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Investigating the Interplay Among Energy Consumption, Environmental Quality, and Health Status in Low- and Middle-Income Asian Countries

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Abstract

Energy consumption plays an important role in different economic activities. The growing part of energy consumption in the atmosphere causes enhanced greenhouse gas emissions which increases various health problems. The motive of this study is to explore the correspondence between energy consumption, environment quality, and health status in Asian countries. Life expectancy is dependent and CO_2 mission, Fossil Fuel Energy Consumption, GDP per capita, urbanization, Govt health expenditures are independent variables. We have used panel data from 27 low and 59 middle-income Asian countries from the period 2000 to 2020. The results of this study indicate that there is a positive and significant relationship between life expectancy and GDP per capita, and Govt health expenditures. There is a negative and significant kinship between life expectancy, carbon emission, and fossil fuel energy consumption. The results of Granger causality indicate that there exists uni-variate causality between GDP Per Capita, CO_2 emission Domestic govt health expenditures, and Fossil fuel energy consumption. There is bi-variate causality from fossil fuel energy consumption to CO_2 emission and urbanization, CO_2 emission. There is no causality between urbanization, fossil fuel energy consumption &, Domestic govt health expenditures, and CO_2 emission. The policymakers may introduce green technology in production that may help to mitigate the emission of gases that causes environmental degradation. The planners may introduce renewable energy sources that may help to reduce carbon emissions. Further Govt spending on the health sector may improve healthcare facilities.

Keywords: Fossil fuel energy consumption, govt health expenditures, urbanization, life expectancy

1. Introduction

Energy plays an important role in economic growth. The main factor of production is energy besides labor and capital. Production in all fields like agriculture, transport system, and industries depend on energy. Energy consumption affects the health of human beings indirectly or directly by prompting air pollution, poor infrastructure of health, and a shortage of safe water. Energy consumption by fossil fuels raises the risk to human health and also raises the insecurity of energy. When energy consumption is increased to improve the growth of an economy that tends to reduce the life expectancy of the population. The use of Non-renewable energy sources (coal, oil, gas) is harmful to health as it releases CO_2 emissions that directly affect human health. The higher carbon emissions cause to reduce the average life of people (Murthy et al. 2021). The major factor that causes environmental degradation is the expansion in carbon dioxide emissions. The use of pollutant energy sources is the main cause of to increase in the emission of carbon dioxide which causes different health problems. The negative impact on health tends to reduce human capital power. Infant mortality and life expectancy are the main indicators of health. Carbon dioxide emission is a major cause of global warming. Due to global warming, different natural disasters such as floods and drought raises as the sea level rises. Carbon dioxide emission is the most important cause of different health problems that instantly affect the quality of life (Abokyi et al. 2019; Audi and Ali, 2023).

The most important and dangerous factor that badly affects the quality of life is environmental degradation and the great source is greenhouse gas emissions The emission of greenhouse gas is rapidly increasing and generating panic circumstances to climate change. The primary offender of air pollution is carbon emission which causes to increase in the harmful particles that have an unfavorable effect on human health and expend hospitalization. Increased death rates and hospitalization adversely affect labor productivity. CO_2 emission is a major cause of different diseases involving asthma, skin allergy, and cardiovascular diseases (Ali and Audi, 2016). There is a strong and long relationship between energy consumption and health outcomes. Modern sources of energy increase welfare and also improves the quality of all sectors such as agriculture, trade, education, and health. Air pollution causes different health problems such as lung cancer, asthma, and heart problems. It also increases the mortality rate. Environmental degradation also causes to increase in malaria and dengue fever. It affects human health adversely which leads to reduce labor productivity (Narayan, 2008; Shahbaz et al., 2016; Ali et al., 2022).

Good health is a basic human right. In modern times all human beings are facing different health problems all over the world, due to the lack of proper meditation. Non-renewable energy consumption affects life expectancy by increasing the mortality rate. On the contrary, due to renewable energy consumption life expectancy increases and the mortality rate decreases. There is a strong association between public health and environmental quality. It is also noted that pollutant emission is a great cause of an increase in different diseases (Sharma et al. 2018). The impact of the increase in gases like NO_2, and CO_2 and environmental degradation on public health is the most serious problem in recent times. The majority of the population uses biomass fuels and firewood for their energy needs. Biomass gases directly affect the environment, which influences human

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health that leads to reduced labor productivity. The population is the main factor that affects the urban environment. The insufficient drainage system, inadequate supply of water, and over-urban population increase the cost of public health Environmental degradation causes to increase in the burden on health care and also causes different diseases that unfavorably affect the spending on the health of the household (Jerrett et al. 2003; Senturk and Ali, 2022). Several factors affect the population's health. Some are sanitation, diet, literacy, lifestyle, and environmental factors. The environmental impact on health is more complex and extremely varied (Audi et al., 2020). An increase in greenhouse gas emissions and global warming due to fossil fuel energy consumption badly affects the environmental quality. The emission of different gases is the main cause to increase the in pollution. Poor environmental quality causes different serious health issues (Abdullah et al. 2016; Ali et al., 2021; Ali et al., 2021; Ali et al., 2022).

2. Review of Literature

Table 1 shows the summary of studies on environmental quality and health status and studies on energy consumption and health status.

Table 1: Summary of the Studies on CO_2 Emission and Health Expenditures.

