



# RETRACTED: PM<sub>2.5</sub>, Household Income, and Health Hazard: The Role of Economic Integration in the Process of Decarbonization in the Developing Economies

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### Specialty section:

This article was submitted to  
Environmental Economics and  
Management,  
a section of the journal  
Frontiers in Environmental Science

**Received:** 13 April 2022

**Accepted:** 18 May 2022

**Published:** 20 June 2022

### Citation:

Jiang X, Zhong S, Munir F and Cai F  
(2022) PM<sub>2.5</sub>, Household Income,  
and Health Hazard: The Role of  
Economic Integration in the Process of  
Decarbonization in the Developing  
Economies.  
Front. Environ. Sci. 10:919413.  
doi: 10.3389/fenvs.2022.919413

The goal of this study is to examine the impact of household income and air pollution on the health of developing-country residents. The panel dataset of twelve developing nations used for this purpose. High levels of fine particulate matter in the air are linked to increased health problems, and lower incomes for households in the economies studied. However, effective environmental management and renewable energy resources have a significant role in controlling the harmful impact of fine particulate matter in the air. It highlights that developing economies could lower the fine particulate matter in the air by strengthening the regional environmental policies and adopting renewable resources. In emerging countries, environmentally friendly strategies and the shift from carbon base to non-carbon-based energy would minimize pollution in the atmosphere and improve the quality of life for inhabitants and other organisms. Improved quality of life and lower levels of fine particulate matter pollution are expected to increase people's per capita income in the region. Finally, air pollution is a transboundary phenomenon; therefore, strict compliance with environmental protection policies at the regional level is a prerequisite for improved quality of the natural environment.

**Keywords:** health hazard, PM<sub>2.5</sub>, environment policies, economic integration, fossil energy

## 1 INTRODUCTION

As the global economy continues to grow, the most pressing issues include climate change, carbon emissions, greenhouse gas emissions, and PM<sub>2.5</sub> in the atmosphere, which is causing health problems around the world. The World's temperature has risen steadily over the past few decades as a result of the ever-increasing emissions of greenhouse gases. As a means of achieving social, economic, and technological progress, the world's energy systems have relied heavily on conventional energy sources (fossil fuels). It's not all good news: enhanced energy systems have also led to increased CO<sub>2</sub> and PM<sub>2.5</sub> in the atmosphere, as well as a corresponding increase in health concerns. As we are living in the era of the fourth-generation industrial revolution, energy has become a key source part in bringing of about worldwide transformation as a result of the industrial revolution. A high standard of living is generally assumed in countries with high energy usage. As a result, the entire ecosystem is depleted by

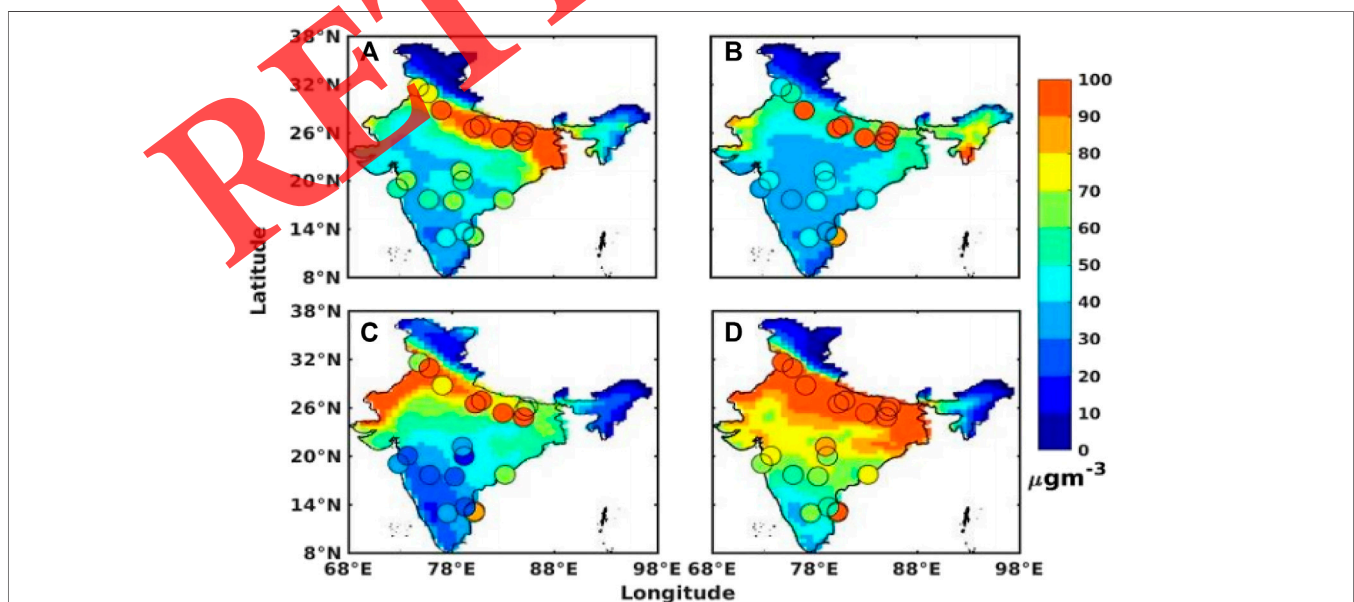
cumulative PM<sub>2.5</sub> altitudes in the air and placing people and other species at increased risk of illness. The usage of fossil fuels, especially coal and oil, is a major contributor to global climate change (IEA, 2011). Non-renewable forms of energy in the Middle East and North Africa (MENA) zone are among the main motivations to focus this region's economies. As per the most recent figures of the world air quality report (2020), The MENA region is reported to witness the highest global usual PM<sub>2.5</sub> absorption degree. This region has a high yearly average concentration of PM<sub>2.5</sub> concentrations, weighted by demographic, according to the (Baloch et al., 2020). As a result, warnings about the health and financial consequences of widespread use of such nonrenewable resources and degraded ecological integrity must be made public. **Figure 1** depicts the present incarnation of environmental stewardship based on the Global Map's estimates of PM<sub>2.5</sub> concentrations by nation.

