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**ORIGINAL ARTICLE**

# An Overview of Different Approaches to Managing '$CO_2$' Emissions from a Legal Perspective

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**KEYWORDS**

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**ABSTRACT:** Rising greenhouse gas (GHG) concentrations are exacerbating global warming. The recognition of the right to a healthy environment as a human right has compelled countries to prioritize the fulfillment of basic human needs and ecological reserves. Governments take other legal and effective measures to strengthen the law, ensure its effective enforcement, and develop a legal basis for preventing and controlling air pollution. Despite the State's commitments to fulfilling the right to a healthy environment, there are still various international challenges in realizing these commitments. The main question of this research is what are the multiple approaches to managing Carbon dioxide '$CO_2$' emissions from a legal perspective. So, from a legal standpoint, this review study is aimed at of current examining the critical international instruments on climate change and '$CO_2$' emissions and assessing the strengths and weaknesses of international instruments addressing air pollution, the role of various industries, and the States' commitments to reduce 'GHG' emissions by 2050, and in the end, identifying some of the most effective strategies to achieve net-zero and net negative '$CO_2$' emissions by the world's major emitter states. It concludes emissions decreasing global ' $CO_2$' emissions requires all States' cooperation and technical assistance. In this regard, the evolution and development of world legislation regarding the control of '$CO_2$' pollution and creating roadmaps to reduce the '$CO_2$' footprint up to 2050 in different countries is significant. As the world's major emitters, some countries have committed themselves to reducing 'GHG' emissions according to their proposed roadmaps.

## INTRODUCTION

Global warming has risen due to increased greenhouse gas 'GHG' concentrations. One of the reasons for the rise in Carbon dioxide '$CO_2$' emissions is the intensification of urbanization and industrialization. The research aims to find different approaches that could be employed to reduce '$CO_2$' emissions from a legal perspective and examine how the states cut '$CO_2$' emissions considering their commitments. Today, humans are increasingly urbanizing and distancing themselves from natural systems, and as a result, many natural systems are under increasing pressure from humans and economic activities. This has led to an unintended enhancement in the concentration of energy-

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trapping gases in the lower atmosphere, which poses a fundamental challenge to the international community, reducing 'GHG' emissions rather than preventing dangerous interference in the Climate system. National governments are committed to achieving this vital goal under the United Nations Framework Convention on Climate Change (UNFCCC) [1]. Solving the problem of air pollution and global warming requires the action of individuals, communities, nonprofits, and policymakers worldwide. In this regard, having a plan as a first step is crucial. Humans' polluting gas emissions have caused air pollution and accelerated global warming worldwide. That is why various international communities are looking for alternatives to fossil fuels. Climate change is just one of many large-scale destabilizing environmental changes driven by human domination of the ecosphere. This dominance is on the rise and includes significant global changes such as stratospheric ozone depletion, biodiversity loss, worldwide land degradation, and freshwater depletion. Other factors include disruption of nitrogen and sulfur elemental cycles and the dissemination of persistent organic pollutants worldwide. The adverse effects of all these factors are on the sustainability of ecological systems, food production, economic activities, and human health.

Regarding the adverse impacts of climate change on human beings and the realization of human rights, an agreement called Malé Declaration explicitly states that climate change has clear and direct consequences for the full enjoyment of human rights [2]. Subsequently, following the immediate and far-reaching threat to people and communities worldwide, the 'U.N.' Human Rights Council adopted Resolution 7/23 on Human Rights and Climate Change and requested the Office of the 'U.N.' High Commissioner for Human Rights (OHCHR) to study the linkages between climate change and human rights [3].

This study begins by exploring the correlation between global warming and air pollution. The first approach examines the evolution of world legislation regarding controlling carbon dioxide ($CO_2$) pollution and their effective global actions in Ozon layer protection, considering the most important international instruments in this area. It has applied a combined descriptive, analytical, and legal methodology based on a rigorous examination of primary and secondary sources related to this topic. In addition to the international treaties on climate change, it has tried to consider some practical proposals provided by researchers to decrease 'GHG' emissions.

The second approach considers the classification of 'GHG' emissions sources in various sectors and the role of industries in reducing ' $CO_2$' emissions. It counts some effective efforts taken by some countries, especially the main emitters, to diminish 'GHG' emissions worldwide in this field.

The third approach, according to the leading roles of the United States (U.S.), China, the European Union, and India as the significant emitters in the world, reviews their Roadmaps to reducing the '$CO_2$ ' footprint up to 2050 along with the critical goal of each country to reduce 'GHG' emissions. And the last section summarizes the study's findings. It assesses the States' commitments to reduce 'GHG' emissions by 2050. It counts down some successful strategies to net-zero and net negative '$CO_2$' emissions, along with the researchers' practical proposals to decrease 'GHG' emissions. Also, it summarizes the study's findings concerning the role of States' cooperation and technical assistance in decreasing global ' $CO_2$' emissions and the main emitters' roles in international efforts to reduce 'GHG' emissions according to their proposed roadmaps.

And the last section is the fourth approach, in addition to the successful techniques and realistic proposals for lowering "GHG" emissions which have been mentioned in approach three, reviews the other functional solutions to improve the current pollution situation, which could be an excellent example with so many lessons for the other countries and their industries around the world.

***Review steps and Investigation proocedure***

***The correlation between global warming and air pollution***

Climate is determined as 'the long-term prevailing weather in an area and is primarily determined by temperature and precipitation [4].' So, the slightest changes in climate affect the ecosystem. As mentioned in the latest Intergovernmental Panel on Climate Change (IPCC)

Report, these changes in different ways have already affected all regions on Earth, and Climate Change will increase in the following decades [5]. Climate change is a change in temperatures and weather patterns in the long term, and it is caused by human activities or has natural origins [6]. With increasing population, urbanization, and consequent increase in human activities, 'GHG' emitted into the atmosphere has increased, which leads to the release of vehicle pollutants, an increase in airborne particles, and contamination of foods and water resources. For this reason, in most industrialized and developing countries, allergic diseases and asthma have been observed in recent decades [7].

For further explanation about the emissions of 'GHG,' it should be stated that when sunlight reaches the Earth, it warms the Earth. Thirty percent of sunlight reaching the Earth is returned to space by clouds, atmospheric particles, reflective ground surfaces, and oceans. Oceans, air, and Earth absorb 70% of the remaining carbon dioxide. This warmth is required to sustain life. After the Earth warms, some solar energy is radiated and released into space by thermal radiation and infrared rays, which cool the Earth [8]. But the leading 'GHG, ' including '$CO_2$,' nitrous oxide, methane, and chlorofluorocarbons, accumulate in the atmosphere. These 'GHG' are nearly transparent to solar radiation but trap some infra-red radiation emitted by the Earth, which results in global warming over time [9].

The main reason for the dimming of the surface is black carbon [10]. In addition to 'GHG,' the second major cause of global warming is the degradation of the ozone layer due to chlorine-containing gases. If an effective, adequate, and immediate mechanism to reduce 'GHG' emissions doesn't provide, in that case, global warming will reach 1.5 or even 2 degrees Celsius because human activities have already caused nearly 1.1 degrees of global warming [11].