Author(s)	Period	Country	Methodology	Main Results
Summary of the Studies on CO_2 Emission and Health Expenditures				
Bouchouch (2020)	1996-2018	17 Middle East and North African (MENA)	FMOLS and DOLS	Economic growth (+) on health, CO_2 (-) on health, Quality of governance (+) on health, urbanization (+)
Majeed and Ozturk (2020)	1990-2016	180 countries	2SLS Method	Economic growth (+), Carbon emission (+), Urbanization (-)
Naeem et al. (2021)	1975-2013	Pakistan	ARDL, VECM	Economic growth (+), Urbanization (+), Income inequality (-), CO_2 emission (-)
Zeeshan et al. (2021)	1990-2019	China	NARDL, Granger causality test	Environmental pollution (+), CO_2 emission (+)
Das and Ivaldi (2021)	1991-2019	20 highly polluted countries	Granger causality, Error Correction Mechanism (ECM)	Economic growth (+), Carbon emission (+)
Wireko et al. (2021)	2000-2018	25 developing countries	Pooled Mean Group (PMG) and Dynamic Ordinary Least Square (OLS) methods	Income (+), Natural resources (-), Economic growth (+) to health
AY (2021)	1970-2018	41 highest CO_2 emission countries	Auto-Regressive Distributed Lag (ARDL) approach	Health (+), CO_2 emission (-), Gross Domestic Product (+)
Fan et al. (2021)	1995-2018	Mexico	NARDL	Tourism (-) on environment, CO_2 (+) on Health Spending
Summary of the Studies on Energy Consumption and Health Status				
Osakede and Sanusi (2019)	1960-2014	Nigeria, South Africa	ARDL	Fossil fuel consumption (-) to life expectancy, economic growth (+) to life expectancy
Safdar et al. (2020)	1975-2017	Pakistan	ARDL	Renewable energy consumption (+), industrialization (+).
Hesary et al. (2020)	1991-2018	18 middle and low-income Asian countries	GMM	Fossil fuel consumption (+), carbon emission (+), economic growth (-)

Rahman and Alam (2020)	2002-2017	SAARC countries	ARDL	Energy consumption (+), Economic growth (+)
Akbar et al (2020)	1991-2018	Southeast Asian countries	Structure Equation Modeling (SEM) technique	Trade liberalization (+), energy consumption (+)
Anser et al. (2020)	1995-2018	Asian countries	ARDL	Per capita income (-), greenhouse gas (+), fossil fuel (+)
Sade et al. (2020)	1980-2017	Nigeria	ARDL	Poverty (-), Fossil fuel consumption (-)
Rasoulinezhad et al. (2020)	1993-2018	Commonwealth of independent states (CIS)	GMM	Fossil fuel consumption (+), Human Development Index (HDI) (-)
Caruso et al. (2020)	1990-2015	12 European countries	Panel Vector Auto-Regressive (PVAR) technique	Renewable energy consumption (+), fossil fuel consumption (-)
Ibrahim and Ajide (2021)	1990-2017	4 African countries	FMOLS	Renewable energy consumption (-), income per capita (+)
Sasmaz et al. (2021)	2004-2017	27 European union countries	ARDL	Renewable energy consumption (-)

In the first section, the studies showed the association between CO_2 emission and health expenditure. In these studies, infant mortality rate, and life expectancy were used as the proxy of health expenditure. Greenhouse gas emission, pollution, and environmental degradation measured the impact of CO_2 emission on the health of the population. The findings of these studies showed a mixed relationship between CO_2 emission and health expenditure. Most of the studies reported a positive association between variables. In a few studies, there was a negative relationship between carbon emission and health expenditure. The positive relation between carbon emission and health expenditures showed that environmental degradation raised the expenditures on population health.
The second section examined the impact of energy consumption on health expenditure. In these studies, lungs and respiratory disease, undernourishment and death ratio, and healthcare per capita expenditure were used as a proxy of health expenditures, and fossil fuel consumption, solid fuel consumption (for cooking), electricity consumption, industrialization, coal consumption, was used as the component of energy consumption. The outcome of these studies showed a mixed relationship between energy consumption and health expenditures. Most studies showed the positive but some studies affirmed the negative kinship between energy consumption and health. In this study, we use data from different low and middle-income Asian countries to examine the relationship between energy consumption, environment quality, and health status of the population. In previous studies, data from 27 countries are taken but we have taken data from 59 low and middle-income Asian countries.

3. Model Specification

To explain the relationship between energy consumption, environment quality, and health status we have used data from 27 low and 59 middle-income Asian countries.
The functional form of the life expectancy model is:

$$LE = f(CO2, FFEC, GDPPC, URBAN, DGHE) \quad \textbf{(1)}$$

The econometric form of the life expectancy model is:

$$LE_{it} = \phi_0 + \phi_1 CO2_{it} + \phi_2 FFEC_{it} + \phi_3 GDPPC_{it} + \phi_4 URBAN_{it} + \phi_5 DGHE_{it} + \varepsilon_{it} \quad \textbf{(2)}$$

Equation (1) and (2) exhibits the functional and econometric form of our model. Where *i* subscript indicates countries and *t* refers to the time of different years and ∅ interpret the slope of variables. LE shows the life expectancy which is used as the proxy of health and is the dependent variable. CO_2 is used as the proxy of environmental quality, FFEC is Fossil Fuel Energy Consumption which is used as the proxy of energy consumption, GDPPC is gross domestic product per capita and urbanization are the independent variables that are used in the model.

4. Data: Description, Definition and Sources

The data for this study was gathered from a panel of Low and Middle-Income Asian countries over the period of 2000 to 2020.

