



## **Relationship between Emissions of Carbon Dioxide from the Cement Industry, Health Expenditures and Economic Growth in Pakistan**

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### **ABSTRACT**

Carbon Dioxide emissions are not suitable for human health, and it also creates hurdles in the economic growth of any economy. The current study aims to reinvestigate the impact of greenhouse gases like CO<sub>2</sub> emissions, including other gases, in the cement industry of Pakistan and its outcome in the shape of an increase in the health expenditures of the citizens. The study employs the ARDL methodology to find the empirical results in the short and long run. For the empirical analysis, the study used time-series data from the WDI database and covered the range from 1990 to 2019. The study finds a strong relationship between CO<sub>2</sub> emissions from the cement industry, health expenditures, and economic growth in Pakistan. There is a uni-directional causality running from CO<sub>2</sub> emission to health expenses in both the short and long run. The present study makes a significant contribution to the literature on industrial economics and energy economics and its effects on the well-being of people in society. The study explains the changes in the health expenditures of people by considering the emission of CO<sub>2</sub> from the cement industry, which is a new dimension in the case of Pakistan. Moreover, the study suggested that the government and policymakers should make environment-friendly and eco-friendly policies to clean the environment for better health and high economic growth. The government should encourage investors to invest in green technology to increase production capacity and improve the environment.



## **1. Introduction**

The most challenging issue for the world in the current scenario is climate change. Temperature is rising globally due to man-made problems. There is an important link between high concentrations of greenhouse gases and climate change that there is the impact of climate change on public health. However, in recent decades, the relationship between economic growth, environmental deterioration, and health expenditure has received increasing attention in the literature. Economic growth, environmental degradation, and health care expenditures vary between these relationships are complex and vital. Therefore, the negative externalities of low environmental quality due to the impact on human health expenditure are ignored. Carbon is one of the elements that cause serious illness upon sufficient inhalation. Keeping an equilibrium between the emissions of carbon dioxide and health outcomes is the biggest challenge of the

21<sup>st</sup> century affecting human capital (Gillani, Shafiq, & Ahmad, 2019) hence reducing the emissions of CO<sub>2</sub> without reducing the economic pace and performance of a country (Bano, Zhao, Ahmad, Wang, & Liu, 2018).

Since 1950 the main cause of global warming has been human activities involving burning wood, coal, bio material, and industries advocated by the Inter-Governmental Panel on climate change. According to a report by NASA in 2019, the main causes of global warming are greenhouse gasses, including carbon dioxide with 47% atmospheric concentration after industrialization in the whole world, Methane, Chloro-fluoro Carbons, and Nitrous Oxide. The issue of climate change starts after the world enters the industrial era in the mid of the 20th century (Mirza & Kanwal, 2017). In 2004 the share of Carbon dioxide as a greenhouse gas was 77% (He, Xu, Shen, Long, & Chen, 2017). Industries are a major source of pollution in the atmosphere.

On the other hand, it also plays a vital role in the economic prosperity of any country by value addition to the existing stock of capital. The first industrial revolution in the world came in 1760-1830 (Maram Qartavol, 2019). During this period, the manufacturing sector consumes about 37 % of the world's energy sources, more than any other economic sector. This energy is utilized by different industries like construction, manufacturing, agriculture, mining industry (Abdelaziz, Saidur, & Mekhilef, 2011). When an economy is in the wake of position as described by Rostow stages of development, it strongly affects the environment because of a high level of industrialization and growth process and hence emissions of CO<sub>2</sub> in the atmosphere. The carbon dioxide emissions are directly proportional to economic growth, i.e., emissions are high when growth is high and vice versa (Aye & Edoja, 2017; Fazal, Gillani, Amjad, & Haider, 2020).

Pakistani industry is playing a vital role in the economic prosperity of Pakistan but on the cost of pollution in the environment (Bakhsh, Rose, Ali, Ahmad, & Shahbaz, 2017). Climatic change adversely affects Pakistan's atmosphere. Pakistan is listed among the major polluted countries of the world that are adversely affected by climate change. Global emissions of CO<sub>2</sub> are increasing in Pakistan as Pakistan is in a transition phase from agriculture to the industrial sector. It shows upsurges in heat strokes and 1200 deaths because of these heatwaves in Karachi (Sharif, Afshan, & Nisha, 2017). The Greenhouse Gases (GHG) emissions are increasing annually compared to the GHG emissions in the 1990s, but still this extent is low compared to the global emission of CO<sub>2</sub>. Pakistan depends on non-renewable energy resources, and these non-renewable energy resources are the major source of emissions of carbon dioxide gases in the atmosphere. The result of renewable energy resources like natural gas and many other resources has a significant impact on the reduction of carbon dioxide emission in the short run and long run (Dong, Sun, & Dong, 2018).

