.249	1.080	7.514	5.399
7	2.929	77.260	3.138	0.270	1.277	9.467	5.659
8	3.015	74.807	3.213	0.287	1.521	11.362	5.796
9	3.118	72.568	3.273	0.297	1.811	13.084	5.848
10	3.242	70.510	3.316	0.305	2.131	14.630	5.866
Variance decomposition of EI							
1	0.226	2.945	96.829	0.000	0.000	0.000	0.000
2	0.142	3.269	94.023	0.899	1.268	0.387	0.013
3	0.190	6.085	90.335	1.070	1.613	0.277	0.430
4	0.223	11.100	83.959	1.305	2.804	0.254	0.355
5	0.326	15.948	78.159	1.583	3.292	0.414	0.278
6	0.465	20.808	71.835	1.885	3.862	0.868	0.277
7	0.609	24.682	66.393	2.199	4.138	1.650	0.328
8	0.746	27.936	61.234	2.514	4.344	2.792	0.434
9	0.870	30.408	56.721	2.819	4.414	4.228	0.540
10	0.977	32.310	52.610	3.111	4.422	5.923	0.646
Variance decomposition of EE							
1	0.534	0.188	16.005	83.273	0.000	0.000	0.000
2	1.102	1.775	14.232	80.957	0.233	0.273	1.428
3	0.904	3.701	13.965	78.613	0.156	0.254	2.407
4	0.778	6.280	14.194	75.750	0.150	0.363	2.484
5	0.690	8.612	14.763	72.934	0.115	0.511	2.375
6	0.630	11.102	15.308	70.118	0.092	0.633	2.117
7	0.583	13.290	15.969	67.466	0.096	0.734	1.862
8	0.544	15.371	16.595	64.958	0.121	0.798	1.613
9	0.512	17.216	17.241	62.612	0.183	0.839	1.397
10	0.484	18.903	17.861	60.413	0.273	0.858	1.209
Variance decomposition of CO_2							
1	0.647	0.379	11.059	0.824	87.091	0.000	0.000
2	3.538	5.205	13.497	1.357	73.608	0.265	2.530
3	4.142	3.483	15.780	1.362	72.459	1.020	1.756
4	5.533	5.197	16.068	1.593	67.369	1.532	2.708
5	6.434	4.695	17.039	1.613	65.110	2.500	2.609
6	7.421	5.269	17.244	1.715	61.998	3.182	3.172

Table 10 (continued)

Period	HE	FDI	EI	EE	CO_2	SD	GDPc
7	8.236	5.210	17.602	1.749	59.853	3.986	3.365
8	9.020	5.424	17.732	1.802	57.600	4.670	3.752
9	9.702	5.428	17.883	1.833	55.804	5.355	3.996
10	10.339	5.495	17.957	1.868	54.084	5.978	4.279
Variance decomposition of SD							
1	0.190	7.695	2.686	1.234	2.241	85.953	0.000
2	0.402	7.377	1.915	0.979	1.668	87.336	0.323
3	0.292	9.080	1.425	0.925	1.697	86.313	0.268
4	0.234	8.812	1.222	0.886	1.362	87.268	0.215
5	0.215	9.190	1.008	0.836	1.239	87.247	0.265
6	0.235	8.980	0.872	0.820	1.080	87.742	0.271
7	0.292	8.863	0.763	0.801	0.984	87.965	0.332
8	0.383	8.573	0.683	0.799	0.890	88.301	0.371
9	0.502	8.282	0.632	0.801	0.821	88.535	0.428
10	0.647	7.936	0.603	0.812	0.757	88.768	0.476
Variance decomposition of GDPc							
1	1.092	2.290	1.259	2.208	0.124	0.661	92.366
2	5.769	1.828	2.959	1.974	0.426	2.049	84.994
3	6.089	1.985	2.847	2.015	0.409	2.170	84.483
4	6.235	2.293	2.819	1.996	0.496	2.177	83.984
5	6.254	2.566	2.812	1.989	0.494	2.180	83.704
6	6.238	2.907	2.806	1.991	0.500	2.221	83.336
7	6.221	3.111	2.815	2.000	0.500	2.303	83.050
8	6.199	3.320	2.817	2.013	0.498	2.419	82.734
9	6.179	3.463	2.825	2.027	0.501	2.545	82.459
10	6.159	3.595	2.830	2.042	0.504	2.681	82.188

is 2.17 in 5 years and 2.68 in 10 years. CO_2 emission shows 49% and 50% variation in GDP, respectively.

