Environmental Quality and Health Status in SAARC Countries: Assessing the Impact of Pollution, Economic Growth and Public Services on Life Expectancy

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https://doi.org/10.62345/jads.2025.14.2.3

Abstract

The study evaluates the nexus between environmental quality and health status in seven SAARC countries by using life expectancy as a proxy for health status. The nexus is being investigated by using the panel data from 2000 to 2023. CS-ARDL approach is used to find out both the short-run and long-run results. Life expectancy is employed as dependent variable while the key independent variables are CO_2 emissions, $PM_{2.5}$ and ecological footprint. These three variables represent our main variable that is environmental quality. Moreover, GDP growth, urban population, sanitation services, prevalence of undernourishment, unemployment and health expenditures also used in the paper as independent variables. The findings indicates that GDP growth, urbanization, health expenditures and sanitary services has a positive impact on life expectancy. While, the life expectancy is negatively influenced by CO_2 emission, ecological footprint, $PM_{2.5}$, prevalence of undernourishment and unemployment. These variables cause serious health hazards to human health in SAARC countries. The paper gives the recommendations that the authorities should take steps to improve the environmental quality which would lower the health hazards. In this regard, CO_2, $PM_{2.5}$, and undernourishment should be controlled by proper channels. More job opportunities should be created. Government should increase public spending to provide medical facilities. There must be focus on better sanitation services for people. Lastly, the government should raise economic growth with more investments and equal distribution of resources that would improve health outcomes.

Keywords: Life Expectancy, Urban Population, Undernourishment, Unemployment, Health Expenditures

Introduction

Environmental quality (EQ) is the condition and situation of the surroundings that effects human health. Environmental quality is a multidimensional idea. Different theories and works discussed the various dimensions of environmental quality (Kamp et al,2003). Air pollution and many other pollutants have negative impact on EQ. Quality of environment is now becoming worse because of industrialization, traffic and rising population. Poor EQ causes many respiratory diseases

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Compliance with ethical standards: There are no conflicts of interest (financial or non-financial). This study did not receive any funding.

(Kassomenos et al., 2012). Health is a very important element for various social and economic activities. Efficiency of labor depends on better health status (Zhong et al., 2022). Health status can be improved with the increase in health expenditures (Sirag et al., 2016). Poor environmental quality is a cause of global climate change. Because of increase in greenhouse gasses, the temperature on earth is increasing (Yazdi et al., 2014). Environmental quality and its impact on health has become a public concern. Various air pollutants such as CO_2, SO_2 and PM2.5 have negative impacts on human health. Air pollution effects both mental and physical health (Liu et al., 2023). In many previous studies the effect of EQ on health has been discussed. Environmental degradation is the change in natural resources due to human actions. Life expectancy falls and mortality rate increased because of poor environment and health. It is also difficult to measure the impact of environment on health accurately. There is no proper method of measurement especially in case African countries (Mutizwa & Makochekanwa 2015).

Because of great danger to human health, air pollution is now become a global phenomenon. World Health Organization (WHO) make the estimate that because of pollution about 6.5 million people died annually. Environmental destruction is increasing in developing countries. In such countries, pollution caused breathe diseases and early deaths among children. Due to smoke of vehicles, asthma increased in children. Recently, because of air pollution smog is increasing in Asian countries (Nakao et al., 2019). Improvement in health can be assured by increasing health expenses. Lack of medical facilities rises the risk of spreading diseases. Therefore, medical expenses can control the mortality rate and thus life expectancy increased (Nathaniel & Khan 2020). The significance of human health and environment was presented by Earth Summit 1992 for the first time. The problems and dangers of worse environment conditions are national and international phenomena. It also explains that due to degradation of EQ the biodiversity and ecosystem is affected in a large number (Ullah et al., 2020).

Environmental quality is very important for human health. The condition of environment both indoor and outdoor is crucial for a healthy life. The research work shows that indoor quality of environment is of great significance. Poor indoor quality causes health issues among children and old age people. Although it is clear that indoor quality is essential but to maintain and to keep the environment clean is not an easy task. Sometimes, people don’t care about the importance of clean environment. The indoor quality can be improved by regular policies and efforts. For this education can play a beneficial role. People should be aware about the importance of clean indoor environment for health. The structures of the buildings also another cause of spread of diseases. Populated areas with heavy traffic have negative influence on health of the citizens. Indoor quality is also critical in the sense that people spend more of their time at homes. That's why indoor environmental quality is decisive for environmental human health and it must be improved (Wu et al., 2007).

As it is clear that population is increasing globally in the same way the use of natural resources by human beings is also increasing day by day. All these human activities result in degradation of environment. The citizens must understand the issues of the environment and play their positive role to improve the quality of the environment. In this respect, environmental educators can play a very crucial role to aware the citizens about the importance of environment and its role for health condition. The current problems of environment must be solved locally and worldwide both. Environment education must be spread to everyone, so they take care their actions and adopt such steps that protect the environment. As improved air quality is of key importance for the health of growing population (Short, 2009). Human health is adversely affected by polluted environment. The difference between socio-economic status of people different impacts on health and also caused various environment risk. The income of people has negative relation with socio-economic status. Higher income results in better health, education and medical facilities. Human health and environment also negatively influenced by wastes, polluted particles in the air, the poor quality of environment at homes, the poor quality of drinking water, noise, population and lack of medical opportunities. When all the above facilities are absent and not provided to people, then they suffer from many diseases. Human health and environment quality both can be improved by proper strategies. In this respect, equal distribution of income and end of poverty can play a very vital role. It controls many factors that affects health and then the environment as well (Evans & Kantrowitz, 2002).