One of the fundamental reasons for climate change is the increased concentration of '$CO_2$' and other 'GHG,' [12] impacting the ecosystem, climate, and human systems [13]. Because of the close tight of the ecosystems to primary human rights have been considered preconditions for the full realization of human rights [14]. Climate change's negative consequences on human rights include socioeconomic and political instability, food, water, and health insecurity because of shifts in the average temperature, wind patterns, extreme weather events, species extinction, biological diversity reduction, and other factors. This phenomenon has been recognized as the most hazardous global risk [15].

Among other 'GHG,' carbon dioxide counts as one of the leading air pollutants, with the most significant share among others in air pollution (Figure1). Studies have shown that from 1800 to 2019, '$CO_2$' in the atmosphere has increased by more than 40% due to human activities, especially since 1970 onwards and after the acceleration of energy utilization worldwide. The most significant increase in global average temperature has been reported since the middle of the twentieth century due to the rise in the concentration of 'GHG.' Human activities have played a major role in producing these gases [16]. Therefore, climate change is one of the consequences of air pollution; These two are tightly linked and have particular influences on each other.

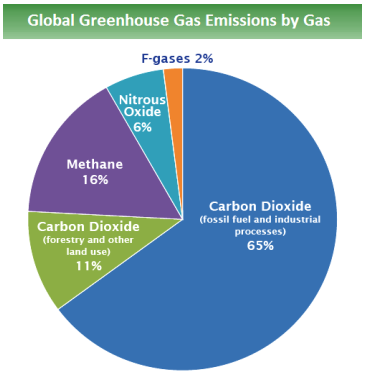


**Figure 1.** Global Greenhouse Gas Emissions by Gas [17].

## RESULTS AND DISCUSSION

### *The first approach - Evolution, and development of world legislation regarding the control of $CO_2$ pollution*

This section has addressed the evolution of international treaties related to climate change. The importance of these agreements is due to their effective global actions in Ozon layer protection. Countries around the world agreed to stop using ozone-depleting substances in order to halt the depletion of the ozone layer. Once a mere urban or local problem, air pollution spreads across continents and oceans due to fast, long-range transport. Atmospheric brown clouds (A.B.C.s) contain submicron-size particles concentrated at the metropolis's hotspots, which these fast, long-range transports from the metropolis's hotspots create considerable masses in adjacent oceans. The release of these airborne particles reduces the amount of sunlight received by the Earth, increases atmospheric temperature and monsoon winds, and suppresses rainfall. Also, in this line, it has reviewed the most important international agreements related to environmental protection specified on climate change and reducing 'GHG' emissions. Some global agreements to guide progress include the Vienna Convention for the Protection of the Ozone Layer, the 'UNFCCC, ' and the Paris Agreement. Three broad categories of action are: cutting emissions, adapting to climate impacts, and financing required adjustments.

The Vienna Convention for the Protection of the Ozone Layer as a multilateral and legally binding environmental agreement was the first legal effort dedicated to protecting the ozone layer by the 'U.N.' in 1985. One of the most outstanding achievements of this Convention was the Montreal Protocol in 1987, which had a leading role in healing the ozone layer [18]. Despite the problems in implementing the Montreal Protocol, it can be said that the Vienna Convention and the Montreal Protocol in addressing the global issue of stratospheric ozone depletion have been the most successful agreement of the international community since 2009 [19].

'UNFCCC,' also known as the Rio Earth Summit in 1992, was another intergovernmental treaty concerning climate change. This Convention is more comprehensive than the former one. The provisions of (Art. 4) of this Convention imply that this Convention could make it up for the defects of the Montreal Convention on the ozone layer. In this Convention, due to the largest share of developed countries in 'GHG' concentrations, the burden of obligations is borne by developed countries. There are no specific commitments for other States to reduce 'GHG' emissions [20].

As the most significant international action on climate change thus far, the Convention's goal was to stabilize atmospheric concentrations of 'GHG' at a level that would prevent dangerous anthropogenic interference with the climate system. With the Berlin Mandate, the first Conference of the Parties to the Convention began discussions on a protocol or other legal instrument containing more substantial commitments for developed and developing countries. As a result, the approval of the Kyoto Protocol to the 'UNFCCC' was the cornerstone, thus the most effective climate change measure that had been done until that point. An example of a global effort by world leaders to reduce carbon dioxide emissions was the Kyoto Protocol, signed in 1997 in Kyoto, Japan. Global action to mitigate climate change entails enormous economic, social, political, and technical challenges. According to the Kyoto Protocol, industrialized countries and the European Union had to cut back on their 'GHG' emissions from 2008 to 2012.

The Kyoto Protocol to the 'UNFCCC,' in 2005, focuses on decreasing the emissions of six kinds of 'GHG' that contribute to global warming, including '$CO_2$.' The Kyoto Protocol applies to developed countries [21] and, in its Annex B, committed the member states to reduce

'GHG' emissions considering their assigned amounts. Annex A enumerates 'GHG' that have not been controlled by the Montreal Protocol and their sources in different sectors. Also, examining the parties' obligations to this protocol is another remarkable feature [22]. Developing countries welcomed the Kyoto Protocol, which has set binding emission reduction targets through a collective process of international negotiations. Still, developed countries that were the main target of the Kyoto Protocol, such as the (U.S.) and China, sought to support a more global approach [23]. The Kyoto Protocol can be considered the critical first step toward the worldwide reduction of 'GHG' emissions and its stabilization, serving as the foundation for a future international climate change agreement [24]. Paris Agreement in 2015 is another legally binding international agreement that has set long-term goals, including the reduction of the global 'GHG' emissions to decrease the global temperature, examining the states' commitments, providing financial support to mitigate climate change and its impacts, and achievement to the Sustainable Development Goals [25]. The Paris Agreement's international popularity stems from its adaptability. As a result of the Paris Agreement and other international agreements, countries can make significant contributions to multi-national climate strategies while also leveraging other countries' reciprocal action to reduce overall global emissions.

Contrary to the Kyoto Protocol, this agreement includes developed and developing countries and defines the same essential obligations. Parties' collective accomplishments and proposed emission reduction strategies will assess every five years, establishing an expectation of gradually more decisive action over time and a common transparency and accountability framework. It is considerable to note that although the Paris Agreement is a legally binding international agreement, its provisions are not binding and do not create a legal obligation. This agreement contains Hard and Soft Laws and non-obligations in the international legal system, which the distinctions between them are blurred, while each plays a prominent role [26].

The most critical features of this agreement are comprehensive regulations and greater involvement of member states, emphasizing the countries' national participation program, and aligning the implementation of an international agreement on mitigating climate change with States' strategic interests. As well as the context of the Paris Agreement (Art.7) implies that there is a possibility of failure to achieve the agreement's long-term goals of reducing 'GHG' emissions and global warming, but it also has provided some plans to mitigate and adapt to climate change impacts [27].