The MENA countries rely heavily on industrial development to achieve their growth goals and improve the quality of life for their citizens. In the event that all other alternatives are abandoned, current production processes render industrial resource extraction increasingly unattractive and untrustworthy as time progresses. The influence of these nonrenewable minerals on Growth is greater than the influence of the country's population, and they provide a major contribution to the overall well-being of the country. However, initiatives to concurrently increase production and consumption levels in order to grow GDP degrade sustainability performance. As a consequence, the hazard of environmental elements and problems such as air pollution, respiratory sickness, and disease predisposing factors grow (Shen et al., 2021). Individuals must have a high level of living and good quality of life in order to nurture creative abilities. A clean and safe environment, on

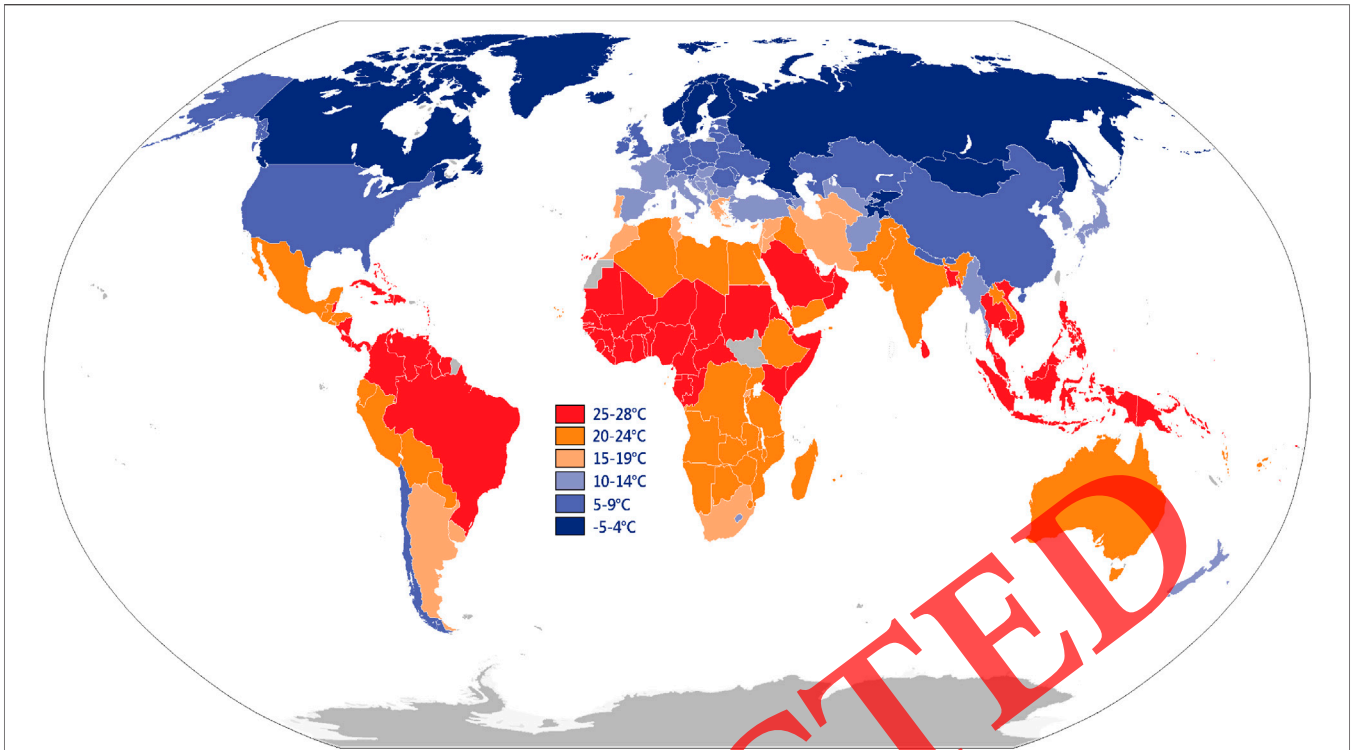
the other hand, appears to be a prerequisite solely for advanced civilizations and economic progress.