Health status now becomes the topic of interest for government and nongovernment institutions. The political parties also very keen about promotion and betterment of health. In this respect, the sustainable development can play a very crucial role. WHO is promoting such factors and methods for the betterment of the health of people all around the world. WHO is also playing attention on such factors that improves the quality of environment. Better environment conditions then help to maintain a healthy life. Environment health indicators (EHI) is promoted by WHO for better health and clean environment. The importance and significance of environment for health is clear from this point that for about 50 years WHO is promoting these two factors. They focus on the availability of drinking water, sanitary and medical facilities in order to promote health and keep the environment clean (Kjellstrom & Corvalan, 1995).

The significance of the study is represented by the following factors. First, there is very limited research that determines the nexus between environmental quality and health status. This study fills this gap by dealing with these two factors in detail. This study analysis their relationship for the improvement of the environment. Second, the previous research work depends on traditional and old methods of analysis such as OLS, ARDL and fixed effect model which are the approaches of first-generations, the while this study used the second-generation CS- ARDL approach. This advance methodology is extremely useful as it analyzes the slope homogeneity, cross-sectional dependence and the existence of short-run and long-run relationship. This technique provides the exact analysis of data. Lastly, the study is a valuable addition in the limited research work concentrated on SAARC countries. It offers new understanding of the connection between environmental quality and health status in SAARC countries.

The study is organized into five sections. Section 2 provides the literature reviews of the previous research work and studies and also describes the research gap which this study fills and addresses. Section 3 describes the model specification, data and methodology that is used in this study. Section 4 investigates the nexus of life expectancy and various environmental aspects by using the CS-ARDL approach. Finally, Section 5 sums up the findings of the study and presents the policy recommendations.

Review of Literature

This section presents a review of previous studies on environmental quality and health status. Table 1portays the summary of the studies on environmental quality and health status.

Table 1: Summary of the Studies

Author(s)	Time Period / Observations	Country	Methodology	Main Results
Bouchoucha 2023	1990-2019	49 African countries	Simultaneous equation method	Trade openness was positively related with CO2 and infant mortality rate. It also reduced the life expectancy
Liu et al. 2023	2021	Hong Kong	Spearman rank correlation coefficient	There was significance association between the air quality and respiratory symptoms reported by people.
Omri et al. 2023	2000-2018	Saudi Arabia	Health production model	CO2 emission had negative effect on health outcomes. And, because of research and development (R&D) health outcomes improved.
Okogor 2022	1990-2015	Nigeria	Ordinary least square method	CO2 emission had negative relationship with life expectancy. Due to improvement in water and sanitary facilities and GDP, LE improved.
Zhong et al.2022	2000-2020	SAARC countries	Fully modified ordinary least square, Dynamic ordinary least square methods	Because of increase in CO2 emission, air pollution increased, as a result health expenditures also increased. Due to availability of facilities, sustainable development controlled the health expenditures.
Alharthi et al. 2022	2000-2019	20 MENA countries	Pooled mean group regression approach	Clean and renewable energy improved the health and income status of people.
Arifin et al. 2022	2019	Brunei Darussalam	Logistic regression model	Improvement in environmental quality, healthy lifestyle and employment opportunities, resulted in health status improvement in Brunei.
Niu et al. 2022	2018-2019	China	Spearman correlation, Structural equation modeling	Depression symptoms was controlled by the improvement in air quality satisfaction and family relationships.
Omri et al. 2022	2000-2018	Saudi Arabia	Dynamic ordinary least square	Increase in government spending on health care facilities and research and development (R&D), improved health outcomes in Saudi Arabia.
Alharthi et al. 2021	1995-2018	20 Asian countries	Autoregressive distributed lag	Poor energy sources and CO2 emission increased health risks. While, health status improved by increase in income and the use of clean energy sources.
Beyene and Kotosz 2021	2000-2016	24 African countries	Autoregressive distributed lag, Dynamic fixed effect	Improvement of environmental quality, urbanization, ecosystem and increase in per capita income, resulted in improvement of LE.
Shittu et al. 2021	1990-2018	45 Asian countries	Pooled ordinary least square, Fixed effect method, 2-stage least square method	Because of the wastage of natural resources and energy security, environmental degradation increased in Asia.

Grazuleviciene et al. 2021	2021	Lithuania	Multivariable logistic reg.	Because of physical activities stress and blood pressure was controlled. Mental health also improved due to better environmental quality.
Bouchoucha 2021	1996-2018	17 MENA countries	Fully modified ordinary least square, Dynamic ordinary least square methods.	Environmental destruction was a danger to human health status. It caused various diseases.
Ullah et al. 2020	1995-2016	Asian countries	Levin Lin Chu, Im, Pesaran and Shin, Dynamic ordinary least square methods.	Poor environmental quality had bad impacts on the health. Increase in per capita income provides better medical facilities.
Nathaniel and Khan 2020	1970-2014	Nigeria	Bayer and Hanck test	Urbanization caused environmental degradation. LE was badly affected by immigration towards cities.
Mirzaei et al. 2020	2005-2008	Iran	Systematic review approach	Green buildings had good and positive impact on health in Iran.
Alimi et al. 2020	1995-2014	15 ECOWAS countries	Ordinary least square, Generalize method of moments, Fixed effects.	Health expenditures increased due to inflation, increased income and air pollution.
Afolayan et al. 2019	1980-2016	Nigeria	Dynamic ordinary least square method, Granger causality.	Increased CO_2 emissions and fossil fuel burning caused high mortality rates.
Naddafi et al. 2019	2006-2017	Iran	World Indices	Air pollution decreased during 2012 to 2015. But now it has increasing trend in Iran.
Nakao et al. 2019	2010-2015	Japan	Generalized estimation equation.	Health was negatively affected by air pollution and lower EQ in Japan.
Rahman et al. 2018	1995-2014	15 SAARC-ASEAN countries	Panel data estimation approach	Better sanitation services and healthcare funds improved people's health.
Yuan et al. 2018	2016	China	Ordinary least square method.	Air pollution badly impact life satisfaction. Life satisfaction was improved because of green areas.
Xueyan et al. 2018	2003-2013	China	Theil index, Exploratory spatial data analysis, Spatial Durbin model.	Health improved due increased urbanization and per capita income.
Giovanis and Ozdamar 2018	2013-2015	19 European countries	Ordinary least square, Structural equation modelling, Instrumental variables.	Health became poorer because of smoking, old age and air pollution.
Li and Hu 2018	2012	China	Structural equation modelling, Contingent valuation method.	Environmental quality rise due to knowledge and strong social background.
Gray et al. 2018	2003-2013	U.S.	Bayesian, Mixed effects regression modelling.	In U.S. asthma increased by poor air, land and water quality.