Table 2: Variables: Description and Sources

Variable	Description	Source
CO2	CO2 emissions (metric tons per capita)	WDI
GDPPC	GDP per capita growth (annual %)	
URBAN	Urban population (% of total population)	
DGHE	Domestic general government health expenditure (% of GDP)	
LE	Life expectancy at birth, total (years)	
FFEC	Fossil fuel energy consumption (% of total)	

4.1. CO2 Emissions (metric tons per capita)

CO_2 emission is an important indicator of greenhouse gas diffused through different human activities. CO_2 emission is present in the atmosphere naturally as a part of the carbon cycle of the earth. The major source of carbon emission is the burning of fossil fuels (coal, oil, and natural gas) and through different chemical reactions. CO_2 emission causes different serious health problems that cause to reduce Life expectancy.

$$CO_2\ Emission = \frac{CO_2\ emission}{Population} \times 100 \qquad \textbf{(3)}$$

4.2. Urban Population (% of the total population)

The urban population turns to settle in areas that have more eminent population solidity than rural areas. In simple words, people live in cities. The growth of the urban population has both negative and positive impacts on the lives of people and the environment. As the urban population increased the energy demand also increased. People move from rural areas to cities in search of good food, education, health facilities, and for better jobs. The percentage of people living in urban areas is increasing gradually as people migrate from rural to urban areas. (World Urbanization Prospect, 2018)

$$Urban\ population = \frac{Urban\ Population}{Total\ Population} \times 100 \qquad \textbf{(4)}$$

4.3. Domestic general government health expenditure (% of GDP)

The financing of health is a severe factor in the health system. Expenditures on health consist of the provision of nutrition activities, emergency aid, family planning, and health services. But the provision of clean drinking water and improved sanitary conditions are not included in health expenditures. Increasing health expenditures are related to better health outcomes. When a govt spends less on health facilities it may reveal that health is not regarded as a priority. General govt health expenditures from the sources of GDP can be expressed in terms of percentages.

$$DGHE = \frac{Total\ Govt\ Health\ Expenditures}{Total\ GDP} \times 100 \qquad \textbf{(5)}$$

4.4. Life Expectancy at Birth, total (years)

The term life expectancy can be explained as the average number of years a person can live from birth (Bilas et al. 2014).

$$\text{Life Expectancy} = \sum_{Current\ age}^{\max imum\ age} Fi \qquad \textbf{(6)}$$

4.5. Fossil Fuel Energy Consumption (% of total)

Economic development and environmental sustainability play a key role in the field of energy. The Consumption of fossil fuels is the main source to produce energy (biomass, gasoline, and natural gas) that is used in different ways to meet different human needs. It causes different environmental problems, such as global warming and air pollution which causes health problems and affects the Quality of Life of the population. Due to different health problems, there is a negative association between growth and FFEC (Martins,2019).

$$\text{Fossil Fuel Energy Consumption (\%)} = \frac{E_{solid\ fuels} + E_{oil} + E_{gas}}{Gross\ annual\ production} \qquad \textbf{(7)}$$

5. Methodology: Panel ARDL

The Unrestricted Error Correction Models (UECMs) relating to the determinants of Life Expectancy for Low and Middle-Income Asian Countries are shown as follows:

$$\Delta(LE)_{it} = \alpha + \varphi_1(LE)_{it-1} + \varphi_2(CO_2)_{it-1} + \varphi_3(FFEC)_{it-1} + \varphi_4(GDPPC)_{it-1} + \varphi_5(URBAN)_{it-1} + \varphi_6(DGHE)_{it-1} + \sum_{i=1}^{v_1}\lambda_{1i}\Delta(LE)_{it-i} + \sum_{i=0}^{v_2}\lambda_{2i}\Delta(CO_2)_{it-i} + \sum_{i=0}^{v_3}\lambda_{3i}\Delta(FFEC)_{it-i} + \sum_{i=0}^{v_4}\lambda_{4i}\Delta(GDPPC)_{it-i} + \sum_{i=0}^{v_5}\lambda_{5i}\Delta(URBAN)_{it-i} + \sum_{i=0}^{v_6}\lambda_{6i}\Delta(DGHE)_{it-i} + \mu_{it} \quad \textbf{(8)}$$

In equation (8) φ_i are the parameters of proportional long-run multipliers moreover λ_i (for i=0) are the dynamic coefficients of short-run and others λ_i (for i=1, 2, ..., $v_1, v_2, ..., v_6$)are VAR coefficients of ARDL model. Δ is the first difference operator and μ_{it} is the error term.

If there exists a long-run relationship then the parameters of the long-run can be estimated by using the equation for Asian countries.

$$(LE)_{it} = \alpha + \sum_{i=1}^{v_1}\pi_{1i}(LE)_{it-i} + \sum_{i=0}^{v_2}\pi_{2i}(CO_2)_{it-i} + \sum_{i=0}^{v_3}\pi_{3i}(FFEC)_{it-i} + \sum_{i=0}^{v_4}\pi_{4i}(GDPPC)_{it-i} + \sum_{i=0}^{v_5}\pi_{5i}(URBAN)_{it-i} + \sum_{i=0}^{v_6}\pi_{6i}(DGHE)_{it-i} + \mu_{it} \quad \textbf{(9)}$$

In equation (9) the parameters related to the sign of summation indicate the long-run parameters. The dynamics of the short-run can be found by estimating the following equation for Low and middle-income Asian countries.

$$\Delta(LE)_{it} = \alpha + \sum_{i=1}^{v_1}\theta_{1i}\Delta(LE)_{it-i} + \sum_{i=0}^{v_2}\theta_{2i}\Delta(CO_2)_{it-i} + \sum_{i=0}^{v_3}\theta_{3i}\Delta(FFEC)_{it-i} + \sum_{i=0}^{v_4}\theta_{4i}\Delta(GDPPC)_{it-i} + \sum_{i=0}^{v_5}\theta_{5i}\Delta(URBAN)_{it-i} + \sum_{i=0}^{v_6}\theta_{6i}\Delta(DGHE)_{it-i} + \sigma ECM_{it-1} + \mu_{it} \quad \textbf{(10)}$$

In equation (10), the parameters related to the summation sign express the short-run parameters and coefficient of the Error Correction Model (ECM) in both equations. σ exhibits the speed of adjustment towards long-run equilibrium. For convergence, the coefficient of adjustment should be negative and statistically significant.