Furthermore, it is expected that rising development in emerging nations will exacerbate air quality and meteorological difficulties, as it is believed that reaching such goals will necessitate a greater quantity of energy use than already exists (Abbas and Sharif Chaudhry, 2017). A geographical impact is possible for nearly every form of fuel. The use of fossil fuels has increased deforestation, species extinction, ecologies, and water consumption, as well as the destruction of hygiene, natural waste resources, and land use, all of which are detrimental to the environment. A large portion of the electricity is presently generated by coal-fired power plants, which restricts the usage of non-fossil fuels in the electricity grid. Coal-fired power plants produce large amounts of pollutants and air pollution that contribute to global warming, which is one of the primary causes of climate change (Abbas et al., 2020a). Global warming as a result of rising temperatures has been more severe in recent years, as illustrated in **Figure 2**, which depicts a glimpse of the shift in weather in major world cities.

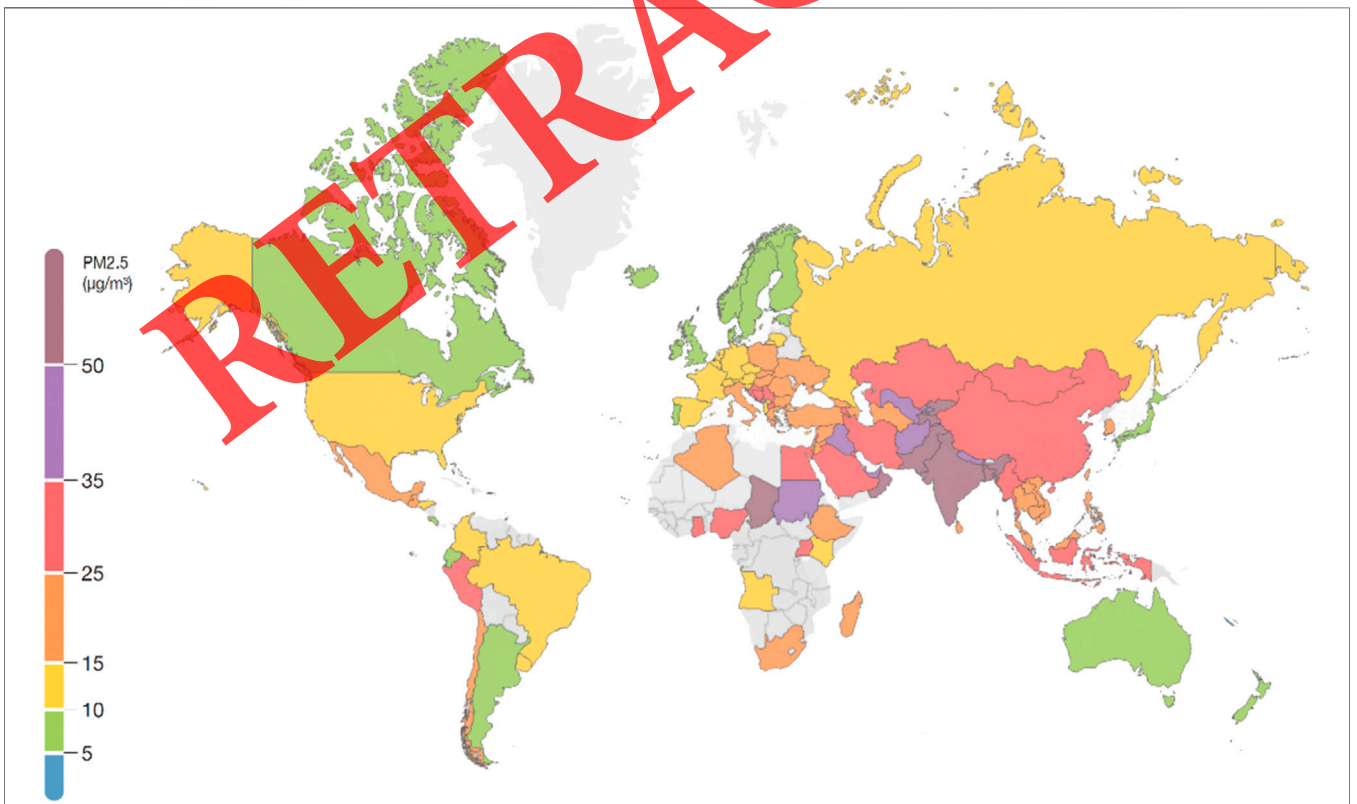
As long as humans continue to emit carbon dioxide into the atmosphere, the earth will continue to warm. As a result, the increased dependence on fossil fuels is increasing the risk of energy security challenges and diminishing the resources for assimilating. There has been a growing concern that our economic and energy systems are overly reliant on fossil fuels, which could lead to unpredictable long-term global warming and supply issues. Nuclear and hydroelectric power plants have been the exceptions to the rule, with most large-scale power plants relying on fissile energy sources to generate their electrical energy. MENA economies rely heavily on non-renewable resources while