Various survey shows a sector-wise decomposition that adds pollutants to the environment. The cement industry is one of them. The cement industry of Pakistan consumed about 387 mm cft natural gas in 2018 (Economic Survey of Pakistan). The current study follows (Dong et al., 2018), who employ the use of natural gas to significantly reduce emissions of CO<sub>2</sub> in China in the short and long run. The present study employs an Auto Regressive Distributive Lag model to test the cointegration among the variables in the short and long run. This study also discusses the demand for natural gas consumption in the country. To assess the causal relationship between CO<sub>2</sub> emissions, economic growth (GDP), and health expenditure provides a deep insight to the policymakers.

### **1.1. Problem Statement**

The current study explores the impact of CO<sub>2</sub> emissions, particularly from the cement industry. This study encircles the carbon dioxide emission and its outcome on human health proxied by changes in the health expenses. Furthermore, the study also explores the association between health expenditures and their role in determining economic prosperity in terms of GDP.

## **1.2. Objectives of the Study**

- To explore the emissions of carbon compound gas from the cement industry of Pakistan and its impact on the health outcome of the people.
- To find the relationship between health expenditures and the economic growth of Pakistan.

## **2. Literature review**

The association between the emission of CO<sub>2</sub>, health expenditures, and GDP growth has very important subject for debate over the many past years. The emission of CO<sub>2</sub> has been a global problem over the past many years. Now explain the literature of independent variables with the dependent variable economic growth.

### **2.1. CO<sub>2</sub> Emission with Economic Growth**

Rehman, Ikram, Feng, and Rehman (2020) studied the Pakistan CO<sub>2</sub> emission on sectoral-based. The core aim was to check the effect of population growth, GDP growth, and energy consumption on those sectors of Pakistan in which CO<sub>2</sub> emission is high, including household, industries, and transport sectors. The data was taken from 2000-2018. The novel grey relation model was used to check the relation between the variables. The Hurwicz method was applied to study the CO<sub>2</sub> emission in each sector. The outcomes showed emission of CO<sub>2</sub>, population growth, energy consumption, and GDP per capita have a strong connection between all sectors of the country. This study suggested making environmental-friendly policies to reduce CO<sub>2</sub> emissions for further development.

Malik (2020) investigated the environmental changes and its impact and implications in Pakistan. The main objective was how to combat climate change and all its processes. Climate change affects the country from different effects and mostly all sectors of the country. The paper concluded that we should move towards a low carbon economy and clean generations, which is beneficial for industries and other country sectors. Also, introduce new cleaner technologies. The paper also suggested that government should need to take difficult steps for the country's safety.

Khochiani and Nademi (2020) described the connection between economic growth, consumption of energy, and emission of CO<sub>2</sub> in highly polluted countries of the world, including China, India, and the USA. The study used time-series data from 1971-2013 and wavelet correlation and partial wavelet coherence approach to analyze the data. The result showed that in all three countries USA, China and India have positive relation between GDP and emission of CO<sub>2</sub>. The study also suggested that experts make policies that are less carbon intensive and friendly to the environment and use renewable energy sources.

Ofosu-Adarkwa, Xie, and Javed (2020) described that one of the major suppliers of CO<sub>2</sub> emission is the cement industry in China. The major purpose was to estimate the CO<sub>2</sub> emission from the cement industry from an uncertainty-driven technical perspective. A novel grey prediction approach was used to forecast the future CO<sub>2</sub> emission from the cement industry. The V-GM (1, N) model was used for the accuracy of data. The result showed that the China cement industry is the result of government innovation and energy efficiency policies. But the government must pay attention to the emission problem from the cement industry and make policies for alternative fuels that are environmentally friendly.