Li et al. 2018	2008-2016	China	Energy efficiency evaluation.	Pollution increased due to heating emission. Increase in heating also resulted in worsen EQ.
Patel et al. 2018	2000-2005	U.S.	Multi-level regression method	Infant deaths increased due to polluted environment.
Abdullah et al. 2016	1970-2014	Malaysia	Autoregressive distributed lag.	Polluted environmental quality was a cause of increased medical expenses.
Wang et al. 2016	1995-2015	Europe	Systematic review approach.	Policies of air quality management were crucial. Air pollution was controlled by appropriate policies.
Bradley et al. 2016	2000-2009	Columbia	Multivariable modeling method	Both the health and social spendings improved human health.
Sirag et al. 2016	2002-2012	53 LMI countries	Generalize method of moments.	Life expectancy improved by income, education and medical services.
Sulemana 2016	2007	Ghana	Ordered Probit regression.	Worse environmental quality had negative impact on health status in Ghana.
Khan et al. 2016	1995-2012	SAARC countries	Seemingly unrelated regression, Dynamic ordinary least square methods.	GDP caused increase in health expenditures. During old age due to spread of diseases HE increased.
Mutizwa and Makochekanwa 2015	2000-2008	Southern Africa	Ordinary least square method, Pearson's, Hausman test	Infant mortality rate decreased by better environment, income and sanitary facilities.
Rappazzo et al. 2015	2000-2005	U.S.	Effect estimation method	Air pollution caused premature deaths. Socio- Demographic index had positive impact on premature deaths.
Yazdi et al. 2014	1967-2010	Iran	Autoregressive distributed lag.	Because of SO_2 and CO emissions health expenses rise.
Kassomenos et al. 2012	2004-2009	Thessaloniki (Greek)	Air Quality Indices.	Air pollutants caused poor air quality and health. On weekends air quality improved.

Table 1 presents the information about the environmental quality and health status. Various studies indicated that the poor environmental quality had negative relation with health status. Some studies also explained that betterment of environmental quality had positive relationship with human health. These studies focused on various air pollutants such as carbon dioxide, nitrogen oxide, ozone and Sulphur dioxide. While, some research studies analyzed the social and welfare facilities and their impact on health status. It was also presented that air pollution was controlled by some countries, while many countries still suffered from the negative impacts of air pollution. All the studies had a clear motive that improvement in environmental quality was essential for the betterment of health status.

The relationship between environmental quality and health status was examined in very few studies. The relationship of life expectancy was not vey broadly discussed. There was also very limited work on the impact of ecological footprints. Moreover, the particulate matter $PM_{2.5}$ was rarely used. There were a few studies that used this particulate matter. There were very limited research studies about the association between these two variables on SAARC countries. Mostly, the studies used the old methods such as ARDL, OLS and fixed effect method. Thus, our study is beneficial as it used the data taken from SAARC countries, in order to explore the connection between environmental quality and health status. The impact of ecological footprint is also discussed in this study. This study used the $PM_{2.5}$ air pollutant that caused air pollution and negatively effects the environment. This study used the modern technique such as second-generation CS-ARDL approach to estimate the results. This method provides the accurate and reliable results. Shortly, this study is an important addition in present research.

Model, Data and Methodology

This section presents the model, data and the methodology used in this paper. Three models are estimated. The sources of data also presented in this section.

Model Specification

This section presents the theoretical framework and the methods which are used in the study. The objectives of the study are; to find out the nexus between environmental quality and health status in SAARC countries, to analyze the factors that affects life expectancy, and to determine the impact of ecological footprint on life expectancy in SAARC countries. In order to attain these objectives, the study uses three models.

Model 1: CO_2 Emissions and Life Expectancy

The first model examines the factors that affects life expectancy. Its main focus is on CO_2 emissions in the environment. The dependent variable is life expectancy at birth (LE) and independent variables are carbon dioxide (CO_2) emissions, GDP growth, urban population growth (URBAN), people using at least basic sanitation services (SANS), prevalence of undernourished (PUN), unemployment (UNEMP) and current health expenditures (HE). All these variables affect life expectancy. The functional form of the model is expressed as:

$$LE = f(CO_2, GDPG, URBAN, SANS, PUN, UNEMP, HE) \quad \textbf{(1)}$$

The econometric form of the model is:

$$LE_{it=}\beta_o + \beta_1 CO_{2it} + \beta_2 GDPG_{it} + \beta_3 URBAN_{it} + \beta_4 SANS_{it} + \beta_5 PUN_{it} + \beta_6 UNEMP_{it} + \beta_7 HE_{it} + \varepsilon_{it} \quad \textbf{(2)}$$