**FIGURE 1** | The PM<sub>2.5</sub> around the globe in 2020. Source: Navinya, C.D., Vinoj, V. and Pandey, S.K. (2020).



**FIGURE 2 |** Country's yearly temperature variation. Source: World air quality report (2020).



**FIGURE 3 |** The Middle East and North African countries based on PM<sub>2.5</sub>.

**TABLE 1 |** Correlation Matrix.

	HC	Ipc	Equi	EmangP	ES(n)	ES (r)	PopG
HC	1.00						
Ipc	0.25	1.00					
Equi	-0.33	-0.19	1.00				
EmangP	-0.17	-0.20	0.09	1.00			
ES(n)	-0.289	-0.18	0.19	0.25	1.00		
ES(r)	0.19	-0.24	-0.18	0.08	0.10	1.00	
PopG	-0.20	0.20	0.31	0.21	0.14	0.02	1.00

All results generated with log form of variables.

the environment is given scant consideration. Affluence and cost-effectiveness can be achieved through the use of non-renewable substances. Due to MENA economies' high absorption of PM<sub>2.5</sub> ambient, using nonrenewable energy could result in poor environmental quality. As per a World Air Quality assessment 2020, five countries in the MENA region are ranked in the top five in the world for high concentrations of PM<sub>2.5</sub> particles. It has been presented in **Figure 3** for more understanding. Production has continued to expand in economies all over the world, despite the fact that employing non-fossil sources is a global concern that is equally favorable to both environmental protection and health improvement (Wei et al., 2021; Wu et al., 2021).

It is predicted by the World Energy Council that the MENA, and in notably the countries of Egypt, Turkey, and Iran, will account for the vast majority of global increases in energy consumption during the twenty-first century. Compared to other alternative options like nuclear, hydro, coal, and biomass, carbon-based fossil fuels are responsible for a disproportionate amount of energy production. At various points in their history, the countries of the Middle East and North Africa (MENA) have a wide range of institutions and policies that varies greatly in quality (Chaudhry et al., 2021; Hao et al., 2021). Significant gaps exist in their methods of climate management, making it difficult at this time to discern between their impact on environmental quality and their efforts to address health complications. The country-level environmental sustainability rating was developed by the World Bank (2018) to acknowledge governments' readiness to enforce pollution regulations. This depiction depicts how current policies and institutions are safeguarding mineral wealth while also improving the quality of life by reducing carbon dioxide emissions and exposure to the sun's rays (Ullah et al., 2021; Zhao et al., 2022).

To better understand the probable relationships between environmental stewardship and national well-being, this research examines both ecological and non-renewable power sources with a large population and per capita GDP in the MENA countries. Regarding environmental policies and practices, the findings of this study will be valuable to policymakers and practitioners in defining an acceptable pathway and proposing substitutes at the regional level, according to the researchers. The primary goal of the study is to determine whether there is a relationship between environmental concerns and per capita income. The secondary goal is to draw attention to the role that non-fossil energy sources play in reducing the incidence of environmental health hazards in MENA economies.

There is a review of related literature in Segment 2, and a technique in Segment 3. In section four, the results have been discussed, and in section five, the conclusion is reached.

### 1.1 Literature Review

There is a strong correlation between supply and demand, and this means that growth in the manufacturing industry, expansion of international trade, and enlargement of services cannot be accomplished until governments give more energy, especially in developing nations. However, the most important question is about the type of resources employed in the production of the goods. As a result, experts have conducted numerous energy assessments in order to produce big quantities of stock. According to statistics on China's energy utilization, the country is one of the world's top 10 energy users. China's economic expansion is heavily influenced by the country's energy usage. In accordance with (Abbas et al., 2021), the consumption of energy has a considerable economic impact in the MENA. An ongoing relationship between energy use and GDP has been established by academics over the course of time.

It was also found that there was a direct correlation between worldwide GHG emissions and energy demand. The ten most energy-intensive countries are all found in the most developed parts of the world, indicating a strong correlation between energy consumption and GDP. It discovered that energy demand in these economies was related directly to GDP in all ten of these economies (Amin et al., 2021). Although energy use is pushed in countries with high GDP, this is not always the case. According to (Qayyum et al., 2019), China's GDP and energy use are intertwined. In their estimation, China's GDP is heavily dependent on the country's ability to consume energy. A study by (Li et al., 2020) compared statistics from one-belt road countries with statistics on the influence of highway systemizing on comprehensive utilization of energy and GDP levels. Similarly, studies have indicated that energy use is associated with economic growth in Asian countries. When (Abbas et al., 2020b) examined the data from 24 MENA countries, they found an association between GDP and energy use.