Although the most critical international instruments in climate change like the 'UNFCCC' set out different commitments depending on the developed or developing countries, as mentioned in Art. 3(4) states that the programs and policies to protect the climate system should be proper for the specific conditions of each party considering its economic development, and there are some other general obligations to all member states. According to the 'UNFCCC,' the Paris Agreement, and the Kyoto Protocol, all states have some legal obligations concerning climate change: Stabilize 'GHG' emissions by states based on the 'UNFCCC' (Art.2) and the Kyoto Protocol (Art.3(1)). Following the 'UNFCCC,' the stabilization of 'GHG' emissions should be implemented as the first step from developed countries because of their leading 'GHG' emissions shares. In contrast, developing countries' economic, social, and development needs for economic growth have been recognized. Also, the Paris Agreement (Art.4) has mentioned this commitment as a key to achieving the long-term agreement's goal. By tackling all 'GHG' emissions from human sources and removals by sinks of all 'GHG,' States are obliged to develop, update, implement, and publish national and regional programs to mitigate climate change addressed in 'UNFCCC'

(Art.4(b)) and the Kyoto Protocol (Art.10 (a & b)).

Also, the states are obliged to publish national statistics of the total 'GHG' emissions by the type of gas and its sources by using the methodologies to be determined by the Conference of the Parties ("UNFCCC"(Art.4(1)(a), & (2)(b)), "Paris Agreement" (Art.10(2), & Art.13(7)), "The Kyoto Protocol" (Art.7(1), & Art.3(3)) as well as the enhancement and implementation of public education and their access to climate change's information and its impacts on human lives. These obligations have been enshrined in 'UNFCCC' (Art. 6(a)), the Paris Agreement (Art.2(1)(b) & Art.12), and the Kyoto Protocol (Art.10(e)).

Precautionary measures regarding climate change are other states' obligations. The importance of implementing this principle, along with the role of sustainable development in declining the risks or damages of climate change, is recognized in the Paris Agreement (Art.8) and predicted in Art. 3(3) of the 'UNFCCC.' For the states parties to anticipate, prevent, or reduce climate change's causes and negative consequences, precautionary steps should be taken. ("UNFCCC." Art.3(3)) The necessity of balancing economic development and environmental protection as the basis of sustainable development, as mentioned in the International Court of Justice's Case named '*Pulp Mills on the River Uruguay* [28].' The Kyoto Protocol in Art. 12 sets out the clean development mechanism's purpose to achieve sustainable development.

Furthermore, under the 'UNFCCC,' to achieve a sustainable development policy, all states considering their differences in their responsibilities, priorities, circumstances, and aims, must cooperate to adequately adapt to climate change's impacts, promote an open international economic system to achieve economic growth in all states, especially in developing countries, enhance their cooperation and sustainable management to increase sustainable environmental development. Besides, the state parties must develop their national policies and implement appropriate actions to mitigate climate change by limiting 'GHG' emissions. ("UNFCCC" Art.3(5), 4(2)(a)). Art. 2 of the Paris Agreement in implementing the Convention's goals, also intended to improve response on a global scale to the threat of climate change in sustainable development and poverty alleviation. So, collaborate in the development, implementation, and transfer of technologies, processes, and effective practices in controlling, reducing, or preventing 'GHG' emissions, cooperation in different areas of research on climate change, its timing and economic and social consequences, and support international and intergovernmental organizations or programs related climate change are the other states obligations concerning the climate change. ("UNFCCC" Art. 4(1)(c), (g), and Art. 5(a)).

In different chapters, the 'U.N.' Charter has dealt with the principle of collaboration, including achieving international cooperation, solving global issues with economic, social, cultural, or humanitarian dimensions, and upgrading universal respect for human rights and fundamental freedoms for all. Also, the other Arts. of this instrument have recognized the promotion of constructive development measures as an obligation of the 'U.N.' members. States should encourage scientific research and cooperate with each other or with specialized international organizations to access the economic, social, and scientific objectives [29]. Subsequently, without cooperation, technical and financial assistance in this regard, achieving net-zero emissions for developed countries would be more challenging and prohibitive, as well as developing countries, this route would be ambiguous [30].

On the other hand, it seems that by recognizing the right to a healthy environment as a human right by the 'U.N.' Human Rights Council [31], the establishment of an International Court on the Environment to enforce it, especially in weighing relative roles and responsibilities for causing global warming, taking some practical

actions to address it and examining the fairness of global emissions reduction targets worldwide would be helpful. This proposal has already been raised in the Hague Declaration on the Environment in 1989 [32] and the UNEP Global Judges Symposium in 2002. This Symposium considers the necessity for an independent, impartial, and trustworthy judicial mechanism to resolve environmental disputes [33].

In addition to the above-mentioned international treaties on climate change, proposals have been made by a group of researchers to reduce '$CO_2$' emissions in various countries. For example, Jacobsen et al. have prepared a roadmap called wind, water, and solar (W.W.S.) for 139 countries. The report predicts that by 2030, 80 percent of countries will be using "W.W.S.," and by 2050, 100 percent will be using "W.W.S.."

They also suggest that electricity should be supplied to all sectors to increase energy efficiency, as the processing of fossil fuels increases energy efficiency and reduces energy consumption. 'WWS.' power generators are needed in this case, including onshore and offshore wind turbines, solar photovoltaics on rooftops and in power plants, concentrated solar power, geothermal power, tidal and wave power, and hydroelectric dams.

Suppose the Jacobson et al. roadmap is implemented. In that case, the following are expected to occur: elimination of a maximum of 4 to 7 million deaths per year (3.5 million fatalities per year are expected by 2050 from air pollution, which is already responsible for 4–7 million deaths (as well as hundreds of millions of diseases) per year), elimination of pollutant emissions and global warming damage, job creation (especially in the manufacturing industry), Stabilizing energy prices, and reducing social costs, reducing terrorism and the catastrophic risk associated with large power plants, and ultimately improving access to electricity for 4 billion people (people living in energy poverty) [34]. '$CO_2$' emissions must be drastically reduced in order to maintain the current level of 'GHG' concentrations in the atmosphere. Other solutions are available, including using fossil-fuel-based energy sources while cutting '$CO_2$' emissions, which some argue implies a significant drop in fossil-fuel usage. The subsurface sequestration of '$CO_2$' from fossil fuel combustion might delay its release for millions of years [35].

Therefore, to reduce '$CO_2$' emissions, investment in technology and the development of non-fossil energy sources is a helpful solution. Concentrating on air pollution for this aim, especially aerosols and tropospheric ozone, is critical due to the environmental effects on human health. In this regard, the World Bank's support for investment in modern technology and air quality control (e.g., in India and China) effectively improves local health, increases agricultural productivity, and improves global climate quality [36].

***The second approach- Attention to the role of industries in reducing $CO_2$ emissions***

The sources of 'GHG' emissions are classified as follows: the energy sector, including electricity, heat, and transport with 73.2%, Agriculture, Forestry, and Land Use with 18.4%, the industry section with 5.2%, and the waste section with 3.2%, are the critical sources of 'GHG' emissions [37].

***Energy sector***

The primary energy consumers are the two sectors of transportation and industry, which are also considered applicants for petroleum products globally. In addition to their positive effects, these sectors cause a lot of social damage due to the release of pollutants into the environment. Fossil fuels in factories and industries cause air pollution. Automotive and industrial fuels produce pollutants such as ozone, carbon dioxide, oxides of sulfur, nitrogen, lead, aerosols, and toxic compounds such as benzene [38].