6. Results and Discussions

This section explains the results and discussion of this paper.

6.1. Unit Root Analysis

In panel unit root analysis four tests are used. These are the Levin-Lin-Chu test, Augmented Dickey-Fuller, Fisher Chi-square test, and Phillips-Perron test. Three types of specifications that are used for every test are intercept, intercept & trend, and none. For Low-Income Asian countries as stated in Table 3. The probability value of the LE series is greater than 0.05 which indicates that we accept the null hypothesis and the series is integrated of order one I (1) or non-stationary. In the unit root test CO_2 and GDPPC have stationary series as the probability value of these series is less than 0.05. So, we reject the null hypothesis. The probability values of the series of FFEC, URBAN, and DGHE are greater than 0.05 which exhibits that the series are non-stationary or unit root I (1).

The lower part of Table 3 shows the panel unit root test for Middle-Income Asian Countries. According to the results, the probability value of series LE, FFEC, URBAN, and DGHE is greater than 0.05 so, the series are unit root I (1) or non-stationary. The unit root test indicates the series of CO_2 and GDPPC have a probability value less than 0.05 which indicates the series is stationary or I (0). The results are the same as those we found in low-income Asian Countries.

Table 3: Results of Panel Unit Root Tests

Variable	Intercept				Intercept and Trend				None			Conclusion
	LLC Test	IPS Test	ADF-Fisher Chi-Square	PP-Fisher Chi-Square	LLC Test	IPS Test	ADF-Fisher Chi-Square	PP-Fisher Chi-Square	LLC Test	ADF-Fisher Chi-Square	PP-Fisher Chi-Square	
Low-Income Asian Countries												
LE	0.62830 (0.7351)	2.37617 (0.9913)	39.1739 (0.9354)	33.4162 (0.9875)	-3.60106 (0.0002)	-1.33989 (0.0901)	68.1005 (0.0939)	61.1813 (0.2339)	1.75337 (0.9602)	27.9434 (0.9987)	25.3710 (0.9997)	I(1)
CO2	-26.8851 (0.0000)	-24.8845 (0.0000)	781.774 (0.0000)	188.238 (0.0000)	-44.0995 (0.0000)	-46.9685 (0.0000)	399.099 (0.0000)	28.4858 (0.9983)	-1.99144 (0.0232)	94.9888 (0.0005)	0.72315 (1.0000)	I(0)
FFEC	0.75127 (0.7738)	2.59638 (0.9953)	8.89595 (0.9841)	7.41101 (0.9951)	1.10665 (0.8658)	1.01728 (0.8455)	11.7266 (0.9252)	6.97782 (0.9968)	0.26400 (0.6041)	8.72454 (0.9859)	8.28588 (0.9963)	I(1)
GDPPC	-3.95755 (0.0000)	-5.67329 (0.0000)	132.996 (0.0000)	245.145 (0.0000)	-4.63470 (0.0000)	-5.56768 (0.0000)	119.601 (0.0000)	259.424 (0.0000)	-9.05870 (0.0000)	189.978 (0.0000)	293.835 (0.0000)	I(0)
URBAN	36.8517 (1.0000)	120.470 (1.0000)	62.9631 (0.1888)	45.3555 (0.7927)	7.55340 (1.0000)	18.4087 (1.0000)	131.337 (0.0000)	96.0634 (0.0004)	61.7661 (1.0000)	0.17979 (1.0000)	0.42032 (1.0000)	I(1)
DGHE	-3.01981 (0.0013)	-1.17549 (0.1199)	54.5993 (0.2381)	56.7988 (0.1800)	-3.53209 (0.0002)	-1.82031 (0.0344)	62.0691 (0.0835)	68.6017 (0.0270)	-2.34007 (0.0096)	52.4192 (0.3803)	53.9823 (0.3248)	I(1)
Middle-Income Asian Countries												
LE	-1.69996 (0.0446)	2.80741 (0.9975)	110.073 (0.5866)	112.792 (0.5144)	-1.10835 (0.1339)	1.71908 (0.9572)	105.910 (0.6931)	121.458 (0.2989)	-22.2315 (0.0000)	62.8168 (1.0000)	59.4696 (1.0000)	I(1)
CO2	-47.1891 (0.0000)	-36.7633 (0.0000)	2473.15 (0.0000)	1142.45 (0.0000)	-1.81856 (0.0345)	9.88781 (1.0000)	215.630 (0.0000)	127.267 (0.1536)	0.41080 (0.6594)	0.24053 (1.0000)	0.29089 (1.0000)	I(0)
FFEC	-3.83499 (0.0001)	-0.73585 (0.2309)	86.4361 (0.2918)	96.9877 (0.0951)	-4.88709 (0.0000)	0.41080 (0.6594)	91.5640 (0.1773)	111.945 (0.0107)	1.09876 (0.8641)	35.8616 (1.0000)	35.9538 (1.0000)	I(1)
GDPPC	-5.37015 (0.0000)	-7.35260 (0.0000)	275.551 (0.0000)	276.522 (0.0000)	-7.48788 (0.0000)	-6.01777 (0.0000)	253.158 (0.0000)	267.061 (0.0000)	-10.8222 (0.0000)	426.938 (0.0000)	419.993 (0.0000)	I(0)
URBAN	2.28690 (0.9889)	12.8516 (1.0000)	1580.08 (0.0000)	792.905 (0.0000)	1.07066 (0.8578)	17.4860 (1.0000)	572.476 (0.0000)	544.801 (0.0000)	133.082 (1.0000)	83.7465 (0.9928)	66.6703 (1.0000)	I(1)
DGHE	-2.37067 (0.0089)	-0.82435 (0.2049)	135.595 (0.0819)	162.568 (0.0019)	-4.18634 (0.0000)	-1.43035 (0.0763)	144.728 (0.0274)	165.659 (0.0011)	3.73465 (0.9999)	65.1250 (0.9999)	65.7269 (0.9999)	I(1)

6.2. Long Run and Error Correction Analysis

Now we examine the long-run and error correction results of the model. Table 4 explains the Panel ARDL estimates of energy consumption, environmental quality, and health model for Low-Income Asian Countries. In this table, the dependent variable is Life Expectancy (LE) and CO_2 Emission, Fossil Fuel Energy Consumption (FFEC), GDP Per Capita (GDPPC), Urbanization (URBAN), and Domestic Government Health Expenditures (DGHE) are independent variables.