Furthermore, a number of research have examined the relationship between GDP and fossil energy sources and non-fossil energy sources. In both developed and developing countries, research has found a

**TABLE 2 |** Panel unite test.

Variables		Intercept	Trend with intercept	Decision
HC	LLC	-11.12 (0.00)	-08.06 (0.00)	I(1)
	IPS	-11.33 (0.00)	-10.04 (0.00)	I(1)
Ipc	LLC	-10.02 (0.00)	-10.21 (0.00)	I(1)
	IPS	-13.05 (0.00)	-04.02 (0.00)	I(1)
Equi	LLC	-03.91 (0.00)	-04.10 (0.00)	I(1)
	IPS	-04.40 (0.00)	-04.01 (0.00)	I(1)
EmanP	LLC	-5.07 (0.00)	-04.00 (0.00)	I(1)
	IPS	-10.45 (0.00)	-08.22 (0.00)	I(1)
ES(n)	LLC	-5.03 (0.00)	-06.33 (0.00)	I(0)
	IPS	-07.12 (0.00)	-05.16 (0.00)	I(0)
ES(r)	LLC	-10.03 (0.00)	-11.01 (0.00)	I(1)
	IPS	-12.06 (0.00)	-05.24 (0.00)	I(1)
PopG	LL and C	-19.01 (0.00)	-11.66 (0.00)	I(0)
	IPS	-05.06 (0.00)	-07.75 (0.00)	I(0)

All results generated with log form of variables.

**TABLE 3** | Residual of CSD test.

CSD-test	Statistics	df	Probability
<b>For model one</b>			
Pesaran and Yamagata	03.025***		0.007
LM (Pesaran)	234.126***	111	0.001
LM (Bias-corrected scaled)	06.952***		0.003
LM(Pesaran scaled)	023.950***		0.004
<b>For model two</b>			
Pesaran and Yamagata	03.216***		0.005
LM (Pesaran)	02.034***	189	0.001
LM (Bias-corrected scaled)	02.258***		0.000
LM(Pesaran scaled)	02.159***		0.001

\*\*\*designates the one percent level of significance.

favorable correlation between GDP, fossil energy sources and non-fossil energy sources use (Sun et al., 2020). While the use of fossil energy sources has unable to safeguard the environment superiority in mature and developing societies, non-fossil energy sources facilitates economic growth without diminishing environmental resources. It was found that the non-fossil energy sources and economic growth were linked in United States, Germany, and Italy (Iqbal N. et al., 2020). It has not been demonstrated that non-fossil energy sources have a major influence on stimulating GDP in Canada, France, Japan, or the United Kingdom.

Overall energy use and GDP were found to be closely linked in G7 panel data analyses. The ARDL model was used by (Abbas et al., 2020a) to assess the impact of non-fossil energy sources on economic growth in the United States. There is a strong correlation between RER use and GDP in the United States. (Anser et al., 2020a) argue that RER can have a considerable impact on GDP growth in advanced and emerging economies, based on their studies. Overall energy use and GDP were found to be closely linked in G7 panel data analyses. The ARDL model was used by (Iqbal W. et al., 2020) to assess the impact of RER on GDP in the United States. There is a strong correlation between RER use and GDP in the United States. (Anser et al., 2020b; Iram et al., 2020) argue that RER can have a considerable impact on GDP growth in developed and developing economies, based on their studies. With respect to the overall RER, it's easy to see. Scientific investigations, however, demonstrate a definite correlation between fossil energy sources and environmental dangers, which is important for economic development. Because of their focus on fossil energy sources, we've upped the level of environmental danger dramatically. Resilience in developing economies has dwindled as the rate of environmental degradation has accelerated. Findings from earlier research have shown a rise in energy usage and GDP as a result of these increases. This is accompanied by an equal growth of greenhouse gas emissions from developed and emerging countries (Qayyum et al., 2019).

(Sahban and Abbas, 2018) research also showed the impact of high health risks in African countries on energy use and emissions of greenhouse gases. People's health is adversely affected by both indoor and outdoor contamination, which is exacerbated by the use of fossil fuels. According to (Ali et al., 2021), GDP and energy use are the key offenders in global warming and climate change. In

addition, the research conducted by (Yang et al., 2021) examined the impact of energy utilization in the United States on climate change. According to the interpretations, climate change and sustainability threats are exacerbated by the usage of energy and the emission of CO<sub>2</sub>. Analysis of greenhouse gas emissions by (Huang et al., 2020) analyzed data from fifteen emerging economies to see how GDP and fossil energy sources consumption correlated with greenhouse gas emissions. Increased usage of fossil energy sources and GDP is expected to lead to a rise in greenhouse gas emissions, according to the research. (Amin et al., 2021) found that China's greenhouse gas emissions were more influenced by energy use than initially expected. The study found that China's booming farming industry and greenhouse gas emissions are linked in a bi-directional manner. Data from 42 countries over the next 10 years was used by (Hanif et al., 2019) to determine the pollution impact of non-fossil energy sources. According to prior research, renewable energy consumption reduces CO<sub>2</sub> emissions dramatically in developing nations.

(Sun et al., 2021) performed a qualitative analysis and showed that environmental degradation could be controlled by reducing fossil fuels' use. To begin with, bio-based polymeric polymers need biomass as their primary feedstock, which can be viewed as a pollutant and can affect traditional plastics recycling streams. The health of Asian societies was examined by (Asbahi et al., 2019; Iqbal et al., 2019) and Fossil fuels were determined to be a substantial contributor to the escalation of environmental problems, which in turn raises the already high impermanence rates.