On the other hand, most air pollution, especially '$CO_2$'

emissions, is released from the combustion of fossil fuels and chemical reactions to provide intense heating in industrial sectors by middle-income countries to manufacture goods and provide services to export to high-income countries. Along with the increase in energy consumption and oil revenues, 'GHG' emissions in oil countries have occurred due to dependence on oil and oil revenues in production and consumption structures and the lack of policies to improve energy efficiency. OPEC member states have experienced high pollution levels in the early stages of industrialization. One of the reasons for this is the entry of polluting industries in these countries. Most of these countries are developing countries where energy consumption is more dependent on fossil fuels and therefore has more '$CO_2$' emissions than developed countries [39].

In general, in developing countries, technology's production is not up to date, and the use of old technologies reduces energy efficiency, which increases the severity of environmental damage. Since reducing '$CO_2$' prevents developing countries from achieving their legitimate goals, they are exempted from Kyoto restrictions. For more information, it should explain that, in the oil sector, oil price shocks affect carbon emissions; In this way, higher oil prices improve the quality of the environment because rising oil prices lead to reduced consumption of fossil fuels. So, the abundance of resources leads to higher energy consumption and more '$CO_2$' emissions as prices fall. The 'U.S.' shale oil industry has doubled its crude oil production capacity since 2012. Of course, the expected effects of shale oil as an alternative to conventional oil are to reduce '$CO_2$' emissions and create a positive environmental impact [40].

However, traditional oil and shale abundance has generally led to lower oil prices, higher oil consumption, and carbon dioxide emissions. Oil price shocks have heterogeneous effects on '$CO_2$' emissions. Reducing global oil demand could also help reduce 'GHG' emissions. The main concern of policymakers in the worldwide oil market should be to focus on the environment and deal with the adverse effects of carbon emissions by stabilizing global price fluctuations.

***Transportation sector***

The transportation sector has had the largest share in increasing the concentration of '$CO_2$' in recent decades. According to international standard industry classification, the transport industry is divided into road, railway, navigation, aviation, and pipeline. The importance of preventing and reducing carbon dioxide concentrations, especially in the transport sector, is addressed in the Kyoto Protocol, based on the global response to climate change. According to the World Bank, global '$CO_2$' emissions in 1960 were 9.4 million kilotons, which increased 3.6 times to 33.6 million kilotons in 2010. Also, according to statistical evidence, about 20% of global '$CO_2$' emissions are related to the transportation sector [41]. The International Energy Agency ranked the transportation sector second in its 2017 report, with a 23.96% share of carbon emissions among other sectors in 2015. Carbon emissions in the transportation industry are influenced by a variety of factors like per capita ' G.D.P.,' urbanization level, energy consumption structure (with a positive effect on carbon emissions), technology level, and degree of commercial openness (with a negative impact on carbon emissions). For instance, for every 1% increase in urbanization, carbon emissions in the transportation industry increase by about 7.7%, or for every 1% increase in technology, carbon emissions decrease by 0.2% [42].

The main strategies proposed for Western Asia and Eastern Europe (which have high levels of urbanization and per capita ' G.D.P.') to reduce carbon emissions in the transportation industry are enriching energy consumption structure, including biomass energy, natural gas, and solar energy, etc. In addition,

controlling the excessive growth of carbon due to the consumption of fossil fuels and improving the level of foreign trade is also helpful in this regard. Other practical and valuable measures have been taken to control this type of pollution in the transportation industry. For example, between 1999 and 2015, Japan reduced '$CO_2$' emissions from passenger vehicles in a different direction from Europe to 37.7%, partly due to the greater use of petrol hybrid cars in 2014. The choice of diesel cars instead of other engines with other fuels in Europe was a mistake, and this issue is further clarified by considering the adverse effects of 'GHG' emissions on health. Using low-emission vehicles, such as electric vehicles (which use electricity from renewable energy sources), is a way forward [43].

Another example was in the 'E.U.,' in which transportation accounts for almost one-quarter of all energy-related 'GHG' emissions in there. The 'E.U.' to reduce '$CO_2$ ' emissions regarding urban pollution control and reaching climate neutrality by 2050 has adjusted some regulations and has established percentage-based '$CO_2$ ' reduction goals of 15% and 30% for the years 2025 and 2030, respectively, compared to 2019/2020 emissions levels for heavy-duty vehicles which were responsible for 6% of all energy-related 'GHG' emissions in the 'E.U.' [44] On the other hand, they have used car taxation to reduce '$CO_2$' emissions regarding urban pollution control, thus encouraging consumers to buy a car with less pollution and taxes. For this purpose, a combination of taxes on the vehicle (purchase, ownership, and use) is considered. Taxation on assets has been very effective in controlling 'GHG.'

***Industry and agriculture sectors***

The majority of '$CO_2$' emissions come from the industrial sector, which focuses on improving energy efficiency and is very effective in this area. Proper methods of reducing '$CO_2$' in the electricity industry include energy-saving and improving energy efficiency, using renewable energy and optimization of energy structure, improving the tax system ('$CO_2$' emission tax), and pollution management mechanism. One of the most effective protection policies to reduce '$CO_2$' emissions is the carbon dioxide tax policy. This policy reduces 'GHG' emissions and the harmful effects of climate change, which helps improve the environment [45].

The aluminum industry is another primary source of global perfluorocarbon (P.F.C.) emissions [46]. Aluminum is a corrosion-resistant, light-weight, and malleable metal in various products. It is used in transportation, construction and building, consumer durables goods, electricity, machinery and equipment, and other items. The aluminum production process involves the production of primary metal from bauxite ores and secondary metal production from aluminum scrap. Primary aluminum production is associated with 'GHG' gas emissions. These gases are produced due to alumina production, aluminum non-combustion activities, and the combustion of fossil fuels. Melting aluminum emits carbon dioxide into the atmosphere. The amount of energy required to reduce aluminum is provided by the combustion of fossil fuels for secondary aluminum and the electricity purchased for primary aluminum. The amount of '$CO_2$' emissions from this energy consumption is higher than the aluminum production process. In this regard, one of the substantial measures that have been taken by the 'U.S.' in this sector was that the Aluminum Association and its members pledged to reduce the intensity of direct carbon emissions from 'PFC.s' and the amount of '$CO_2$' emissions from carbon anode consumption from the initial aluminum reduction process. The goal was to reduce carbon from total resources by 53% by 2010 compared to 1990 [47].

Also, the manufacturing sectors emit a significant amount of energy and 'GHG.' Carbon dioxide emissions will rise due to the rapid growth of manufacturing

industries. A total of 58.27% of China's total '$CO_2$' emissions were attributed to the country's manufacturing sector between 1995 and 2015. The development of industrial activity is the primary cause of increased '$CO_2$' emissions in China's manufacturing sector. China's carbon dioxide emissions in 1995 were 1.91 billion tonnes, up from 6.25 billion tonnes in 2015. The largest share of carbon dioxide emissions is related to ferrous metal smelting and rolling, chemical raw materials, and non-metallic minerals, respectively. In 2010, China's 'G.D.P.' exceeded Japan's for the first time. China became the world's second-largest economy after the (U.S.), increasing fossil fuel consumption and high 'GHG' emissions. China's 'GHG' emissions in 2007 were even higher than in the 'U.S.'