Table 4: Panel ARDL Estimates of Energy Consumption, Environmental Quality and Health Model for Low-Income Asian Countries

Dependent Variable: D(LE)				
Method: ARDL				
Model selection method: Akaike info criterion (AIC)				
Selected Model: ARDL (1,1,1,1,1, 1)				
Long Run Equation				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
CO2	-0.0705	0.0165	-4.2754	0.0000
FFEC	-4.3628	0.9251	-4.7162	0.0000
GDPPC	0.0705	0.0165	4.2754	0.0000
URBAN	0.1401	0.0725	1.9343	0.0553
DGHE	3.6630	0.2870	12.7613	0.0000
C	0.6635	0.5186	1.2796	0.2030
Short Run Equation				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
COINTEQ01	-0.1401	0.0725	1.9343	0.0553
D(CO2)	4.3628	0.9251	4.7162	0.0000
D(FFEC)	2.7521	0.8143	3.3798	0.0010
D(GDPPC)	0.4468	0.1644	2.7187	0.0075
D(URBAN)	0.0047	0.0029	1.6066	0.1106
D(DGHE)	-0.0189	0.0148	-1.2796	0.2030
C	0.4533	1.1589	0.3911	0.6959

CO_2 is the first independent variable in the table. The sign of CO_2 is negative and is statistically significant which suggests that an increase in carbon emission causes to decrease the life expectancy. CO_2 emission is an essential factor of greenhouse gas diffused by different human activities. The main sources of carbon emission are burning fossil fuels (coal, natural gas, and oil) and through different chemical reactions. The main cause of different health problems is an increase in carbon dioxide emissions that affect the Quality of Life (QOL) directly. Environmental degradation causes lung and respiratory disease that reduces the average number of years that people live. The studies by Mahalik et al. (2022), Murthy et al. (2021), Ayomitunde et al. (2020), Majeed and Ozturk (2020), Nkalu and Edeme (2019), Yildim et al. (2019), Hossain et al. (2019), Hashmi et al. (2017), Hailemariam and Pan (2012) also found the negative relationship between life expectancy and carbon dioxide (CO_2) emission[4].

The consumption of fossil fuels is a major cause of pollution. When fossil fuels burned as a result carbon dioxide (CO_2) is produced which is a major driver of climate change. The effect of Fossil fuel energy Consumption (FFEC) is negative and significant. Climate change due to the use of fossil fuels creates various health problems for children and also causes millions of early deaths each year. The increased amount of fossil fuel consumption causes to enlarge the danger of lung and respiratory diseases (LRD) which leads to reduced Life Expectancy (LE). Without the emission of fossil fuels, the average

[4] Amuka et al. (2018), Breitbart (2017), Monsaf and Mehrjardi (2015), Delavari et al. (2008) are of the view that there is a positive link between carbon emission and life expectancy. More carbon emission is helpful in agriculture for food production. When more CO_2 is released in the atmosphere it is absorbed less by plants to produce food. Carbon emission in the air helps to provide healthier food available to man that has positive impact on the quality and longevity of life.

life expectancy of the world`s population would increase by more than one year. Some with the same results are Sade et al. (2020), Banerjee (2020), Osabohien et al. (2020), studies Caruso et al. (2020), Osakede and Sanusi (2019). All these studies also show the inverse relation between Life Expectancy and Fossil Fuel Energy Consumption (FFEC)[5].

The third independent variable in Table 4 is Gross Domestic Product Per Capita (GDPPC). The influence of GDPPC is positive and significant. As the growth rate of a nation increases then people get better health facilities which play an important role to raise Life Expectancy (LE). The growth rate of an economy enhances the individual's income and they can obtain effective housing, diet, education, and health facilities that tend to enhance health outcomes and also increases life expectancy. An increase in GDP per capita manipulates the increased Life Expectancy and Quality. Further increase in GDPPC (income) helps in attaining modern health facilities that can be applied to control different health issues. This result is in line with the work of Ibrahim and Ajide (2021), Das and Ivaldi (2021), Majeed and Ozturk (2020), Xing et al. (2019), Nkalu and Edeme (2019), Erdogan et al. (2019), Mulali (2015), Bayati et al. (2013), Hailemariam and Pan (2012) who found the positive and significant kinship between Life Expectancy and GDP per capita in their studies.