Model 2: $PM_{2.5}$ Air Pollution and Life Expectancy

The second model explains the effects of PM2.5 air pollution (PP) on life expectancy. In this model life expectancy is used as dependent variable and PM2.5 air pollution, GDPG, urbanization (URBAN), sanitation services (SANS), prevalence of undernourished (PUN), unemployment (UNEMP) and current health expenditures (HE) are used as independent variables. PM2.5 are the pollutant particles present in the air. The increase in these particles effect life expectancy. GDP growth is very crucial in defining the life expectancy. When GDP increased, government spend om medical facilities that improve health and LE. Urban population growth also very important factor that influences life expectancy. In the same manner, availability of sanitation facilities and unemployment both have very significant effects on LE. The functional form of the model is:

$$LE = f(PP, GDPG, URBAN, SANS, PUN, UNEMP, HE) \quad \textbf{(3)}$$

The econometric specification of the model is:

$$LE_{it} = \beta_o + \beta_1 PP_{it} + \beta_2 GDPG_{it} + \beta_3 URBAN_{it} + \beta_4 SANS_{it} + \beta_5 PUN_{it} + \beta_6 UNEMP_{it} + \beta_7 HE_{it} + \varepsilon_{it} \quad \textbf{(4)}$$

Model 3: Ecological Footprint and Life Expectancy

The third model determines the effects of ecological footprint on life expectancy by using other independent variables. In this model, LE is used as dependent variable while ecological footprint (EF), GDP growth, urbanization, sanitation services, prevalence of undernourished, unemployment and current health expenditures are used as independent variables. Ecological footprint shows the environment destruction. It includes such factors that badly impact environment quality. The functional form is shown as:

$$LE = f(EF, GDPG, URBAN, SANS, PUN, UNEMP, HE) \quad \textbf{(5)}$$

Now the model is structured in econometric specification as:

$$LE_{it} = \beta_o + \beta_1 EF_{it} + \beta_2 GDPG_{it} + \beta_3 URBAN_{it} + \beta_4 SANS_{it} + \beta_5 PUN_{it} + \beta_6 UNEMP_{it} + \beta_7 HE_{it} + \varepsilon_{it} \quad \textbf{(6)}$$

Variables and Data Sources

This section presents the description and sources of the variables used in this study. The study used panel data of seven SAARC countries namely: Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka for the time period of 2000 to 2023. The study used life expectancy as dependent variable while CO_2 emission, GDPG, URBAN, SANS, PUN, UNEMP, HE, EF and PP are used as independent variables. Table 2 provides the variables description, their measuring units and also the sources from which data is collected.

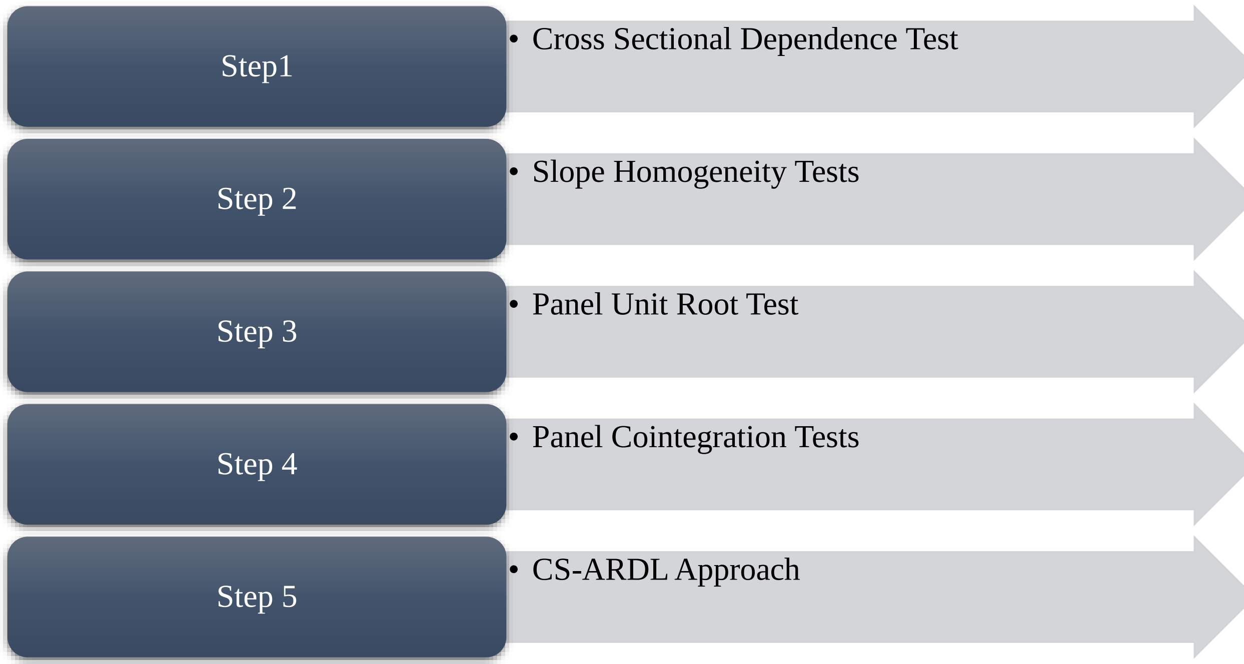
Table 2: Variables Description, Measurement Units and Data Source

Variables	Description	Unit of Measurement	Data Sources
LE	Life Expectancy at birth	(Years)	WDI
EF	Ecological Footprint	(Global hectares per person (Gha))	
CO_2	Carbon dioxide emissions excluding LULUCF per capita	(t CO_2e/capita)	
GDPG	GDP Growth	(Annual %)	
URBAN	Urban Population Growth	(Annual %)	
SANS	People using at least basic Sanitation Services	(% of Population)	WHO/ UNICEF
PUN	Prevalence of Undernourishment	(% of Population)	FAO
UNEMP	Unemployment, total	(% of total labor force)	ILOEST
HE	Current Health Expenditures	(% of GDP)	WHO
PP	PM2.5 Air Pollution, population exposed to levels exceeding WHO guideline value	(% of total)	WDI

Methodology

This section presents the estimation methodology used in the study. In the study, there is used advanced econometric methods and presented into five major steps. First, the study applied cross-sectional dependence test. Secondly, in order to check the slope homogeneity, we used two tests Delta and adjusted Delta test. Figure 1 elaborates the econometric modeling approach used in this study. Thirdly, study determines the stability and stationarity of the variables by using Panel Unit Root test. Fourth, to examine the existence of long-run relationship, we applied the cointegration analysis. Panel cointegration used three tests to estimate long run relationship such as Westerlund, Kao and Pedroni test. Lastly, study used CS-ARDL approach to estimate both the short-run and long-run results.