Guo et al. (2021) studied cement production globally from 1930 to 2019 and its carbon dioxide absorption. In 2019 the global production of cement was 4.10 Gt. To check CO<sub>2</sub> absorptions from 1930 to 2019, a comprehensive model was adopted with cement materials. The result of the study showed about 21.12 Gt carbon dioxide was absorbed in the cement industry globally between the years 1930-2019. The absorbed CO<sub>2</sub> in the cement industry was

0.90 Gt in 2019. According to estimation, about 52% of the total emission of CO<sub>2</sub> was absorbed in the cement industry. China is the greatest producer of cement but has also increased its capacity to absorb CO<sub>2</sub> emissions.

## **2.2. Health Expenditures with Economic Growth:**

C.-M. Wang, Hsueh, Li, and Wu (2019) described the association among emission of CO<sub>2</sub>, health expenditures, and economic development of 18 OECD countries. For the analysis, the data was taken from 1975- 2017. The Bootstrap ARDL model was used to investigate the results of the study. The results showed cointegration between variables in the Netherland when GDP was kept as a dependent variable. At the same time, health expenditure in New Zealand as a dependent variable showed cointegration. Finally, the case of the USA showed cointegration between variables when emission of CO<sub>2</sub> was kept as a dependent variable. The results also showed the bidirectional and uni-directional relationships in different countries among variables.

C.-M. Wang, Chang, Yuan, Wang, and Feng (2020) described the affiliation of economic development, health factors, and ecological pollution of china both in the short run and the long run. The time-series data was used from 1978 to 2018. ARDL test technique was applied to the data. The study results showed that the critical impact of the emission of CO<sub>2</sub> and medical cost on economic development in the long run. The result also revealed the two-way causal affiliation among health expenditures and economic development and health expenditure and CO<sub>2</sub> emission. This study suggested that the china government must make environmental-friendly policies to reduce the emission of CO<sub>2</sub> and provide better health facilities to its citizens.

The literature is about the emission of carbon dioxide and health expenditure with economic growth. The above literature indicates that carbon dioxide emission is a major problem of the world both developed and developing countries. The emission of toxic gasses is increasing because every country consumes more and more energy to compete in a global world. The emission of CO<sub>2</sub> affects every economy of the world, but the carbon dioxide emission affects the economic development of less developed countries. This carbon dioxide emission also causes many health problems and dangerous diseases in the world. Pakistan is also affected by the emission of CO<sub>2</sub> in the context of economic growth and terms of health.

## **2.3. Research Gap**

There are various studies on the causation of carbon dioxide emissions and its effects on the economic progress of any country. Yet, this study focused on the carbon dioxide emission and health expenses of the individuals on the cost of GDP growth of Pakistan.

## **3. Methodology**

Previous studies employ various techniques to check the impact of CO<sub>2</sub> emission from the cement industry and health expenditures on Pakistan's economic growth. Unlike the earlier versions, this study focuses on dynamic modeling to capture short and long-run effects. The current study applied the Auto-Regressive Distributed Lag (ARDL) model to verify the relationship between CO<sub>2</sub> emissions, health expenses, and economic growth in the case of Pakistan. In this regard, some pre-requisite test like unit root test is applied to check the stationarity level. After that, if the data is stationary at level, first difference, or a mix of both, ARDL is estimated to gauge the data's short-run and long-run dynamics. An ARDL is a technique that provides a robust estimate of the short-run variables without losing long-run information. After finding a short-run analysis, the Wald test is used to find a long-run cointegration among the variables followed by some stability tests, e.g., the cumulative sum of squares (CUSUM) and square of the cumulative sum of squares (SQCUSUM) tests.

### 3.1. Data and Source

The current study used time series data covering a range of 1990-2019. The data for the selected variables is taken from the World Bank database, World Development Indicators (WDI, 2019).

### 3.2. Econometric Model

In this model, the study determines the relationship of CO2 emission from the cement industry of Pakistan and health expenditures in terms of economic growth (GDP) of Pakistan. The present study follows the following functional form based on the Dong et al. (2018) functional form.

$$\ln GDP_t = \beta_0 + \beta_1 \ln CO_{2t} + \beta_2 \ln HE_t + \varepsilon \tag{1}$$

In the above equation, "GDP" represents the economic growth of the country. "CO2" represents the carbon dioxide emission from the cement industry of Pakistan, and "HE" represents the health expenditures of Pakistan on the aggregate level. The term "ε" shows the error term. All variables are taken in log form to estimate the percentage change in the variables. In the above equation, the subscription "t" stands for time.