Traditional factors affecting carbon emissions include energy structure, energy intensity, industrial structure, and economic activity. Reducing energy intensity as an essential factor by improving energy efficiency reduces carbon emissions. Intangible capital, innovation, and information and communication technology play crucial roles in energy intensity and carbon emissions. The Chinese government has implemented policies to reduce carbon emissions in various international and domestic economic environments. In this country, among the multiple factors that affect the reduction of '$CO_2$' emissions in industries, the most critical factor in the oil and coking industry, smelting and rolling of non-ferrous metals, rubber and plastics, and metal products, is the efficiency of the research and development; While an important factor in other industries is energy intensity [48].

The Chemicals sector produces products by converting organic and inorganic raw materials through a chemical process. The 'US' is the world's largest chemical producer. The Chemicals sector includes basic chemicals, specialty chemicals, agricultural chemicals, medicines, and consumer products. The emission of 'GHG' in the chemical sector is due to the energy consumed by the industry as well as the chemical processes themselves. Most fossil fuels generate heat and power in boilers, which create steam to conduct a chemical reaction and separate and complete the product. The feedstock emissions are called non-combustion 'GHG' emissions.

Human health and ecosystems are jeopardized by environmental pollution. This idea first arose at the dawn of the industrial revolution to describe [49]. Different countries have adopted various policies regarding protecting the environment and reducing environmental pollution by these industries. Two of these policies are Emission Reduction Credits and Capped Allowance Systems, implemented, especially in the 'U.S.,' over the past few decades. In Emission Reduction Credits, there is no fixed limit on the maximum allowable level of pollution in a regulated area, which has been widely criticized due to this unspecified amount. This policy means polluters cannot exceed a rate of emissions, so pollution limits are rate-based, and polluters earn credits by lowering their emissions below a predetermined level [50].

In the Capped Allowance Systems, the total emissions are limited, and the total number of allowances given to a polluter group determines the cap. Some of these allowances are exchangeable and traded in the market. Two stages are involved in determining how to operate in the exchange allowances program: first, determining the goals of reducing emissions and its amount, and then allocating allowances or quotas to the industries covered by this plan. As a result of this policy, industries will purchase allowances if the price of the allowances is lower than the costs of pollution control. This program aims to control the level of pollution, and the essential feature is the effort to achieve the goals of environmental and community health [51].

The other sector that affects carbon dioxide emission is the agricultural sector. Pesticides, fertilizers, and other agricultural chemicals are being used at alarming rates

by local farmers in an attempt to keep up with demand. Waste products and industrial effluents significantly contaminate the air, water, and soil [52].

The agricultural sector produces three 'GHG': carbon dioxide, methane, and nitrous oxide, and at the same time plays a vital role in mitigating climate change. By increasing the efficiency of agricultural production units, such as applying industrial and intensive systems, agricultural production units' carbon emissions can be minimized, and the adverse effects of agriculture on the environment can be reduced. Because the arable land absorbs some of the emissions and separates them organically for use as biomass. So, in general, the effects of agriculture on the climate can be divided into positive and negative. The positive impact is that increasing plant photosynthesis leads to increased crop yield at high atmospheric carbon dioxide concentrations. Finally, the negative effect on product performance is due to the increased temperature created by carbon emissions [53].

***Construction and building sector***

Another important '$CO_2$' emission industry is the cement industry, which accounts for about 8% of carbon dioxide emissions caused by human activities [54]. Overall, according to an estimate of carbon emissions in 1994, 63% of the total global carbon emissions in the cement industry were from the top ten cement-producing countries, including China (33%) with the largest share of 'GHG' emissions, the (U.S.)(6.2%), India (5.1%), Japan (5.1%) and Korea (3.7%). There are various methods to reduce '$CO_2$' emissions in the cement industry, including 1-energy efficiency improvement; for this purpose, the old facilities should be replaced with more modern and less consumptive equipment to get maximum profit by improving fuel efficiency. 2-Replace high-Carbon fuels with low-Carbon fuels; expand alternative fuels like natural gas or waste fuel recycling. Nine percent of the thermal energy used in the European cement industry in 1993 came from alternative fuels. Waste fuels do not add new 'GHG,' but they may lead to releasing elements such as Mercury and thallium [55]. 3-Blended cement production; Clinker production in cement factories emits a lot of Carbon dioxide, so in composite cement, part of the clinker is replaced with some products such as coal fly ash and blast furnace slag. Using this method in Europe is more common, and it is estimated that composite cement production will reduce emissions by at least 5% and at most 20% of total '$CO_2$' emissions. 4-Carbon dioxide separation from Flue Gases because of its flexibility and readily be integrated into fossil-fuel power facilities. In determining the best '$CO_2$' separation technique, the Flue gas parameters, namely '$CO_2$' concentration, temperature, and pressure, are the most important criteria [56].

In this kind of pollution, some noteworthy measures have been taken by China. China is the largest cement producer and emitter of '$CO_2$' globally. Factors such as energy efficiency, technology, alternative materials, and management level affect 'GHG' emissions in the cement industry [57]. In 2011, China accounted for 60% of world cement production as the world's largest '$CO_2$' producer. China's carbon emissions have been drastically reduced since 2005 by implementing the National Development and Reform Commission (NDRC) policies. For instance, new efficient large-scale production facilities have replaced the shaft, wet, and long dry kilns. In general, the cement industry's comprehensive approach to reducing carbon emissions involves using technology and innovation in the cement industry and transforming the cement industry into an environmentally friendly industry by using renewable energy and solid waste [58].

Considering the classification of 'GHG' emissions sources in various sectors and the role of industries in reducing '$CO_2$ ' emissions, the main emitters states have implemented various policies aimed at reducing 'GHG'

emissions. As a significant player in convincing industry and consumers to adopt climate-friendly practices, the government can do so by offering clear, predictable, long-term, and substantial incentives. It is critical to ensure that policies do not have an adverse effect. In its recent research, the European Union Emission Trading System (EU ETS), the world's first significant 'GHG' emission pricing program and the first activation of the Kyoto Protocol, argued that indirect 'GHG' emissions from international trading might affect the success of global climate initiatives. Therefore, it has been proved that controlling '$CO_2$ ' emissions via regulations is ineffective because a country's economy may respond by importing more from developing and uncontrolled areas (which often use a more carbon-intensive manufacturing method), even if rules in industrialized countries restrict or price emissions to reduce them [59]. In many cases, public policies for promoting new technological innovation can be applied across various industries. One of the examples of existing policies and measures is regulations and standards, such as fuel economy standards for automobiles or appliance efficiency standards [60]. Consumer preferences, costs, competitiveness, and government regulation will influence long-term industrial investment decisions. Governments can influence these decisions with standards, tradable permit systems, subsidies, and tax credits [61].

So, reducing 'GHG' emissions and creating climate-resilient communities will require the cooperation of three bodies of government legislative, executive, and judicial bodies. By enacting some laws governing their various sectors as the key sources of 'GHG' emissions, the states would be able to set strict rules and 'GHG' emissions reduction requirements to reduce their carbon footprint. Legislative requirements to reduce 'GHG' emissions and compile an inventory in this regard are in place in some countries, but because of the wide range of regulations in different countries, it's possible to set more ambitious goals in response to cutting down the 'GHG' emissions.