Results of impulse response functions

The impulse response function is also used to examine how the dependent variable health expenditure responds to a one standard deviation shock given to the independent variables foreign direct investment, energy intensity, energy efficiency, CO_2 emission, sustainable development, and GDP, respectively. The dependent variable health expenditure is modelled as a function of the independent variables foreign direct investment, energy intensity, energy efficiency, CO_2 emission, sustainable development, and GDP (see Fig. 4). The immediate reaction to a one standard deviation shock to sustainable growth will increase health expenditures over the following 10 years. Health expenditures will rise in response to a one standard deviation shock to GDP, stay steady for 4 to 5 years following the shock, and decline gradually.

To determine how much health expenditures respond to energy efficiency, we can see that a one standard deviation shock to energy efficiency initially has no effect on health expenditures but later causes them to rise, indicating that energy efficiency policies must be carefully considered. Energy intensity will initially raise health expenses, but energy intensity will cause health costs to decrease as time progresses.

Discussion

The health indicators in the SAARC region are abysmal, and there is a significant impact of energy and environmental unsustainability on it. As discussed in previous sections, energy is one of the most important factors in environmental degradation and the use of inefficient and non-renewable energy use is putting a considerable population at risk of different brain, heart, and respiratory diseases. Renewable energy production, consumption, and energy-efficient technologies in the energy sector can play an essential role in addressing climate change (Akbar et al. 2021b), ultimately improving health indicators. Previous studies such as Weimin et al. (2021), Hussain and Rehman (2021), and Chishti et al. (2021) concluded that renewable energy consumption improves environmental quality by reducing CO_2 emissions and shown a negative association between energy