### 3.3. Auto-Regressive Distributed Lag (ARDL) Model

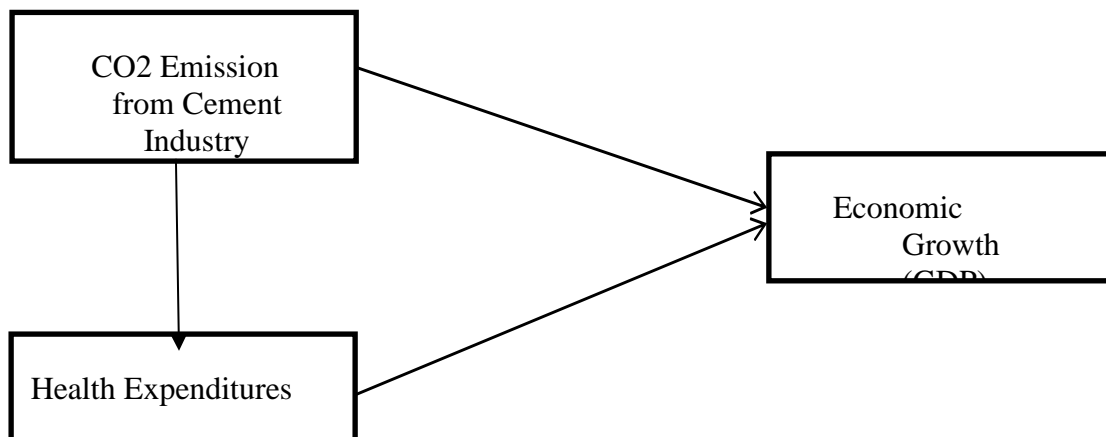
After applying the unit root test, if data is stationary at I(0) and I(1), the following ARDL is estimated to test the model's short run and long dynamics. The specific equation of the ARDL model is given as;

$$\Delta \ln GDP_t = \alpha_0 + \sum_{i=1}^n \alpha_1 \Delta \ln GDP_{t-i} + \sum_{i=0}^n \alpha_2 \Delta \ln CO_{2t-i} + \sum_{i=0}^n \alpha_3 \Delta \ln HE_{t-i} + \gamma_1 \ln GDP_{t-1} + \gamma_2 \ln CO_{2t-1} + \gamma_3 \ln HE_{t-1} + \varepsilon_t \tag{2}$$

Where α's and γ's are short-run and long-run coefficients respectively, various studies like (Abbasi & Riaz, 2016; Ahmad et al., 2016; Attari, Hussain, & Javid, 2016; Mansoor & Sultana, 2018; Mirza & Kanwal, 2017; Shafiq, Hua, Bhatti, & Gillani, 2021) use the ARDL test to investigate the long run and short-run relationship among variables.

### 3.4. Description of the Variables

Based on the literature about the health expenditures and CO2 emissions nexus, the following diagram explains that hazard gases directly affect health expenditures, which in turn affects a country's economic growth.



**Figure 1**

## a. Economic Growth

Economic growth is the production of all goods in-country produce in a year. It includes all tangible and intangible goods and services. The living standard of citizens improves with the increase in the economic development of the country (Yang & Shafiq, 2020). Here in this study, GDP growth is considered as a dependent variable.

## b. CO2 Emissions

CO2 emissions are toxic gases that have many harmful effects on people health living around the industrial zone. It decreases economic growth, environment, and human health. This gas also affects other living organisms of the world. The major sources of CO2 emission are the industrial sector, transportation sector, burning of fossil fuels, etc. Here we only target CO2 emission from the cement industry of Pakistan, and this study takes this variable as an independent variable.

## c. Health Expenditures

Health expenditures include individuals acquiring adequate health facilities, including medical check-ups, tests, and medicines. On the aggregate level, the government also allocates a portion of earnings to be spent on the health care of its citizens so that they can enjoy better health facilities (Majeed & Gillani, 2017; Shafiq & Gillani, 2018). These health expenditures also include all health-related services, emergency aid for citizens, and all nutrition activities. In this study, health expenditures act as the independent variable.

## 4. Results and Discussions

### 4.1. Unit Root Test

The unit root is the preliminary test to find whether the variables are stationary or not. The reason for checking the stationarity levels is to use data for further steps. Different researchers have used unit root tests to check the stationarity level of the variables. If three conditions of series, including mean and variance, are constant, and covariance depends on lag, not on time, are satisfied, then the series is stationary. If we use non-stationary series, the results will be spurious. If data is stationary at the first difference of at least a mix of that, a co-efficient slope truly represents the relationship.