Figure 1: Econometric Modeling Approach



Results and Discussion

Summary Statistics

This section presents the summary statistics of the key variables. Table 3 presents the summary statistics. Life expectancy (LE) at birth (total years) has 68.207 mean value while the median is 67.351. The maximum value of LE is 75.748, on the other hand, the minimum value is 62.421. The standard deviation of LE is 3.502, which shows that there is variation in the values of the countries used in the study. The skewness value is 0.421 which indicates that data is positively skewed and kurtosis is 2.369 that is platykurtic which is flatter. Jarque- Bera probability value is 0.380, it shows normal distribution.

Carbon dioxide (CO_2) emissions excluding LULUCF (per capita) possesses the mean 0.728 and median is 0.693. It has maximum value 1.837 and minimum is 0.105, with standard deviation of 0.427 explaining the low variations. The skewness is 0.710 that shows long right tail with positively skewed, and kurtosis value is 3.197 and it indicates high peak. Jarque-Bera test with the probability of 0.166 shows normal distribution.

PM2.5 air pollution (PP), population exposed to levels of exceeding WHO guideline value (% of total) has 92.857 mean and 100.000 median. It has maximum 100.000 and minimum 0.000. Standard deviation is 26.066, indicated that there is high deviation among the countries studied. The skewness is -3.328 and it is negatively skewed and kurtosis value is 12.077 which is leptokurtic and it shows very high peak, proved by Jarque-Bera probability value 0.000 that indicates that data is not normally distributed.

Table 3: Summary Statistics of Key Variables

	LE	CO2	PP	EF	GDPG	URBAN	SANS	PUN	UNEMP	HE
Mean	68.207	0.728	92.857	1.328	5.320	2.566	53.452	13.810	6.156	3.237
Median	67.351	0.693	100.000	0.650	5.451	2.619	50.794	14.350	5.110	3.410
Maximum	75.748	1.837	100.000	4.940	8.669	5.625	91.629	24.100	10.672	5.470
Minimum	62.421	0.105	0.000	0.428	-1.545	0.665	16.513	4.700	0.423	1.934
Std. Dev.	3.502	0.427	26.066	1.612	2.118	1.144	20.812	4.088	3.124	0.863
Skewness	0.421	0.710	-3.328	1.777	-0.696	0.109	0.288	-0.189	-0.026	0.234
Kurtosis	2.369	3.197	12.077	4.182	3.817	2.983	2.063	3.585	2.000	2.306
Jarque-Bera	1.935	3.595	221.722	24.551	4.555	0.083	2.115	0.849	1.753	1.226
Probability	0.380	0.166	0.000	0.000	0.103	0.959	0.347	0.654	0.416	0.542

Ecological footprint (EF) (global hectares per person (Gha)) has 1.328 mean and 0.650 median, with 4.940 maximum and 0.428 minimum value. Standard deviation is 1.612, indicates the spread of the values of countries used in study. The positive skewness 1.777 with long right tail of distribution, while leptokurtic kurtosis that is 4.182 shows high peak of values. Jarque-Bera probability is 0.000 which shows that values are not normally distributed.

GDP growth (annual %), it's mean is 5.320 and 5.451 median. It's range from 8.669 maximum to -1.545 minimum. The standard deviation is 2.118 that highlights the variations of the values, and negative skewness is -0.696 with long left tail. The kurtosis is 3.817 that is known as leptokurtic and shows the high peak confirmed by Jarque-Bera probability that is 0.103, it highlights normal distribution.

Urban population growth (URBAN) (annual%) possesses 2.566 mean and 2.619 median. The maximum value is 5.625 and minimum is 0.665. Standard deviation 1.144 shows the variations of the individual values from central value. Skewness is 0.109 with long right tail and it is positively skewed. Kurtosis is 2.983 that is flatter. Jarque-Bera probability with 0.959 indicates normally distributed.

People using at least basic sanitation services (SANS) (% of population) has the mean of 53.452 and median is 50.794. It possesses the maximum from 91.629 to minimum 16.513. The standard deviation is 20.812 that indicates that there is high variation in the values of the countries. It is positively skewed at 0.288 with right hand tail and kurtosis is 2.063 known as platykurtic and it highlights that it is flatter. The probability value is 0.347 that confirmed the Jarque-Bera test and it shows normal distribution.

Prevalence of undernourishment (PUN) (% of population) has mean 13.810 and median is 14.350. The range is from maximum 24.100 to minimum 4.700. The value of standard deviation is 4.088 that identifies the value dispersion. Skewness is -0.189 and it is left tail negatively skewed, and kurtosis is 3.585 leptokurtic which shows high peak of the values. The data is normally distributed as it is confirmed by Jarque-Bera probability value 0.654.

Unemployment, total (% of total labor force) (UNEMP) acquires the mean 6.156 and median is 5.110. It has the maximum of 10.672 and minimum of 0.423. Standard deviation is 3.124 indicating the dispersion in the values from the mean value. Skewness is -0.026 and it is negatively skewed, with 2.000 kurtosis that shows the platykurtic broad peak. Jarque-Bera confirmed by probability value that is 0.416 which shows that values are normally distributed.