***The third approach – Creating roadmaps to reducing $CO_2$ footprint up to 2050 in different countries***

According to the Carbon Dioxide Information Analysis Center (2014), China, the 'U.S.,' and India had the most significant '$CO_2$' emissions because of fossil fuel combustion, cement production, and gas flaring [62]. Following the up-to-date statistics on the country's total contribution to 'GHG' emissions, especially their cumulative '$CO_2$', between 1751 and 2017, the 'U.S.,' accounting for 25% of carbon dioxide emissions, which is twice more than China as the second-largest contributor. With a share of 22% in third place and then India, the European Union has been known as the largest emitter of 'GHG' globally (Figure 2) [63,64].

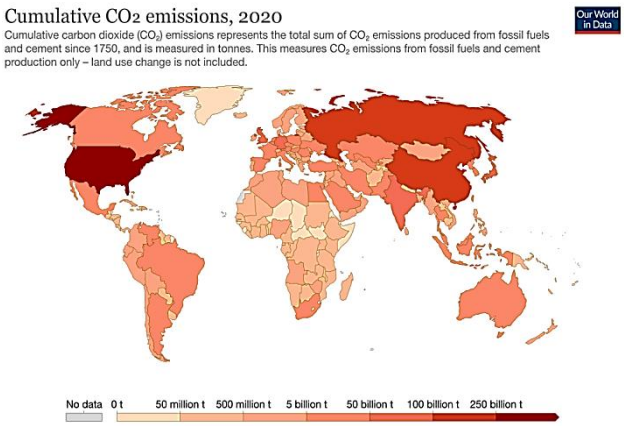


**Figure 2.** Cumulative $CO_2$ emissions, 2020 [64].

***The United States***

The 'U.S.,' as one of the significant emitters in the world, has set targets to reduce 'GHG' emissions in 2016, named the 'United States Mid-Century Strategy.' The established aims were to reduce 'GHG' emissions by 17% in 2020 and 26-28% in 2025, with both targets set compared to 2005 levels. The US Mid-Century Strategy (M.C.S.) examines 'GHG' reductions by sector and offers a roadmap to cut 'GHGs' by 80% below 2005 levels by 2050 [65]. In 2021, the 'U.S.' officially rejoined the Paris Agreement and committed itself to reduce 'GHG' emissions. In the same year, the 'U.S.' set its climate strategy to reach net-zero emissions by 2050, providing near-term and long-term strategies. Achieving the long-term strategy's goal, net-zero emissions by 2050, requires measures from every economic sector.

The ambitious goal of this strategy is to diminish net 'GHG' emissions 50-52% below 2005 levels by 2030 through multiple routes: increasing '$CO_2$' removal, investing in clean energy, transportation, and building electrification, decarbonizing electricity, energy waste elimination, the transformation of the industrial sector, decreasing non-$CO_2$ 'GHG,' and bolstering the natural and working lands [66]. More than 80% of current gross 'GHG' emissions in the 'U.S.' are due to energy and industrial sectors. Some scholars have shown that to achieve net-zero and net negative '$CO_2$' emissions by mid-century in these sectors, taking some measures like price reductions in solar, wind, and vehicle batteries help decarbonize the 'U.S.' economy more affordable on its terms even before accounting for the economic benefits of prevented climate change and air pollution.

Generally, there are four primary strategies for net-zero and net negative '$CO_2$' emissions by 2050 in all paths: energy efficiency, carbon capture, '$CO_2$' sequestration, and decarbonized electricity [67]. Research has been done on the benefits of integrating the climatic impact of specific air pollutants and air quality policies, and it has been predicted that merging the two in the 'E.U.,' the 'U.S.,' and China could complement policies designed to mitigate the effects of air quality of these pollutants [68].

***China***

Since the reform and opening in 1978, China has become one of the world's major emitters, and between 2000 and 2015, China's total '$CO_2$' emissions have risen dramatically. So, it is committed to establishing a low-carbon economy to address environmental issues concerning climate change, as President Xi Jinping announced an ambitious plan for ecological civilization. It has committed to cutting its carbon emissions intensity to 60–65% of 2005 levels by 2030. According to China's 13th Five Year Plan (F.Y.P.) and 13th Five Year 'GHG' Emission Control Workplan for 2016 to 2020, it was predicted that the country would control non-$CO_2$ 'GHG' emissions; however, the plans didn't provide specific targets or timelines beyond the Kigali Amendment's commitment [69].

Therefore, based on studies on China's non-$CO_2$ 'GHG' emissions, China could use a combination of '$CO_2$' and non-$CO_2$ mitigation strategies to decrease yearly non-$CO_2$ 'GHG' emissions by 870 Mt '$CO_2$' equivalent by 2050. Thus, by setting clear policy targets, mitigation actions, and increased nationally determined contributions, China would be able to commit to its obligation under the Paris Agreement framework. The mitigation strategies will be implemented through efficiency improvements, reduced manufacturing activity, fuel switching, and applying the existing cost-effective non-$CO_2$ 'GHG' mitigation strategies. These strategies could help balance the predicted growth in non-$CO_2$ 'GHGs,' especially in agricultural and industrial operations, which will account for more than 70% of non-$CO_2$ 'GHG' emissions by 2050.

Despite some issues and weaknesses in implementing China's road map to reduce 'GHG' emissions and climate change mitigations, such as the lack of public participation, long-term planning for low-carbon growth, and the inefficacy of united policy, China has made significant progress. Some of the noticeable improvements of China's

low carbon economy since 2000 include setting goals for reducing carbon emissions, improving energy efficiency and conservation, eliminating the capacity for backward production with a focus on high-energy industries like the cement and iron smelting factories, development of carbon sinks, and low-carbon cities [70]. To implement China's roadmap in reducing 'GHG' emissions, China, through technological innovation in reducing '$CO_2$' emissions, which would peak early in 2020–2025, should embark on a new urbanization path that fulfills low-carbon development criteria. The low-carbon technology roadmap focuses primarily on five primary initiatives and technological investments to achieve low-carbon urbanization, including applying Carbon Capture and Storage technology, final sector energy structure adjustment, industrial production process, non-fossil fuel power generation, and energy efficiency technologies, the last two have the tremendous potential for decreasing emissions [71].

***European Union***

The European Union's (EU) energy and climate framework was approved in 2014. According to this, 'EU' has committed to reducing 'GHG' emissions by at least 40% below 1990 levels by 2030 while simultaneously establishing new renewable sources of energy and energy efficiency targets. At the 'E.U.' level, a significant number of legislative initiatives to achieve the goals mentioned above were approved. Following the Paris Agreement's target, the European Commission provided a strategy in 2018 for a climate-neutral economy by 2050 [72]. In the following year, 2019, the European Commission had set the energy transition as one of its essential objectives. It proposed the 'European Green Deal' as a road map for the 'E.U.'s' climate plan to strengthen legislative strategies from 2020 onwards.