In both established and emerging economies, economic expansion and the usage of energy are critical. In the most recent studies, the effects of fossil energy sources and greenhouse gas emissions outbreaks are shown to be significant, and there is discussion as to their respective significance. Additionally, environmental policy analysis on renewable energy, the economy, and the health and well-being of citizens is lacking.

## 2 DATA AND METHODOLOGY

To gain a better understanding of the atmosphere's repercussions, energy usage, and the responses to environmental measures on greenhouse gases in Asian countries, a sample of twenty countries from the World Development Indicators is chosen for a period of 15 years (2006–2020). Twenty counties from the MENA region were chosen.

Recent studies by (Iram et al., 2019; Wang et al., 2020) look at how GDP and energy use in developing Asian nations affect carbon dioxide emissions. In order to meet the objective, the linear functional form has been used:

$$HC = f(EquI^{\delta 1}, EmangP^{\alpha 1}, ES(n)^{\alpha 2}, ES(r)^{\alpha 3}, PopG^{\alpha 4}) \quad (1)$$

$$Ipc = f(EquI^{\delta 1}, EmangP^{\alpha 1}, ES(n)^{\alpha 2}, ES(r)^{\alpha 3}, PopG^{\alpha 4}) \quad (2)$$

In Eq. 1, the slopes of air sustainability, environmental sustainability policies, fossil and non-fossil energy sources, and

population growth are denoted by 1,1,2,3 and '4', respectively. It is necessary to propose the following econometric model for panel data after taking into account logarithms on both sides of the Eq. 2:

$$\log Hc_{it} = \alpha_0 + \delta_1 \log Equ_{it} + \alpha_1 \log EmanP_{it} + \alpha_2 \log ES(n)_{it} + \alpha_3 \log ES(r)_{it} + \alpha_4 \log PopG_{it} + D_i + u_i \quad (3)$$

$$\log Ipc_{it} = \alpha_0 + \delta_1 \log Equ_{it} + \alpha_1 \log EmanP_{it} + \alpha_2 \log ES(n)_{it} + \alpha_3 \log ES(r)_{it} + \alpha_4 \log PopG_{it} + D_i + u_i \quad (4)$$

In Eqs. 3, 4, the nation is denoted by the shorthand *i* and the period is denoted by the shorthand *t*. The intercept is denoted by the symbol  $\alpha_0$ , and the response variable are health status (HC) and per capita income (Ipc). When it comes to independent variables, environmental quality (Equ), environmental management policies (EmanP), nonrenewable energy resources (ES(n)), renewable energy resources (ES(r), and population growth rate (PopG) were all used. When it comes to response variable, nonrenewable energy resources (ES(n)), renewable energy resources (ES(r), and population growth rate (PopG) were used. The error term “*D<sub>i</sub>*” represents a time-invariant error term, whereas the error term “*u<sub>i</sub>*” indicates an idiosyncratic error term.

### 3 RESULTS ESTIMATION

Despite the fact that this article contains a huge number of quantitative numbers and statistics, they are just used to convey the general aptitude of the theoretical model in this case. There is a section on this program that provides descriptive statistics such as mean and median values as well as upper and lower bounds, lower endpoints and standard deviation, among other things.

Multicollinearity has been identified as a potential problem since it involves two variables that indicate how closely they are connected. The dependence on each student on each other in their combinations problem correlates with their poor performance on the correlation matrix has risen with many other students' addition to the matrix's multicollinearity.

Table 1 outlines the correlation matrix outcomes in detail. There may be a problem with multicollinearity and false positives in regression analysis if the variables are highly linked ( $r^2 \geq 0.8$ ). Environment Quality has a weak link with Health Status, according to the results of the correlation matrix (Equ). EmanP; Nonrenewable Energy Resources ES(n); Renewable Energy Resources (ES(r); and Population Growth Rate (PopG). In the Model, there is no evidence of multicollinearity because the correlation between pairs is weak.

Unit root tests have also been conducted in this study's quantitative analysis to determine the order in which the variables are integrated. Panel unit root tests by LLC (Levin, Lin and Chu) established by Levin and Im et al. (2003). Homogeneity can be identified using the LLC test for panel unit roots using dependent lag coefficients and fixed effects that are listed as homogenous in all units (Levin et al., 2002). While the IPS test is an extension of the LLC panel unit root test, it removes the limits imposed on the LLC test's hypotheses.

The panel unit root experiments have been presented in the Table 2. The LLC and IPS tests were used to determine the convergent validity between the parameters. Because both the IPS & LLC examinations show that all bounds are integrated at the initial difference, econometric stationaries require the cointegration test. This means that the co-integration measure must be monitored for cross-sectional dependencies between variables.

TABLE 4 | Test for cointegration: Pedroni.