Table 5: Panel ARDL Estimates of Energy Consumption, Environmental Quality and Health Model for Middle-Income Asian Countries

Dependent Variable: D(LE)				
Method: ARDL				
Model selection method: Akaike info criterion (AIC)				
Selected Model: ARDL (1,1,1,1,1, 1)				
Long Run Equation				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
CO2	-0.2562	0.1254	-2.0433	0.0414
FFEC	-1.6511	0.1651	-10.0020	0.0000
GDPPC	0.0360	0.0120	2.9931	0.0029
URBAN	0.0380	0.0034	11.2506	0.0000
DGHE	0.1351	0.0342	3.9558	0.0001
C	2.4469	0.5176	4.7276	0.0000
Short Run Equation				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
COINTEQ01	-3.3104	0.4897	-6.7601	0.0000
D(CO2)	0.0054	0.0077	0.7041	0.4816
D(FFEC)	0.7522	0.0401	18.7485	0.0000
D(GDPPC)	-0.0005	0.0002	-2.7499	0.0061
D(URBAN)	0.3037	0.0315	9.6313	0.0000
D(DGHE)	-5.6136	0.4603	-12.1968	0.0000
C	0.0994	0.0075	13.2677	0.0000

Urbanization is another explanatory variable in Table 4. Urbanization is dignified by urban growth rate and urban population. There is a positive link between urbanization and the dependent variable Life Expectancy. The coefficient of urbanization is positive and statistically insignificant. The higher level of urbanization creates good food, housing, and education which tends to improve their health and also increase their Life Expectancy. Moreover, urban growth transfers resources that endow infrastructure projects which help to improve the health of people and can re.duce overpopulation. Urbanization is considered an important factor in development strategy. Urbanization works as an economic and social development engine. Urbanization tends to improve public health overall. The role of urbanization is beneficial to health outcomes dignified by life expectancy and infant mortality rate. An increase in urbanization causes a reduction in mortality rate and expands life

[5] According to Xing et al. (2019), Parag and Darby (2019), Jiang et al. (2019), and Emife et al. (2018) Fossil Fuel Energy Consumption is positively related to Health outcomes (Life Expectancy). Fossil Fuel is the main factor to produce energy that is used in different activities and causes improved economic growth. Due to an increase in economic growth, people spend more on their health care services which leads to improving Quality of Life and also improves health outcomes.

expectancy. Urbanization is not only good for health outcomes but also for higher economic growth and development. Our results are in line with Naeem et al. (2021), Tripathi (2021), Bouchouch (2020), Ali et al. (2019), Wang (2017), Kim (2015), Bergh and Nilsson (2010). These studies also found a positive relationship between Urbanization and Life Expectancy[6].
Domestic Govt Health Expenditure (DGHE) is the last independent variable shown in Table 4. The coefficient of DGHE is positive and statistically significant which suggests that Govt health spending plays an important role to improve health outcomes. An increase in healthcare awareness will help to improve the quality of life as a result Life expectancy will also improve. Due to health care services, innovation in methods of treatment also improves the health of people. It is concluded that countries that spend more on health protection have less mortality rates. Due to the proper awareness of the damages of smoking and drinking alcohol and other unhealthy activities, people have a longer life expectancy. The results are in line with studies by Ibukun (2021), Murthy et al. (2021), Gedikli et al. (2019), Rahman et al. (2018), Heuvel and Olaroiu (2017), Jaba et al. (2014), Kim and MSW (2013), Obrizan and Wehby (2012). These studies found the same positive results[7].
Table 5 represents panel ARDL estimates of energy consumption, environmental quality, and health model for middle-income Asian countries. The coefficient value of CO_2 emission & FFEC is negative and significant which shows a negative relation between them.
The sign of coefficients of independent variables GDPPC, URBAN, and DGHE are positive and values are significant which shows their positive relationship with the dependent variable of Life Expectancy (LE) from 2000 to 2020. The signs of the variable's coefficient are the same but there is a small difference in magnitude. The magnitude of the coefficient of DGHE is small here as compared to the coefficient in Low-income countries.

6.3. Error Correction Analysis

In this section, a short-run analysis of variables is explained. Table 4 measures the error correction in terms of energy consumption, environment quality, and health status in low-income Asian Countries. The sign of the coefficient is negative and significant in the short run. The negative sign indicates that the error will remove in the long run that occur in the short run. The value of the coefficient indicates the speed of adjustment and the negative sign of the coefficient means convergence toward equilibrium. The adjustment speed is -0.0705. In Table 5 error correction terms of energy consumption, environment quality, and health status in Middle-income Asian Countries. The sign of the coefficient is also negative and significant in the short run for middle-income Asian countries. The speed of adjustment is -3.3104 in the case of middle-income countries.

6.4. Causality Analysis

This section is embracing the causality analysis and lag selection criterion. Table 6 portrays the lag selection criteria of low-income countries that are based on six methods. The methods are Log-likelihood, sequentially modified LR test statistics, final prediction error (FPE), Akaike information criterion (AIC), Schwarz information criterion (SC), and Hannan-Quinn information criterion (HQ). According to LR, the lag is five. In the same way, the final prediction error, the Akaike information criterion, the Schwarz information criterion, and the Hannan-Quinn information criterion lag are also five. Except for the log-likelihood method, all other methods support lag five. So, the optimal lag is five.

Table 6: VAR Lag Order Selection Criteria of LIC

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1148.533	NA	1138888.	28.13494	28.28169	28.19386
1	-390.7729	1404.628	0.019736	10.26275	11.14326	10.61626
2	-308.8732	141.8262*	0.004960*	8.874957*	10.48922*	9.523059*
3	-295.0841	22.19713	0.006633	9.148393	11.49641	10.09109
4	-275.7959	28.69708	0.007880	9.287705	12.36948	10.52499
5	-252.5665	31.72802	0.008692	9.330889	13.14642	10.86277

The results of the Granger causality analysis interpret the direction of causality. It explains whether there is uni-variate, bi-variate, or no causality among variables. On the base of probability value, the direction of variables can be found. In Table 7 the Granger causality analysis evaluates at a 5% level of significance for low-income countries. If the probability value is greater than 5% then we accept the null hypothesis and on the other hand if the probability value is less than 5% then we reject the null hypothesis. Table 7 portrays fossil fuel energy consumption does not cause CO_2 emission but CO_2 emission cause fossil fuel energy consumption. It shows uni-variate causality between fossil fuel energy consumption and CO_2 emission.