The new growth strategy aims to make a better developed and fair society, have a competitive economy, be resource-efficient, protect citizens from climate change impacts and environmental risks, conserve and enhance the 'E.U.'s' natural capital, and achieve zero net 'GHG' emissions [73]. The most essential, ambitious, and challenging aim of the 'European Green Deal' is to achieve zero net 'GHG' emissions by 2050, as set forth by Communication. Even though the Green Deal Communication has not been addressed explicitly, the effectiveness of global climate action will be primarily dependent on policy coordination between the three most significant 'GHG' emitters, including China, the 'U.S.,' and the 'E.U.' [74] Different factors, such as economic growth, fossil fuel consumption, globalization, urbanization, and the like, have influenced enhancing '$CO_2$ ' emissions in Europe. But one of the leading causes of carbon dioxide emissions in Europe was fossil fuel energy sources, which in 1970 accounted for more than 90% of the 'E.U.' primary energy consumption compared with renewable energy sources by 6.90%. In 2016, using renewable energy sources grew by 25% compared to 2015 [75]. One of the most effective measures taken to reduce 'GHG' emissions in Europe, which has had a significant impact on lowering 'GHG' emissions, was improving energy efficiency, strategies for a transition to alternative fuels, and the penetration of renewable energy sources. So, the 'EU' has isolated 'GHG' emissions from economic growth.

***India***

According to research on the share of different countries in carbon dioxide emissions between 1990-2016, despite India's per capita carbon emissions being four times lower than China and the 'E.U.' and eight times lower than the 'U.S.,' already it has been recognized as one of the largest emitters in the world. It has been predicted that India may soon exceed China and the 'U.S.' because of its fasting growing economies, which require substantial energy to keep its yearly growth rates above 7% [76]. India is one of the countries that have a decisive impact on the growth of '$CO_2$' emissions worldwide. India's carbon dioxide emissions (due to global warming restrictions below 2°C) are expected to peak in 2040. India's climate change roadmap's elements, including adaptation and mitigation strategies, technological shifts, building capacity, financial aspects, transparency of action, and support, have been defined in its Nationally Determined Contributions

(N.D.C.s). The goals of India's 'NDC.s' for 2020-2030 are reducing a 33% to 35% reduction in the emissions intensity of its Gross Domestic Product (G.D.P.) by 2030, lower than 2005 levels, soaring up to 40% in non-fossil energy generation capacity, setting up a new cumulative carbon sink, and increasing investments in development programs in climate-vulnerable sectors for the adaptation strategy [77].

In 2021, India committed itself to reach an ambitious net-zero carbon emissions goal by 2070 in the 'U.N.' Climate Change Conference, also known as COP26 [78]. India's Prime Minister at the COP26 in Glasgow proposed strategies for achieving zero carbon emissions, including reducing coal-fired power generation, increasing clean energy capacities like solar, hydro, nuclear, and wind, and energy efficiency [79]. Still, India has not presented a clear plan or established monitoring mechanisms for achieving net-zero emissions. One of the most admirable efforts made by India to reduce carbon emissions is related to measures taken by the country's cement industry.

The Indian cement industry, as the second-largest cement industry despite the existing substantial number of plants with high energy consumption levels, has been implementing the latest technology to control pollution, conserve energy, as well as quality control and online process according to the expert systems and laboratory automation, with dry process manufacture accounting for 99% of installed capacity. Despite some deficiencies in waste heat recovery systems for power generation and decreasing Nitrogen oxides and Sulphur oxides emission technologies, the cement industry in India has taken several initiatives. These include the use of secondary materials in cement production, the increasing use of newer industrial, municipal, and agricultural waste, the expanding use of alternative fuels, consuming fly ash from thermal power plants as well, as the whole amount of granulated blast furnace slag produced by steel factories in the country. All of these measures helped to reduce emissions and preserve the environment [80].

In general, to diminish '$CO_2$' emissions in a meaningful way for India, it has suggested improving energy efficiency technologies and technological transformation in the primary sectors, developing of non-fossil energy sources, and implementing a tax policy that encourages the use of alternative fuels, applying new renewable sources of energy, and moderating the population growth.

To summarize, regional approaches have substantial gaps in countries and pollutants or sources of pollution they attempted to address, as well as insufficient execution and low compliance with existing rules. It is also impossible to adequately address the global consequences of air pollution within the current regional network. Pollutant-based approaches prevent a coordinated response to air pollution and consider many consequences. Air pollution can't be dealt with in a comprehensive manner if pollutants are used as a sole factor in the decision-making process. Even if air pollution can be brought into alignment with other policy areas, such as climate change and health, the lack of global strategic policy oversight makes it difficult [81].

***The fourth approach – Reviewing the other functional solutions to improve the current pollution situation***

Along with some of the States' commitments to reduce 'GHG' emissions and the most effective approaches to achieving net-zero or net negative '$CO_2$' emissions, as well as successful strategies and practical suggestions for reducing "GHG" emissions from the most significant contributor, mentioned above, there are other strategies that enhance health by reducing '$CO_2$'emissions. One of them is using Hydrogen, a flexible energy carrier that can replace fossil fuels, encompassing industry and transportation. There has been a surge in the past five years in interest in Hydrogen, as many firms, nations, and organizations consider Hydrogen essential to meeting the Paris agreement's aim of below 2°C and toward 1.5°C global warmings. Current hydrogen production is mainly by reforming fossil fuels, most often natural gas, without 'GHG' mitigation measures [82]. So, Hydrogen must be generated efficiently and inexpensively. Several approaches have been proposed for generating low-carbon hydrogens, such as combining natural gas with carbon dioxide collection, transportation, and storage (C.C.S.), as well as hydrogen synthesis from renewable energy.

Another way is raising public awareness and education as well as improving international cooperation to improve air quality and climate change goals. The 2015 Paris Agreement, the recent global climate change agreement, has been adopted by several 'U.N.' and 'E.U.' nations. According to this agreement, the parties should advocate initiatives and efforts that will improve many different areas related to this topic. To maximize the chances of achieving the objectives and targets set for climate change and environmental degradation, it is crucial to increase education, training, public awareness, as well as public engagement [83].

To combat anthropogenic air pollution and its health implications, a worldwide preventive approach considering implementing sustainable development techniques and research knowledge is needed. So, efforts to reduce pollution must include worldwide collaboration in research, development, policy, monitoring, and politics. A significant environmental and health protection mechanism has to be designed and proposed by policymakers to align and update air pollution legislation.

Thus, making policies and implementing legislation to limit air pollution as another effective step has been crucial to improving air quality. Air quality legislation in certain Asian nations has resulted in significant public health advantages despite a deterioration of air quality in many Asian countries over the last few decades. As a result of Hong Kong's 1990 sulfur content limit on fuel oil used in power plants and motor vehicles, ambient sulfur dioxide concentrations dropped by 45 percent. Therefore, because of this intervention, yearly death rates for all causes (down 2.1%), respiratory mortality (down 3.9%), and cardiovascular mortality (down 2.0%) all decreased, and women's and men's life expectancy both increased by 20 and 41 days, respectively. In 2001, Japan limited transportation emissions, and due to this legislation could have increased air quality, leading to a 0.6% and 1.1% decrease in pediatric asthma due to PM2.5 and $NO_2$, respectively. In recent years, China has also taken several major steps to decrease air pollution in its major cities [84].