**Table 1**  
**Augmented Dickey-Fuller Test**

Variables	Results at Level & 1 <sup>st</sup> Difference			
	Level of Integration	t-Statistic	Prob.	Dission
CO <sub>2</sub> (Carbon Dioxide Emissions)	Level	-3.50	0.01	I(0)
HE (Heath Expenditures)	First Difference	-3.90	0.00	I(1)
GDP (Economic Growth)	Level	-4.12	0.01	I(0)

Table 1. shows the output of the unit root test. The augmented Dicky Fuller test is employed to check the stationarity of the underlying variables. ADF test provides robust estimates of the unit root testing compared to the Phillip Peron and other tests. According to the table, CO<sub>2</sub> and GDP are stationary at a level while HE is stationary at the first difference. The table somehow shows mixed results of the unit root test. In this scenario, the ARDL model is best that favors the variable mix of I(0) and I(1). As there is a mixed order of integration, this study employs the ARDL methodology to check the cause and effect among the underlying variables.

## 4.2. Bound Test of Cointegration

Table 2 shows the outcome of the bound test for checking the long-run cointegration among the variables. The bound test employs the F-stat to check the long-run relationship between the selected variables, i.e., CO<sub>2</sub> emissions, health expenditures, and economic growth.

**Table 2**  
**Bound Test Results**

<b>F-Statistics</b>	<b>I(0)</b>	<b>I(1)</b>
43.24	5.15	6.36

The table shows the outcome of the existence of a long-run relationship between CO<sub>2</sub> emissions, health expenditure, and economic growth in Pakistan. The bound test works under the null hypothesis of no existence of a long-run relationship between the variables opposite to the alternative of the existence of a long-run association between the underlying variables. In the light of the above table, the F-stat (43.24) is greater than the value of the upper bound critical value (6.36), confirming the long-run relationship between the underlying variables. If the value of the F-stat is lying below the lower bound of the critical value, it shows no relationship between the variables. The results remain inconclusive if the F-stat value is lying in between the two bounds.

## 4.3. ARDL Model Short-run and Long-run Results

**Table 3**  
**Short-run Estimates of ARDL**

<b>Variable</b>	<b>Coefficient</b>	<b>Std. Error</b>	<b>t-Statistic</b>	<b>Prob.</b>
D(GDP(-1))	-0.035	0.118	-0.298	0.768
D(GDP(-2))	-0.152	0.104	-1.459	0.160
D(GDP(-3))	-0.155	0.088	-1.765	0.093
D(CO <sub>2</sub> )	-0.384	0.049	-7.839	0.000
D(HE)	0.093	0.009	9.866	0.000
CointEq (-1)	-0.790	0.135	-5.842	0.000

Above table 3 shows the ARDL short-run results. So, in the short-run the impact of CO<sub>2</sub> emission from industry is significant according to its probability value. In the short run, the coefficient value of CO<sub>2</sub> is -0.384, and its t-statistic value is -7.839 with 0.000 probability value. It indicates that CO<sub>2</sub> emission from the cement industry has a significantly negative impact on economic growth (GDP) in the short run. It also shows that in the short run increase in CO<sub>2</sub> emission from the cement industry will lead to a decrease in economic growth. The coefficient value of health expenditure is 0.093, and its t-statistic value is 9.866 with 0.000 probability value. It means that health expenditure has a significantly positive impact on economic growth (GDP) in the short run. The positive relationship shows that with an increase in health expenditure, the country's economic growth also increases.

**Table 4**  
**Long-run Estimates of ARDL**

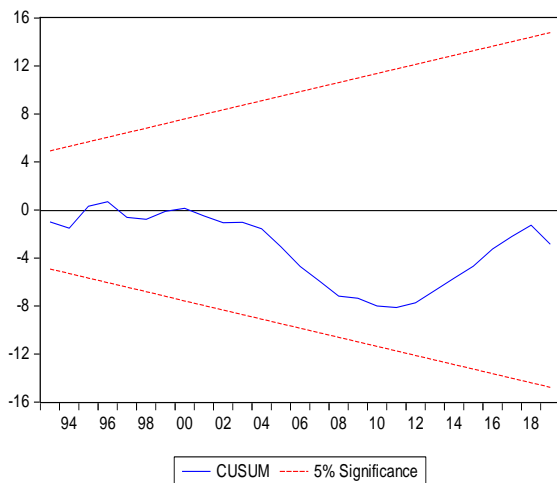
<b>Variable</b>	<b>Coefficient</b>	<b>t-Statistic</b>	<b>P-value.</b>
CO <sub>2</sub>	-0.485	-4.467	0.000
HE	0.118	5.192	0.000
C	4.095	9.915	0.000