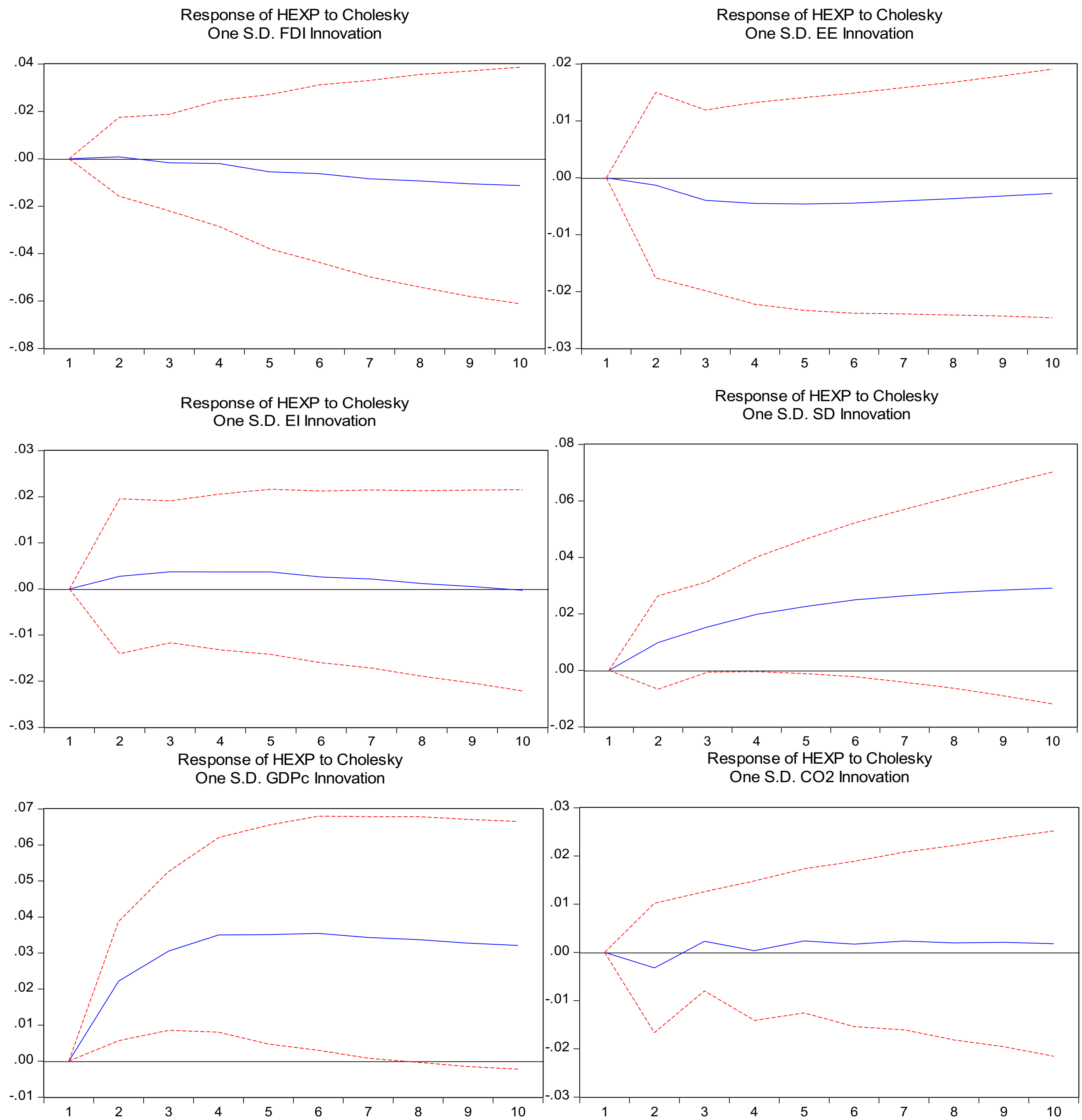

Fig. 4 Impulse response functions

efficiency and environmental pollution. The present study's results also showed that an increase in energy efficiency negatively impacts health expenditures. And there is a unidirectional causality between EE and health expenditures, which means the energy sector can improve human health in the SAARC region. In the literature, we found that FDI reveals a direct link between CO_2 emission and the impact of GDP growth is also adverse, as it raises the ratio of CO_2 emission. According to the data, a decrease in the innovation process leads to an increase in CO_2 emissions. Globalization has a significant impact on reducing the harmful effects of CO_2 emissions in developing countries, implying that this phenomenon has an environmental impact through a technique effect (Weimin et al. 2021). The impact of economic growth and energy intensity on health expenditures is positive, but on the other hand, energy efficiency negatively affects health expenditures. This means the GDP's effect on the health sector can be controlled through energy efficiency.

The results showed that CO_2 emission is positive and statistically significant on health expenditures. The results are in line with Zhang et al. (2018) who found that air pollution is the world's fourth most serious hazard to human health, the environment, and the economy. Furthermore, Chaabouni and Saidi (2017), Chaabouni et al. (2016), Abdullah et al. (2016), Chaabouni et al. (2016), Siti Khalijah (2015), and Toplicianu and Toplicianu (2014) discovered a positive effect of CO_2 emissions on health expenditures. According to Saida and Kais (2018), environmental challenges, notably CO_2 emissions, have had major effects in recent decades, particularly for health. This means that as CO_2 emission increases, it will harm human health. As climate change is expected to diminish the ozone layer and increase UV radiation, it can impair the immune system to numerous illnesses and immunizations. This will make the general public more susceptible to illness outbreaks. Therefore, the energy sector and sustainable development can play a crucial role in achieving environmental sustainability to mitigate environmental degradation and climate change. The designed policies to achieve SDG 7 targets on energy efficiency, renewable energy, and availability will also impact human health. Therefore, a very keen interest and cooperation are required between policymakers in the energy sector and the health sector.

The results showed that there is bidirectional causality between SD and health expenditures, and sustainable development can help to improve the health sector in the SAARC region. Concerns about sustainable development are centered on human beings. They have a right to live a healthy, productive life in harmony with nature. Health has risen as a foremost priority in development as a driver and indicator of sustainable development. Numerous health problems have a significant effect on economic growth and development. Sustainable development objectives cannot be met in the presence of a high incidence of devastating diseases, and health cannot be maintained without environmental sustainability. Several critical determinants of health and illness and potential remedies are found in sectors other than health, including the environment, water and sanitation, agriculture, education, employment, and others. To achieve the 17 SDGs and 169 objectives, SAARC countries will need regional, national, and local authorities to show a heightened interest in all social sectors. To this end, SDG 3 prioritizes health and is inextricably linked to more than a dozen other objectives, including urban health, equitable access to treatments, and no communicable illnesses. The SDGs provide a once-in-a-generation chance to improve public health by integrating public policy across many sectors. Improved education for girls (goal 4.1) improves maternal health (goal 3.1). Combating child malnutrition (goal 2.2) significantly impacts child health (goal 3.2). And ensuring access to safe water (6.1) and combating ambient air pollution (11.6) has a clear, direct impact on several SDG3 targets. Using coal to increase energy availability (objective 7) would, on the other hand, be detrimental to human health. As a result, achieving the health objectives would need policy consistency to maximize synergies across specific SDGs, amplify positive impacts, and avoid trade-offs.

Conclusion, policy implications, and limitations

The existing literature does not explain the link between health expenditures, energy intensity, energy efficiency, sustainable development, and environmental degradation. These links must be established to make evidence-based decisions to improve the SAARC region's health sector. Therefore, this study unfolds the nexus between health expenditures, environmental degradation, energy efficiency, energy intensity, and sustainable development. The study used the panel data for SAARC countries from 2000 to 2020. Along with diagnostic testing, FMOLS and DOLS have been utilized. The Dumitrescu and Hurlin paired panel causality test was used to validate the causality connection between the variables investigated.