[6] Some studies have found inverse relation between urbanization and life expectancy. Salahodajev (2014), Janke et al. (2009), Allender et al. (2008), Oyasawyer et al. (1987) argue that Urbanization causes to damage the health of people by increasing the green house emission and burden on health facilities. Pollution increases due to the development of urbanization.
[7] However according to Zaman et al. (2017), Shahraki (2019) found that there is no direct linkage between health expenditures and life expectancy. Health expenditures are more sensitive to GDP rather Life Expectancy.

Table 7: Granger Causality Analysis of LIC

Null Hypothesis	Obs	F-Statistic	Prob
FFEC ↛ CO2	130	1.71544	0.1841
CO2 ↛ FFEC		3.88514	0.0231
GDPPC ↛ CO2	405	2.61352	0.0745
CO2 ↛ GDPPC		7.55871	0.0006
URBAN ↛ CO2	452	4.02740	0.0185
CO2 ↛ URBAN		9.01835	0.0001
DGHE ↛ CO2	397	0.49565	0.6096
CO2 ↛ DGHE		0.54471	0.5805
GDPPC ↛ FFEC	114	0.33468	0.7163
FFEC ↛ GDPPC		0.74439	0.4774
URBAN ↛ FFEC	127	1.07549	0.3443
FFEC ↛ URBAN		1.34101	0.2654
DGHE ↛ FFEC	116	1.03660	0.3581
FFEC ↛ DGHE		0.57998	0.5616
URBAN ↛ GDPPC	450	3.06886	0.0475
GDPPC ↛ URBAN		3.89601	0.0210
DGHE ↛ GDPPC	409	0.56729	0.5675
GDPPC ↛ DGHE		0.46443	0.6288
DGHE ↛ URBAN	412	0.14654	0.8637
URBAN ↛ DGHE		1.81774	0.1637

GDP per capita does not cause CO_2 emission but CO_2 cause GDP per capita. It means there exists uni-variate causality between these variables. Urbanization cause CO_2 emission and CO_2 emission caused urbanization, which means there is bi-variate causality between variables. Domestic govt health expenditures do not cause carbon emission and in the same way, carbon emission also does not cause domestic govt health expenditures, which shows there is no causality between variables. GDP per capita does not cause fossil fuel energy consumption and fossil fuel energy consumption also does not cause GDP per capita. It shows no causality between these variables. There is no causality between urbanization and fossil fuel energy consumption because both variables do not cause each other. Domestic govt health expenditures do not cause fossil fuel energy consumption and fossil fuel energy consumption also does not cause govt health expenditures which shows no causality between variables. There exists bi-variate causality between urbanization and domestic govt health expenditures, as both cause each other. There is no causality between domestic govt health expenditures and GDP per capita because both variables do not cause each other. Domestic govt health expenditures and urbanization does not cause each other. It shows there exists no causality between these variables.

Table 8 explains the lag selection criteria of Middle-income countries that are based on six methods. These methods are explained in Low-income countries' criteria. According to all tests except the log-likelihood method the lag is five. Thus, the optimal lag is five.

Table 8: VAR Lag Order Selection Criteria of MIC

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-6304.167	NA	91522236	32.52148	32.57252	32.54172
1	-2510.272	7470.452	0.334477	13.09419	13.40045	13.21561
2	-1868.119	1247.896	0.013894*	9.912983*	10.47447*	10.13560*
3	-1847.469	39.59701	0.014211	9.935405	10.75211	10.25922
4	-1830.520	32.06308	0.014817	9.976906	11.04883	10.40191
5	-1798.601	59.55893*	0.014305	9.941245	11.26839	10.46744

The analysis of Granger causality explains the direction of causality. According to the probability value, the direction of variables can find out. If the probability value is greater than 5% then we accept the null hypothesis. On the contrary, if the probability value is less than 5% then we reject the null hypothesis. Table 9 explains the results of the Granger causality analysis for middle-income countries. Fossil fuel energy consumption cause CO_2 emission and CO_2 emission also causes fossil fuel energy consumption. It shows there is bi-variate causality among variables. GDP per capita cause CO_2 emission but CO_2 emission does not cause GDP per capita, which shows there exists uni-variate causality between GDP per capita and carbon emission. There is uni-variate causality between urbanization and CO_2 emission as urbanization cause carbon emission but carbon emission does not cause urbanization.

Table 9: Granger Causality Analysis of MIC

Null Hypothesis	Obs	F-Statistic	Prob
FFEC ↛ CO2 CO2 ↛ FFEC	545	5.35510 3.25687	0.0050 0.0393
GDPPC ↛ CO2 CO2 ↛ GDPPC	952	27.8829 0.43038	2.E-12 0.6504
URBAN ↛ CO2 CO2 ↛ URBAN	969	4.81357 0.69330	0.0083 0.5002
DGHE ↛ CO2 CO2 ↛ DGHE	956	0.70073 1.43975	0.4965 0.2375
GDPPC ↛ FFEC FFEC ↛ GDPPC	543	3.80996 0.23411	0.0227 0.7914
URBAN ↛ FFEC FFEC ↛ URBAN	545	0.12111 1.29495	0.8860 0.2748
DGHE ↛ FFEC FFEC ↛ DGHE	535	2.29482 7.98585	0.1018 0.0004
URBAN ↛ GDPPC GDPPC ↛ URBAN	1100	5.22829 1.58544	0.0055 0.2053
DGHE ↛ GDPPC GDPPC ↛ DGHE	996	0.88922 2.63291	0.4113 0.724
DGHE ↛ URBAN URBAN ↛ DGHE	1012	2.00135 6.97248	0.1357 0.0010

Domestic govt health expenditures cause CO_2 emissions and CO_2 emissions also cause govt health expenditures. It means that there is bi-variate causality between these variables. There exists uni-variate causality between GDP per capita and fossil fuel energy consumption. Because GDP per capita cause fossil fuel energy consumption but fossil fuel energy consumption does not cause GDP per capita. There exists uni-variate causality between urbanization and fossil fuel energy consumption because both do not cause each other. Domestic govt health expenditures and fossil fuel energy consumption cause each other. It means there is bi-variate causality among variables. Urbanization and GDP per capita cause each other. So, there is bi-variate causality between urbanization and GDP per capita. Domestic govt health expenditures cause GDP per capita and GDP per capita also causes domestic govt health expenditures. This shows that there is bi-variate causality between both variables. There exists bi-variate causality between Domestic govt health expenditures and urbanization. Because the probability value of both variables is less than a 5% level of significance.