Table 4. explains the long-run estimates of ARDL. The result shows that there is a significantly negative impact of CO<sub>2</sub> emission from the cement industry on GDP growth in the long run. At the same time, health expenditures have a positive impact on economic growth. The value of CO<sub>2</sub> emission is - 0.48 showing a negative impact in the long run. Also, in the long run, the value of health expenditure is 0.11, indicating a positive long-run impact on economic growth as the emission of CO<sub>2</sub> increases in Pakistan. These results align with

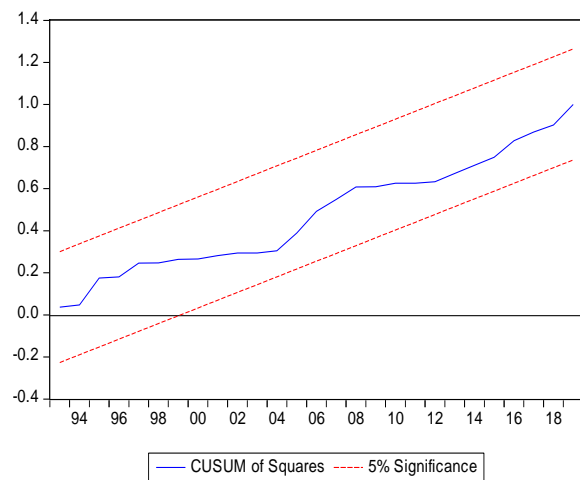
(Chaabouni & Saidi, 2017) that documented the negative impact of CO<sub>2</sub> emissions on GDP growth. Some other studies also verify the same outcome including (Abid, 2016; Dogan & Aslan, 2017; Dong et al., 2018; Gökmenoğlu & Taspınar, 2016; Z. Wang, Zhang, & Wang, 2018). Thus, CO<sub>2</sub> emission from the cement industry has a significantly negative impact on economic growth (GDP), and hence null hypothesis is accepted.

#### 4.4. Stability Tests

To check an ARDL model's stability, the study applies the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) test. The result of these tests is depicted in Graph 1 and Graph 2. The plots of cumulative sum of recursive residuals when GDP is taken as a dependent variable are shown in Graph 1 and Graph 2. The estimated line lies inside the upper and lower critical bounds, verifying the long-run stability of a model at a 5% significance level. The results of both CUSUM and CUSUMSQ tests show stability in the long run.



**Graph 1: Cumulative sum of Square test**



**Graph 2: Square of Cumulative sum of square test**

### 5. Conclusion and Policy Recommendations

In the present study, CO<sub>2</sub> emission from the cement industry and health expenditures are closely related to each other in affecting economic growth. The results show the negative relationship of emission of CO<sub>2</sub> from the cement industry with economic growth. The values indicate that a 1% increase in CO<sub>2</sub> emission from the cement industry will decrease economic growth. In contrast, the affiliation among expenditure on health and Carbon emission is positive. With 1% increase in CO<sub>2</sub> emissions enhances the spending on the health of the people. In light of the model's empirical outcome, this study concludes that carbon dioxides are very dangerous for the lives of people living around. Therefore, particularly cement industry-related emission of CO<sub>2</sub>, their industries must be constructed in the industrial zones that are constructed away from the residential areas. So that people shall not indulge in the hazards of the cement industry released gases. And hence the expenditure on health shall be minimized. The government should need to maintain the economic growth of the country. It is the responsibility of government and policymakers to make environment-friendly and eco-friendly policies to make the environment clean and for high economic growth. The government also charges heavy fines to all those industries that emit greenhouse gases, especially CO<sub>2</sub>, in the environment and affect economic growth. By improving technology, the cement industry can increase its production with less emission of carbon dioxide. The government should encourage foreign investors to invest in green technology to increase production capacity and improve the environment.



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