In East Asia, all ten ASEAN member nations have also accepted the 2015 Paris Agreement and demonstrated their commitment to combat climate change. ASEAN has established numerous organizations and institutions to adapt to climate change in the energy, transport, and agriculture sectors. The ASEAN has achieved significant progress through its regional frameworks and organizations with common objectives to combat climate change and lower 'GHG' emissions. Despite measures to reduce emissions, ASEAN nations lag behind other regions regarding environmental performance. They must make more active adaptation and mitigation measures to restrict temperature increase to 1.5 degrees above pre-industrial levels [85].

## CONCLUSIONS

The growth of urbanization and the oppression of natural systems by humans and economic activities have increased the concentration of 'GHG,' causing air pollution and global warming. The destructive effects of increasing 'GHG' include ozone depletion, biodiversity loss, global degradation, depletion of freshwater, disruption of elemental cycles of nitrogen and sulfur, and the release of organic pollutants. Given the adverse effects of these cases on human health and its economic activities, the importance of a worldwide program to reduce 'GHG' emissions is increasingly being raised. From a legal standpoint, the research aimed to identify various approaches that could be used to minimize '$CO_2$' emissions. For this purpose, in this study, international laws on air pollution control caused by carbon dioxide were studied, considering the relationship between air pollution and global warming. Then different approaches, including the international legislation on '$CO_2$' pollution and its effectiveness in protecting the Ozon layer, industries' role in reducing '$CO_2$' emissions, and some of the main emitters' effective efforts to reduce global 'GHG' emissions, review a variety of strategies for lowering global '$CO_2$' contributors worldwide, the states' 'GHG' emission reduction pledges, outlining some of the most effective methods for achieving net-zero and net negative '$CO_2$' emissions, have been examined.

A review of critical international instruments on climate

change reveals that although the commitment to the respect, protection, and realization of the right to a clean, healthy and sustainable environment as a human right imposed on states and considering the obligation to protect, they have committed to reducing 'GHG' emissions, and protecting citizens from the adverse effects of climate change, still there are various international challenges in this area. One of the main challenges in this area is that international law does not address air pollution comprehensively, and the existing legislative and regulatory responses to air pollution are insufficient. For more explanation, it is essential to note that customary international law in the form of international environmental law principles only has a limited impact. States may not all agree on how these principles should be applied to air pollution in their jurisdictions.

According to Art. 11 and 12 of the Vienna Convention, one of the main problems is that States should consent to be bound by a treaty, and there is no obligation to accede to or ratify environmental treaties. Also, the member states can terminate or withdraw from a treaty under its provisions or by the parties' consent [86]. Therefore, in realizing and implementing the treaties' commitments concerning climate change, the intention of the States has played a crucial role.

On the other hand, climate change's litigations because of the wide range of 'GHG' emitters or exact unknown sources of contamination are challenging. So, the international instruments concerning climate change have failed to design a strict and comprehensive environmental degradation legal liability for inducing the actors to make careful natural environmental decisions in their operations and creating a compensation mechanism for environmental degradation's victims in this regard. Environmental injustice, which means the unequal distribution of advantages and harms concerning climate change, is another problem. As mentioned before, the communities that are least responsible for 'GHG' emissions and consequently climate change are the most vulnerable groups to environmental degradation and its consequences. It seems that by recognizing the right to a healthy environment as a human right by the 'U.N.' Human Rights Council, setting up an International Court on the Environment to examine the fairness of global emission reduction targets might be beneficial, particularly in balancing relative roles and responsibilities for global warming, taking practical steps to address it. Altogether, decreasing global '$CO_2$ ' emissions requires all States' cooperation and technical assistance together, and achieving net-zero emissions would be more complex and prohibitive without cooperation, technical and financial aid. Furthermore, the roadmaps for reducing carbon dioxide by 2050 in different countries were evaluated. Firstly, it has shown that the States' commitments to reduce the 'GHG' emissions according to their proposed roadmaps, including the reduction of 'GHGs' by 80% below 2005 levels by 2050 by the 'U.S.,' 60–65% of 2005 levels by 2030 by China, 40% below 1990 levels by 2030 by the 'EU,' and 33- 35% lower than 2005 levels by 2030 by India.

Secondly, after examining their near-term and long-term strategies and pointing out the shortcomings in each, it has tried to refer to each country's achievements in decreasing 'GHG' emissions. For instance, increasing energy efficiency, developing strategies for the transition to alternative fuels, utilization of electric vehicles, adjusting some regulations in the transportation sector and expanding the use of renewable energy sources in Europe; implementing the latest technologies, consuming fly ash from thermal power plants, using alternative fuels, and the secondary materials in cement production in India; intensity reduction of direct carbon emissions from 'PFC.s,' as well as the amount of '$CO_2$' emissions from carbon anode consumption in the aluminum production process, implementing the Capped Allowance Systems in the Chemicals sector by the 'U.S.,' enacting some policies regarding the carbon emission's reduction in a variety of international and domestic economic contexts in manufacturing sectors, enhancing research and development efficiency in the oil and coking industries, and applying technology and alternative materials with improving energy efficiency, and management in the construction and building sector by China; were the most significant measures to reduce 'GHG' emissions by the world's major emitters. Based on the experiences of the most critical 'GHG' emitters such as the 'U.S.,' China, the

'E.U.,' and India, practical suggestions for reducing 'GHG' can be expressed as follows: Determining short-term and long-term strategies to reduce 'GHG' emissions (having a comprehensive plan); Increasing energy efficiency and investing in clean energy, reducing '$CO_2$' emissions in various sectors such as transportation and industrial sectors, as well as decarbonization in the electrical and power industries; Applying new technologies to reduce '$CO_2$' emissions such as carbon capture and storage technology, the use of non-fossil or alternative fuels to use electricity; considering the public participation in reducing 'GHG' emissions as it has mentioned before in the international area, and various factors affecting '$CO_2$' emissions such as globalization, urbanization, etc.; Investing in vulnerable sectors; and at the end, paying attention to the role of different sectors in reducing '$CO_2$' emissions such as energy, transport, agriculture, industry, and the construction sector.

By investigating the evolution of world legislation regarding controlling '$CO_2$'pollution and their practical global actions in Ozone layer protection, the role of industries in reducing '$CO_2$'emissions and their effective efforts in this area, and reviewing the various roadmaps to reducing the '$CO_2$'footprints and the practical solutions to improve the current air pollution situation by multiple countries around the world, as well as the international cooperation in this regard it concluded that, although there is a lack of a comprehensive approach to air pollution under international law and the States unwillingness to its development, but in practice, the states by proposing roadmaps to reducing '$CO_2$' prioritization air pollution in their domestic policies and development of international cooperation in this regard has shown that non-treaty-based collaboration is likely to take the shape of soft law.

One of the limitations of this study was the high diversity of legislations, proposed roadmaps to reduce '$CO_2$' emissions, and policies adopted by different countries worldwide, which was not possible to examine and analyze all instruments and approaches regarding air pollution and their effective steps to decrease it and combat climate change. So, the focus of this review paper was on some of the most effective strategies for net-zero and net negative '$CO_2$' emissions by the main emitters states in the world, along with examining the strengths and weaknesses of existing international instruments regarding air pollution. Further research could determine the study on the practical methods to reduce '$CO_2$' emissions in industries and their impact on human health.

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### *Conflict of interest*

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence this paper.

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