	Model-1		Model-2	
	Statistic	Weighted statistic	Statistic	Weighted statistic
Panel v-Statistic	-1.052 (0.064)	-1.533 (0.058)	-0.265** (0.022)	-2.146 (0.004)
Panel rho-Statistic	-3.345** (0.035)	-2.566** (0.039)	-5.452*** (0.001)	-3.243** (0.020)
Panel PP-Statistic	-7.342*** (0.010)	-2.317*** (0.008)	-5.342** (0.030)	-3.492*** (0.001)
Panel ADF-Statistic	-1.946** (0.025)	-2.341*** (0.002)	-2.754*** (0.001)	-3.001*** (0.000)
<b>Alternative hypothesis: individual AR coefs</b>				
	Statistic	Prob	Statistic	Prob
Group rho-Statistic	6.583	0.093	8.274***	0.001
Group PP-Statistic	-7.375***	0.004	-9.138***	0.000
Group ADF-Statistic	-2.543**	0.026	-4.055**	0.000
<b>Test for cointegration: Westerlund.</b>				
	Test statistic	Prob	Test statistics	Prob
Variance Ratio (VR)	-02.258**	0.002	-04.464	0.001

\*\*represent five percent of significance level respectively.  
\*\*\*designates the one percent level of significance while.

**TABLE 5 |** Delta & HAC Robust test.

Delta test			
M-1		M-2	
Delta	Probability	Delta	Probability
04.002**	0.001	03.431**	0.001
03.247*** (adj.)	0.001	04.144*** (adj.)	0.001
HAC Robust			
Delta	Probability	Delta	Probability
04.521***	0.000	06.021***	0.001
06.738*** (adj)	0.001	07.866*** (adj)	0.001

\*\*represent five percent of significance level respectively.  
 \*\*\*designates the one percent level of significance while.

There is a core principle that the cross-sections are not affected by time. A cross-sectional examination of independence is conducted, and the Pesaran (CD) evaluation yields the following parameters.

Model- 1

Test statistics = 0.883 ; P – value = 0.517  
 Absolute value Of Diagonal Elements (average) = 0.634

Model 2

Test statistics = 0.624 ; P – value = 0.608  
 Absolute value Of Diagonal Elements (average) = 0.951

According to the cross section dependence (CSD) test, the p-value is over the 5-percent significance level. That is why we can accept the null hypothesis of zero cross-sectional dependency in the test statistics.

TSD and TSB-TH were tested using LMB-TS and the results in **Table 3** were given for all of these tests. Mode-1 and Model-2 Breusch-LM test results were free of heteroscedastic issues. Finally, the results of Pedroni and Westerlund’s co-integration studies are presented in **Table 4**. Results of two co-integration tests disprove the zero hypothesis and confirm the co-integration of the conceptual methodology. Co-integrating the two methodologies shows that there is a long-term relationship between the variables used to assess the empirical investigation (Guan et al., 2020).

These two tests were also utilized to assess the standard Delta’s slope heterogeneity and the HAC robustness test proposed by Pesaran and Yamagata, as well as the standard Delta’s slope heterogeneity and the HAC robustness test (2008). **Table 5** shows the findings for both Model-2 and Model-2.

Delta statistics do not support a path having a homogeneous value, as predicted by the null hypothesis. A group estimator that allows for heterogeneous slopes can be employed as a result. There is adequate evidence to reject the null hypothesis of pitch homogeneity with a 5 percent probability here. This is why we used a medium group estimator in this work, which allows for a wide range of possible paths. Mean Group (MG)/Pool Mean Group estimations (PMG) comparisons were used in Hausman Style testing to ensure that the null hypothesis is homogenous. As shown in **Table 6**, the Hausman test shows that the Mean Group estimator is a more helpful instrument than group means for both short- and long-term processes. To ensure that the process’s specs are uniform, we must examine them.

**Table 6** demonstrates that Environment Quality (Equl) is statistically significant and inversely connected with Health Status (HS), as evaluated by life expectancy in the area. The negative coefficient of Equl indicates that a one percent increase in

**TABLE 6 |** Pool Mean Group estimator.

Variables	M-1		M-2	
	Respond variables = (HC) (20-Panels)		Respond variables = (lpc) (20-Panels)	
	LR coefficients	Error correction	LR coefficients	Error correction
ECT		-0.363*** (0.064)	-	-0.291*** (0.081)
Equl	-0.347*** (0.11)	-0.152*** (0.091)	-0.146*** (0.041)	-0.117*** (0.091)
EmanP	0.489* (0.157)	0.173** (0.094)	0.176* (0.064)	0.143** (0.294)
ES(n)	-0.855** (0.210)	-0.327*** (0.134)	0.764** (0.222)	0.327** (0.153)
ES(r)	0.331** (0.054)	0.103 (0.074)	0.109** (0.061)	0.087** (0.064)
PopG	-0.273** (0.400)	-0.127** (0.063)	-0.955*** (0.302)	-0.927** (0.436)
Equl*EmanP	0.258*** (0.090)	0.179** (0.059)	0.217*** (0.068)	0.179 (0.125)
Intercept	03.418*** (0.945)	2.829*** (1.091)	3.894*** (0.922)	5.101*** (1.738)

\*ten percent of significance level respectively.  
 \*\*represents five percent, and \*\*\*designates the one percent, while.