The empirical results show that the variables under study are linked together. Economic growth, FDI, energy intensity, and CO_2 emissions positively and significantly impact health expenditures; the results are in line with Chaabouni and Saidi (2017), Chaabouni et al. (2016). Abdullah et al. (2016). Chaabouni et al. (2016). Siti Khalijah (2015). and Toplicianu and Toplicianu (2014) discovered a positive effect of CO_2 emissions on health expenditures. According to Saida and Kais (2018), environmental challenges, notably CO_2 emissions, have had major effects in recent decades, particularly for health. Bedir (2016) and Ke et al. (2011) explored a positive and substantial association between economic growth and health expenses. According to the results of Wang et al. (2019), environmental deterioration and economic expansion have a considerable impact on health costs. In contrast, energy efficiency and sustainable development have a statistically significant negative effect on health expenditures. There is two-way causation between health expenditures, sustainable development, and economic growth. At the same time, there is a one-way causation found between energy efficiency, energy intensity, and CO_2 emissions with health expenditures. The improved health status of the SAARC area needs to be protected by laying up appropriate policies for long-term growth, environmental sustainability, and the energy sector. Therefore, the following policy implications may be derived from these results.

Sustainable development goals are vital to better health and better environmental results. Energy access, energy efficiency, and renewable energy goals set out in SDG 7 can help improve human health (SDG 3) and speed up the whole sustainable development agenda. The exploitation of nature without considering its consequences for humans automatically includes severe health impacts. Growth makes it more likely to worsen people's health because of economic, political, and social instability, rising pollution levels, and increasing inequality. Our findings show a strong connection between economic growth and health expenditures. Health funding from domestic and foreign sources must be long-term, stable, and reliable to provide a minimum level of quality healthcare and make progress in the sector. The global health infrastructure needs to change to meet the needs and goals of each country while also playing a more critical role in improving the health of everyone.

A more flexible and cost-effective healthcare strategy that combines public and private efforts is required. In collaboration with developed nations, international organizations like the WHO and UNICEF should fight against rising health expenditures. If there are better connections between health and other sectors, much progress can be made. For example, there should be more inter-sectoral health development plans at the local and national levels. This study also shows that as more people work to make the world a better place, they will spend less money on health care. So, policies should be made and put into place to improve the health of countries in the SAARC region. However, to take advantage of this, more collaboration is needed at all levels, especially between the health and energy sectors.

Environmental degradation negatively impacts human health, such as heart disease, bronchitis, lugs problems, and different types of flu from which COVID-19 is also evolved. As our results show, health expenditures increase with increment in the levels of CO_2 emission. So, clean energy, green development, and reforestation policies that are appropriately implemented may help to reduce pollution while also promoting environmental sustainability. Investments in energy efficiency and renewable energy networks can help people in the SAARC region live better lives. Health expenditure must be increased to levels that are more or less similar to those in developed countries. Effective governance, management, accountability, and transparency are needed to ensure public health funds are used effectively and adequately.

Furthermore, policymakers should consider sustainable measures to rationalize CO_2 emission by paying more attention to highly polluting sectors. Finally, we hope this study and its results provide a catalyst for future research in this region and other regions and help set expectations and opportunities for a more sustainable future.

Limitations

There are limitations of the study, which can be future research directions, mainly when collecting the data for SAARC countries and looking at long-run impacts. Since the long-run impacts are utilized, it can be disputable how environmental degradation in a given year may impact health expenditures in the same year. More research is necessary to look into the time lag between variables. Additionally, this study could not include Afghanistan in the panel due to the unavailability of data. Access to data is a constant limitation for researchers looking at sustainable development. Many critical factors could not be added for the Sustainable development index because of the unavailability of data about complex factors. For example, institutional quality is essential to implementing the policies in every sector of the economy so that institutional quality can be incorporated as a mediator in the future. Additionally, different health-related factors such as public, personal health budgets, cleanliness, and sanitary consideration can be used in the future.

Author contribution The manuscript is a joint effort of all authors. Conceptualization, Muhammad Waqas Akbar; methodology, Xuedi; formal analysis and investigation, Zeenat Zia.; writing—original draft preparation, Muhammad Waqas Akbar and Zeenat Zia; supervised and review by Prof Ruoyu Zhong and Robert Sroufe. All authors have read and agreed to this version of the manuscript.

Data availability The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate We confirmed that this manuscript has not been published elsewhere and is not under consideration by another journal. Ethical approval and informed consent do not apply to this study.

Consent for publication Not applicable.

Competing interests The authors declare no competing interests.

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