Current health expenditures (% of GDP) (HE) owns the mean 3.237 and median 3.410. The range is from 5.470 maximum to 1.934 minimum. Standard deviation is 0.863 that shows slight variation of the values. It is positively skewed with 0.234 right tail. The kurtosis is 2.306 which indicates that it is flatter. The values have normal distribution and it is proved by Jarque-Bera probability value that is 0.542.

Correlation Analysis

Table 4 explains the results of the correlation analysis of the variables. Life expectancy (LE) has weaker positive correlation with CO, PP, GDPG and HE, while it has weaker negative correlation with EF and UNEMP. It also shows moderate negative correlation with URBAN and PUN, while stronger positive correlation with SANS.

CO_2 emissions possess weaker negative correlation with PP, EF, UNEMP and HE, and it has weaker positive correlation with GDPG, SANS and PUN. It also shows moderate negative correlation with URBAN. $PM_{2.5}$ air pollution (PP) shows weaker positive correlation with EF, GDPG, URBAN, SANS and PUN and weaker negative correlation with both UNEMP and HE. Ecological footprint (EF) possesses weaker positive correlation with GDPG, URBAN, PUN and UNEMP, while weaker negative correlation with SANS and HE. GDP growth has weaker positive correlation with URBAN, SANS and UNEMP, and weaker negative correlation with PUN and HE.

Table 4: Correlation Analysis

	LE	CO2	PP	EF	GDPG	URBAN	SANS	PUN	UNEMP	HE
LE	1.000									
CO2	0.162	1.000								
PP	0.120	-0.087	1.000							
EF	-0.181	-0.173	0.123	1.000						
GDPG	0.205	0.142	0.124	0.165	1.000					
URBAN	-0.510	-0.374	0.048	0.045	0.077	1.000				
SANS	0.769	0.268	0.045	-0.155	0.041	-0.811	1.000			
PUN	-0.569	0.062	0.076	0.210	-0.106	0.362	-0.644	1.000		
UNEMP	-0.001	-0.128	-0.120	0.026	0.085	0.015	-0.103	-0.105	1.000	
HE	0.137	-0.016	-0.034	-0.036	-0.023	-0.383	0.282	-0.286	0.773	1.000

Urban population growth (URBAN) has stronger negative correlation with SANS and moderate negative correlation with HE. On the other hand, it shows moderate positive correlation with PUN and weaker positive correlation with UNEMP. People using at least basic sanitation services (SANS) shows weaker positive and weaker negative correlation for HE and UNEMP respectively. While it has moderate negative correlation with PUN. Prevalence of undernourishment (PUN) has weaker negative correlation with both UNEMP and HE. Unemployment (UNEMP) has stronger positive correlation with HE.

Cross-Sectional Dependence Test

The results of the cross-sectional dependence test are presented in Table 5. We used the C.D test to examine the cross-sectional dependence of the variables. The result shows that there exists cross-sectional dependence among all the variables except unemployment (UNEMP) and current health expenditures (HE).

Table 5: Cross-Sectional Dependence Test

Variable	CD-test	P-value
LE	20.110	0.000
CO2	18.463	0.000
PP	3.289	0.001
EF	17.347	0.000
GDPG	9.090	0.000
URBAN	6.931	0.000
SANS	21.936	0.000
PUN	8.357	0.000
UNEMP	0.430	0.667
HE	0.126	0.899

Slope Homogeneity Test

This section is about the results of the slope homogeneity test. In order to check the slope homogeneity, we used two tests such as Delta test and HAC Robust Adjusted Delta test. According to the results in Table 6, we rejected the null hypothesis, as all the P values are 0.000 for both the tests. It shows that the slope of all the three models is heterogeneous across all cross-section units. Simply, there exists slope heterogeneity.

Table 6: Slope Homogeneity Test on Developing Countries

Models	(Pesaran and Yamagata, 2008)		(Blomquist and Westerlund, 2013)	
	Delta Test	P-Value	HAC Robust Adjusted Delta Test	P-Value
1	-5.865	0.000	-4.865	0.000
2	-3.976	0.000	-3.542	0.000
3	-4.866	0.000	-4.364	0.000

Panel Unit Root Test

This section is about the panel unit root test which is used to find out the stationarity characteristics of the variables. Table 7 checks the stationary and non-stationary values of the variables. For this purpose, we apply the cross-sectional-dependence based Im-Pesaran-Shin (CSDIPS) unit root test. We analysis this test both with and without trend. Life expectancy (LE) is non- stationary with order I (0), showing that it has a unit root. CO_2 emissions is non-stationary with order I (1). PM2.5 air pollution (PP) ecological footprint (EF) and GDPG all these three variables are stationary at I (0) lag, it indicates that these variables have no unit root. On the other hand, urban population growth (URBAN), sanitation services (SANS), prevalence of undernourishment (PUN) and current health expenditures (HE) are non-stationary with order I (1), which shows that these four variables have a unit root. Unemployment (UNEMP) is non-stationary with order I (0) and it also has a unit root. Simply, there is a mixed order of integration.

Table 7: Results of Second-Generation Panel Unit Root

Second Generation Panel Unit Root Test						
Cross-Section-Dependence based Im-Pesaran-Shin (CSDIPS) Unit Root Test						
Variables	**Without Trend**			**With Trend**		
	Lags	**Zt Statistics**	**P-Value**	**Lags**	**Zt Statistics**	**P-Value**
LE	0	-2.020	0.022	0	-2.127	0.017
CO2	1	-0.703	0.241	1	0.219	0.587
PP	0	-3.297	0.000	0	-3.489	0.000
EF	0	-11.438	0.000	0	-10.847	0.000
GDPG	0	-3.696	0.000	0	-4.013	0.000
URBAN	1	0.726	0.232	1	-0.753	0.226
SANS	1	0.664	0.985	1	0.902	0.816
PUN	1	0.849	0.802	1	1.404	0.920
UNEMP	0	1.668	0.952	0	0.235	0.593
HE	1	-0.838	0.201	1	1.789	0.963

Panel Cointegration Analysis

This section analysis the existence of long-run relationship. Cointegration means the presence of long-run relationship. We estimated panel cointegration by using three tests such as Westerlund test, Kao test and Pedroni test. Table 8 explains that most of the tests are significant. It means there existed panel- cointegration. In simple words, long-run relationship exists among variables.