particulate matter PM<sub>2.5</sub> in the atmosphere reduces life expectancy or deteriorates health status by approximately 0.35 percent, assuming that all other parameters remain constant in the location where the particle pollution is concentrated. Results from Model-2 support the findings made in Model-1 by revealing a negative relationship between poor environmental quality and a household's per capita income in MENA countries. An easy way to illustrate this channel is to say that bad environmental quality exacerbated local health challenges and hindered the performance of the workforce in production operations. As a result, a person's health and financial well-being are jeopardized when they live in an unhealthy environment. To a large extent, the heavy level of PM<sub>2.5</sub> can be attributed to the widespread use of fossil energy generation, intensive industrialization, lengthy automobiles, open garbage burning, sandstorms, and the construction sector itself.

According to the findings of the study, the MENA economies' current environmental management strategies have a substantial role to play in reducing the risk of disease and increasing life expectancy. A 0.39 percent increase in life expectancy can be achieved with a 1% change in environmental management policy. The study also discovered a negative association between environmental policies and GDP, which contradicts the projected positive correlation. Per capita income rises by 0.14 percent as a result of environmental policy changes. The health and well-being of the area's residents can be considerably improved by adhering to sound policy design and strict enforcement of rules. Pollution levels in the MENA region may be lowered as a result of existing environmental measures in the region.

Fossil fuel consumption has been found to have a negative impact on the life expectancy of people in the Middle East and North Africa region (MENA). One-unit increase in ES(n) usage raises environmental pollution by 0.55 percent, which lowers life expectancy by 0.55 percent, according to the results of Model-1. Model-2's results demonstrate a positive association between ES(n) and per capita income in the nations under study. If all other things are held constant, an increase in ES(n) use of one percent can yield to a per capita income rise of around 0.327 percent. Researchers (Qayyum et al., 2019; Amin et al., 2021), and (Li et al., 2020) all found support for their conclusions in this study, as did (Abbas et al., 2021). So it can be deduced from this study that oil and gas are more commonly used at home in the Middle East and South than they are to raise the per capita income of individuals. Fossil fuels were found to have a favorable impact on per capita income while having a negative impact on health outcomes.

For MENA countries, ES(r) outcomes are more compelling and vital. Using ES(r)'s coefficient, life expectancy and per capita income are positively correlated. The data reveals that a 1% rise in ES(r) increases life expectancy by roughly 0.39 percent, which is a significant improvement in health. Model-2 predicts that a 1% rise in ES(r) will raise per capita income by 0.76 percent. Because of this, it may be stated that MENA economies should prioritize the use of ES(r) in the industrialization era 4.0, which will lead to a significant decrease in health problems and an increase in per capita income while reducing air degradation.

There was a direct correlation between increased population expansion and a decreased life expectancy. There is a direct correlation between increasing the population and increasing healthcare costs in developing MENA economies. Furthermore, an interaction word is used to emphasize the necessity of environmental policy. In order to underline the relevance and efficacy of environmental management policies in the MENA area, Equi's symbol has been

modified from a negative sign to a positive one. According to the conclusions of this study, implementing environmental regulations and advancement in ES(r) to reduce environmental health consequences must eventually be achieved at the individual, per-person income level.

## 4 CONCLUSION AND POLICY IMPLICATION

This research has assessed the effects of environmental contamination, environmental management regulations, fossil energy resources, non-fossil energy resources, and population increase on health issues and household income in twenty MENA economies. Pooled Mean Group (PMG) Regression results suggested that high PM<sub>2.5</sub> concentrations, fossil energy resources use and population expansion exacerbated the regional health risks. Simultaneously, the increase in reliance on ES(r) and environmental management policies' compliance can improve individuals' health status and living standards by improving their life expectancy and per capita income. The study also used interaction term that highlights that the targets to control greenhouse gas emissions can be achieved by following the existing environmental policies and improving the share of ES(r) in total energy production. It can be concluded from the empirical findings of this study that improved environmental management policies and the transition from ES(n) to ES(r) are two factors that could assist in dealing with current environmental challenges. However, this study has sudden limitation of data collection that's why we limited our work to twelve economies of the MENA region. Future research can enhance it up to all MENA region to find the broader understanding of the relationship between dependent variable with said independent variables. Finally, the study suggests that the constitution of environment management policies at the regional level and the regulatory authority formation will ensure that such policies may prove fruitful in reducing the PM<sub>2.5</sub> concentrations in the region's ambient air. Conversely, to reduce dependency on fossil fuels, it is vital to monitor PM<sub>2.5</sub> levels in the atmosphere. There is also a need to put measures to highlight environmental and health considerations in the MENA economies.

## DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

## AUTHOR CONTRIBUTIONS

This research paper contributed by the abovementioned authors in the following way: The "Conceptualization, done by XJ, methodology, form by SZ, software and validation, performed by FM, formal analysis done by FC, investigation, resources by XJ, data curation, performed by SZ, writing—original draft preparation done by FM, writing—review and editing by FC, visualization by SZ and supervision XJ.



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