7. Conclusions and Policy Implications

The purpose of this study is to acquire the impact of energy consumption and environmental degradation on the health of the population in 27 low and 59 middle-income Asian countries. Life expectancy as the proxy of health status is used as an endogenous variable and CO2 (as a proxy of environment quality), Fossil Fuel Energy Consumption (as a proxy of energy consumption), urbanization, and Domestic Govt Health Expenditures are used as exogenous variables. Panel data is used in this study from the period 2000 to 2020. The ARDL approach is used to estimate the kinship between variables in the long and short run. The results show a negative and significant relationship between CO_2 emission and Life expectancy. The correlation between both variables is moderate. Fast economic growth also causes to increase the carbon emission. Higher carbon emission is a great cause to reduce the average number of years that a person can live.

The findings also show an inverse and significant impact of FFEC on Life expectancy. FFEC is a major cause of pollution when Fossil Fuels are burned as a result carbon dioxide is produced which is the main cause to damage the climate. Climate change creates various health problems for children and also causes millions of early deaths every year. The correlation between FFEC and LE is strong. Urbanization shows a positive and significant impact on life expectancy. People move from rural to urban areas in search of a good job, health facilities and a better standard of life, these elements are important to improve the quality of life and better quality of life helps to improve the life expectancy of the population. The correlation between these variables is moderate. DGHE and GDPPC have a direct and significant impact on life expectancy. GDPPC plays an important role to improve the quality of life. As the GDP increases, people spend more on healthcare expenditures which helps to improve the standard of life. Expenditure on health consists of the provision of nutrition activities, emergency aid, and health services. Increasing health expenditure is related to better health outcomes. Govt spending on health helps to expand the life span of people and also saves more lives. The correlation between DGHE and GDPPC is weaker and positive. The sign of error correction term is negative and significant.

It is necessary to recommend economic policies according to the results of this study. These policies may be useful to improve the quality of the environment and extend the life expectancy of people in low and middle-income Asian countries.

- There is a negative relation between CO2 emission and life expectancy. Environmental degradation may cause different health problems which lead to increased pre-age deaths in the population. The planner may use green technology in the production process that may help to mitigate the emission of different gases (CO_2, NO_2). As a result, quality of life may improve and life expectancy also increases.
- Fossil Fuel Energy Consumption is a great and common source to produce energy for different activities. It is a major cause of to damage the environment as it creates a large amount of greenhouse gas emissions which causes various health problems. The policymakers introduce renewable and clean energy sources to meet the requirements of energy for daily use. Renewable energy sources are wind energy, solar energy, biogas, and geothermal energy. The use of these resources may be helpful to reduce air pollution and improve the health status of the population.
- Gross Domestic Product Per Capita (GDPPC) plays an important role to enhance health facilities and improve the quality of life. As GDPPC increases people spend more on their healthcare facilities which improve their standard of living. The planners can introduce a balanced growth policy in the economy. Balanced and sustained economic growth may improve human life by utilizing modern medical technologies which help to improve the health status of people.
- There is a direct relationship between urbanization and life expectancy. People move from rural to urban areas for better jobs and health facilities. Urbanization is considered an important indicator in development strategy. Urbanization is also known as a social and economic engine. The planner introduced a better lifestyle for the urban population which may tend to good health in cities and also improves the quality of life.
- Domestic Govt Health Expenditures are directly related to life expectancy. Govt spending on the health sector may improve the conditions of hospitals and introduce modern techniques to diagnose various diseases. It may be helpful to improve the health status of the population.

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List of Countries

LIC-27	MIC-59	
	LMIC-34	UMIC-25
Afghanistan	Algeria	Albania
Burkina Faso	Angola	American Samoa
Burundi	Bangladesh	Argentina
Central African Republic	Belize	Armenia
Chad	Benin	Azerbaijan
Congo, Dem. Rep.	Bhutan	Belarus
Eritrea	Bolivia	Bosnia and Herzegovina
Ethiopia	Cabo Verde	Botswana
Gambia	Cambodia	Brazil
Guinea	Cameroon	Bulgaria
Guinea-Bissau	Comoros	China
Korea, Dem. People's Rep.	Congo, Rep.	Colombia
Liberia	Cote d'Ivoire	Costa Rica
Madagascar	Djibouti	Cuba
Malawi	Nigeria	Dominica
Mali	Pakistan	Dominican Republic
Mozambique	Papua New Guinea	Ecuador
Niger	Philippines	Equatorial Guinea
Rwanda	Samoa	St. Vincent and the Grenadines
Sierra Leone	Sao Tome and Principe	Suriname
Somalia	Senegal	Thailand
South Sudan	Solomon Islands	Tonga
Sudan	Sri Lanka	Turkey
Syrian Arab Republic	Tajikistan	Turkmenistan
Togo	Tanzania	Tuvalu
Uganda	Timor-Leste	
Yemen, Rep.	Tunisia	
	Ukraine	
	Uzbekistan	
	Vanuatu	
	Vietnam	
	West Bank and Gaza	
	Zambia	
	Zimbabwe	