Table 8: Panel Cointegration Tests

Models	**Westerlund**	**Gt**	**Ga**		**Pt**	**Pa**
1	**Test**	-2.124 (0.000)	2.006 (0.000)		-3.902 (0.050)	-0.010 (0.988)
2		-1.063 (0.094)	-3.032 (0.000)		-3.517 (0.014)	-3.032 (0.088)
3		-1.872 (0.000)	-1.115 (0.000)		-2.047 (0.000)	-2.652 (0.000)
	Kao Test	**Modified Dickey-Fuller**	**Dickey-Fuller**	**Augmented Dickey-Fuller**	**Unadjusted Modified Dickey**	**Unadjusted Dickey-Fuller**
1		-2.465 (0.006)	-1.950 (0.025)	-0.358 (0.359)	-5.119 (0.0000)	-2.846 (0.002)
2		-1.123 (0.030)	-1.533 (0.097)	1.971 (0.065)	-2.936 (0.001)	-1.362 (0.086)
3		-5.071 (0.000)	-4.781 (0.000)	-4.097 (0.000)	-6.057 (0.000)	-4.967 (0.000)
	Pedroni Test	**Modified Phillips-Perron**	**Phillips-Perron**		**Augmented Dickey-Fuller**	
1		1.448 (0.073)	-2.231 (0.012)		-2.774 (0.003)	
2		1.514 (0.065)	-2.935 (0.001)		-2.771 (0.002)	
3		2.328 (0.009)	-3.092 (0.001)		-5.234 (0.000)	

CS-ARDL Estimates

This section presents the results of CS-ARDL model, by focusing on both short-run and long-run effects of environmental quality in SAARC countries. Table 9 shows the results of CS-ARDL approach. In the short-run, the Error Correction Term (ECT) is -1.624 for model 1 and significant at 1% level. For model 2, ECT is -1.363 and significant at 5% level. In model 3, ECT is -1.607 which is significant at 1% level. It shows convergence case. The values can attain the equilibrium. The study used the life expectancy at birth (LE) as dependent variable and CO_2 emissions per capita, $PM_{2.5}$ air pollution (PP), ecological footprint (EF), GDP growth, urban population growth (URBAN), people using at least basic sanitation services (SANS), prevalence of undernourished (PUN), unemployment (UNEMP) and current health expenditures (HE) are used as independent variables.

In long-run, CO_2 has negative impact on life expectancy. The reasons are that because of increase in CO_2 pollution increased that rise the infant mortality rate (Afolayan et al, 2019). Increased emission of carbon also caused environmental destruction and people suffered from diseases. As a result, life expectancy falls (Okogor, 2022). Carbon emission is also a reason of climate change which caused worse environment quality and is a hazardous for human health, so life expectancy is negatively affected (Sirag et al, 2016).

$PM_{2.5}$ air pollution is negatively related with LE. $PM_{2.5}$ is an air pollutant that caused air pollution. There are many reasons of negative relation. Air pollution is an emerging risk for human health. It is the second major cause of deaths and has adverse effects on life expectancy (Naddafi et al, 2019. Increased level of $PM_{2.5}$ in the environment caused polluted air, due to which death rate increased (Giovanis and Ozdamar, 2018).

Ecological footprint (EF) also has a negative impact on LE. In simple words, EF means environmental destruction due to human activities. The reasons are that because of ecological footprint the life expectancy is at risk. It caused poor air provided to people (Iqbal et al, 2013). The life period of a person depends on the environment in which he lives. Due to ecological footprint the climate changed all over the world and air is becoming more worse and caused early deaths (Fatiuma et al, 2021).

Table 9: CS-ARDL Estimates

Variables	1	2	3
Short-Run Estimates			
Δ ECT (-1)	-1.624***	-1.363**	-1.607***
	(0.563)	(0.591)	(0.375)
Δ CO_2	-2.819		
	(3.077)		
Δ PP		-0.363	
		(0.405)	
Δ EF			-0.0519
			(0.486)
Δ GDPG	-1.072	-0.0291	1.471
	(0.798)	(0.227)	(2.380)
Δ URBAN	0.0191	-0.0168	0.0366
	(0.0171)	(0.0587)	(0.0370)
Δ SANS	-0.511	0.793***	1.005***
	(0.382)	(0.162)	(0.209)

Δ PUN	0.0190**	0.211	-0.363
	(0.00905)	(0.275)	(0.591)
Δ UNEMP	-1.577	-0.133	0.0215
	(1.306)	(0.0802)	(0.0550)
Δ HE	0.627*	0.0175	-0.229
	(0.318)	(0.0260)	(0.147)
Long-Run Estimates			
CO_2	-0.170***		
	(0.0390)		
PP		-0.201***	
		(0.0494)	
EF			-0.290***
			(0.0887)
GDPG	0.243***	0.276***	0.331***
	(0.0423)	(0.0506)	(0.0780)
URBAN	0.0331***	0.00693***	0.0271***
	(0.00307)	(0.00214)	(0.00224)
SANS	0.0313***	0.0381***	0.0468***
	(0.00288)	(0.00437)	(0.00682)
PUN	-0.178***	-0.0535*	-0.128***
	(0.0406)	(0.0278)	(0.0363)
UNEMP	-0.848***	-0.363***	-0.510***
	(0.166)	(0.113)	(0.151)
HE	0.0179**	0.0224**	0.0352*
	(0.00865)	(0.0108)	(0.0194)

GDP growth (annual%) has positive impact on life expectancy in all the three models. Improvement in GDPG also improves LE. There are several reasons, such as due to increase in GDP, government has more funds to spend on the availability of medical facilities. Due to increase in income people spend more on health, that improves LE (Okogor 2022). Government medical financing also positively effects life expectancy. Due to better health, death rate controlled (Sirag et al, 2016).

Urban population growth (URBAN) also shows positive relation with life expectancy. Improvement in urbanization improves health that positively effects LE. Due to urbanization people get access to education and hospitals, which improves health and life expectancy (Huang et al, 2020). But the results of some studies are opposite to this. There is also a negative relation between URBAN and LE. Because of movement of people to urban areas, they cause environment destruction and due to increased death rates, life expectancy falls (Nathaniel and Khan, 2020).

People using basic sanitation services (SANS) also shows positive impact on life expectancy. The reasons are that when people get access to better sanitation facilities, their health improves due to reduction of health risks. Better health then improves LE (Okogor 2022). It is observed that better situations of sanitation and because of people's access, life expectancy increases (Rehman et al, 2022).

Prevalence of undernourished (PUN) has negative effects on life expectancy in long-run. As PUN increased LE falls. Due to malnutrition children does not get basic food needed for growth, as a result deaths increased among children of five years and LE falls (Djoumessi2022). Because of lower income levels, people cannot afford food. As a result, malnutrition increases and has negative impact on life expectancy (Wu and Hao, 2024).

Unemployment (UNEMP) possesses negative impact to life expectancy. As unemployment rise, life expectancy falls. The reason is that due to high unemployment people doesn't have resources to spend on health, so they have shorter lives and life expectancy decrease (Laditka 2016). Unemployment means no income and no better medical facilities, thus LE falls (Monsef and Mehrjardi 2015).

Current health expenditures (HE) have a positive relation with life expectancy. As medical expenses rise people enjoy better health and LE also increase. Private health expenses positively effects life expectancy, because rise in income resulted increased health-care facilities (Nkemgha et al, 2021). When GDP increase government spend a lot on hospitals, in this way HE positively affects national life expectancy (Morina et al,2022). Finally, in long-run the independent variables have mixed impacts on life expectancy.

Conclusions and Policy Recommendations

The study aims to determine the factors that affect the environmental quality and health status in SAARC countries. The research has three main objectives: to find out such aspects and factors that affects the quality of environment and also the health of people. To find out the factors that causes environmental degradation and effects the life expectancy. To attain these objectives, the study uses the three models.

The focus of the first model is to examine the effects of Carbon emissions on life expectancy, in second model life expectancy is determined by the level of particulate matter such as $PM_{2.5}$, while third model employs the ecological footprint to examine the life expectancy. The study uses the data of 7 SAARC countries (Pakistan, India, Bangladesh, Nepal Sri Lanka, Maldives and Bhutan) which covers the time period from 2000 to 2023.

To explore the relationship between variables, summary statistics and Correlation analysis are employed. After that cross-sectional dependency of variables is examined by CD test. To determine the slope homogeneity, the Study used the Delta and adjusted Delta tests. The panel cointegration test analysis the long-run relationship by using Wasteland, Pedroni and Kao tests, which shows cointegration between variables. Lastly, to estimate both the short-run and the long run relationship, study used the CS-ARDL approach. In the study, life expectancy is used as dependent variable, while the independent variables are CO_2 emissions, GDP growth, urban population, people using at least basic Sanitation services, Current health expenditures, prevalence of undernourishment, $PM_{2.5}$ air pollution and ecological footprint.

The research objective is achieved by examining the factors which effects the health status that is measured by life expectancy along with environmental quality. Environmental quality that is our main variable in which we are interested are measured by three proxy variables namely: CO_2, $PM_{2.5}$ and ecological footprints. The study used life expectancy as a proxy to measure the health status is taken as dependent variable. On the other hand, the independent variables are CO_2, $PM_{2.5}$ and ecological footprints, GDP growth, urbanization, sanitation facilities, prevalence of undernourishment, unemployment, health expenditures. The result shows that health status is positively affected by GDP growth, urbanization, sanitation facilities and health expenditures. On the other hand, CO_2, $PM_{2.5}$, ecological footprints, prevalence of undernourishment and unemployment have a negative impact on health status in SAARC countries.

The following are policies to improve life expectancy:

- CO_2 has a negative and statistically significant impact on life expectancy. So, the government should improve environmental quality and lower health risks which supports longer life expectancy. It also reduces CO_2 emissions through tougher regulations and promote renewable energy.
- PP has negative impact on life expectancy. So, the policymakers should reduce air pollution by adopting the cleaner transportation systems and improve the life expectancy.
- EF has negative impact on life expectancy. So, the government should encourage sustainable activities to reduce ecological degradation to mitigate the unfavorable consequences on health and life expectancy.
- GDP has statistically significant and positive impact on life expectancy. So, the government should foster economic growth through investment in healthcare systems and equitable resource distribution to enhance public health outcomes.
- Urbanization has positive and significant impact on life expectancy. The government should invest in sustainable urban development to improve healthcare facilities in cities. It also enhances urban living conditions to maximize the benefits of urbanization on life expectancy.
- SANS has positive and significant impact on life expectancy. So, the policymakers should expand access to clean water and sanitation facilities to reduce the prevalence of waterborne diseases and improve overall health outcomes.
- PUN have negative relationship with life expectancy. So, government should address under-nutrition through targeted nutritional programs and health awareness campaigns to combat malnutrition and its detrimental effects on life expectancy.
- Unemployment is negatively linked with life expectancy. So, government should create jobs to reduce unemployment and improve life expectancy.
- HE is positively related with life expectancy. So, the government should boost public spending on access to medical services and healthcare infrastructure in order to improve health outcomes and prolong life expectancy.

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