Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/9hj1zx18

THE DYNAMICS OF GLOBAL WARMING: ANALYSIS OF CAUSES, IMPACTS, AND INTERNATIONAL MEASURES

Syeda Lubna[1], Dr. Nosheen Qayyum[2], Naila Rafique[3*], Dr. Tahir Hamid Ullah[4], Amina Iqbal [5], Arifa Naheed Rana[6,] Maria Ashraf[7,]

[1]Lecturer Law Rawalpindi Law College, PK, lubnasajid7@gmail.com
[2]Assistant Professor Law, Capital University of Science & Technology (CUST), Islamabad, nosheen.qayyum@cust.edu.pk
[3*]Assistant Professor Law, Capital University of Science & Technology (CUST), Islamabad, naila.rafique@cust.edu.pk
[4]Professor Law, Capital University of Science & Technology (CUST), Islamabad, PK, tahir@cust.edu.pk
[5]Lecturer Law, Capital University of Science & Technology (CUST), amina.iqbal@cust.edu.pk
[6]Senior Lecturer Law, Capital University of Science & Technology (CUST), Islamabad, PK, arifa.naheed@cust.edu.pk
[7]Lecturer Political Science, Rawalpindi Law College, PK, Mariah_abbasi@yahoo.com

***Corresponding Author:** Naila Rafique
*Assistant Professor, Capital University of Science & Technology (CUST), Islamabad, PK
naila.rafique@cust.edu.pk

ABSTRACT:
Global warming is not solely a scientific issue but it also extends to various domains including, geopolitics, economics, local politics, sociology and individual lifestyles. The primary driver of global warming is carbon dioxide emissions, primarily resulting from the combustion of fossil fuels. Human activities significantly exacerbate the problem. Among the key international efforts to address global warming is the Kyoto Protocol, an international treaty established in Kyoto, Japan, which imposes obligations on industrialised nations to reduce greenhouse gas emissions. Additionally, the intergovernmental Panel on climate change (IPCC) represents a crucial and effective initiative in combating global warming.

KEY WORDS: global, economics, Kyoto Protocol, green house, climate, carbon dioxide.

Introduction:

The problem of global warming is not merely a scientific issue; it also encompasses various areas such as, geopolitics, economics, local politics, sociology and individual life styles. Addressing global warming cannot be accomplished on an individual level; rather, it requires global cooperation to mitigate its effects. The term “global warming” refers to an increase in the Earth’s average temperature, with major contributors including carbon dioxide emissions from fossil fuels combustion, deforestation, human activities and the release of other greenhouse gases such as methane, nitrous oxide and chlorofluorocarbons.

Human activities significantly exacerbate the issue of global warming, primarily through the use of fossil-fuel-based products. However, there are also non-anthropogenic, or 'natural,' causes that

contribute to global warming. These include volcanic eruptions, natural forest fires, and the melting of permafrost, which are not directly attributable to human actions.

The consequences of global warming are becoming increasingly evident, manifesting as rising sea levels, floods, and droughts. These effects will have significant repercussions on various sectors, including the economy, agriculture, and individual livelihoods. Therefore, it is crucial to address global warming to safeguard future generations, a goal that can only be achieved through international cooperation, given its global nature.

International efforts have been made to mitigate global warming, with notable initiatives including the Kyoto Protocol, the Intergovernmental Panel on Climate Change (IPCC), and the United Nations Framework Convention on Climate Change (UNFCCC). A brief analysis of the Kyoto Protocol will be provided to illustrate its mechanisms and effectiveness.

Among the most significant international efforts to address global warming is the Kyoto Protocol. This international treaty, finalized in Kyoto, Japan, was designed to impose specific obligations on industrialized nations to reduce greenhouse gas emissions. The Kyoto Protocol establishes three mechanisms for achieving these reductions: emissions trading, the Clean Development Mechanism (CDM), and Joint Implementation (JI). While most developed countries have ratified the agreement, notable exceptions include the United States and Australia, both of which are major greenhouse gas emitters.

The Intergovernmental Panel on Climate Change (IPCC) represents a crucial and effective initiative in addressing global warming. The IPCC's role is to provide comprehensive information on the scientific, technological, and socio-economic aspects of climate change to governments worldwide. It produces a series of assessment reports, including the First, Second, and Third Assessment Reports, aimed at evaluating the current state of climate change. The IPCC is recognized by the United Nations Environment Programme (UNEP) for its significant contributions.

Another key international treaty in the fight against global warming is the United Nations Framework Convention on Climate Change (UNFCCC). This treaty was established to stabilize greenhouse gas emissions in the atmosphere and mitigate their impacts. The UNFCCC establishes two core principles of environmental law: "common but differentiated responsibilities" and the "polluter pays principle." The principle of common but differentiated responsibilities emphasizes that, although all states have a shared duty to reduce greenhouse gas emissions, industrialized and developed nations hold a greater obligation compared to developing countries. The polluter pays principle mandates that the nations or states causing the most pollution are responsible for compensating and rectifying the environmental damage they have inflicted.

The United Nations (UN) plays a crucial role in addressing global warming through various programs aimed at combating and reducing the issue. These include organizations such as the United Nations Development Programme (UNDP), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Environment Programme (UNEP), and the World Health Organization (WHO).

Defining Global Warming:

The term "global warming" denotes the increase in Earth's temperature attributed to elevated levels of greenhouse gases. Research has established that this phenomenon is largely driven by human activities. The combustion of fossil fuels releases greenhouse gases like carbon dioxide into the atmosphere, where they trap solar heat and contribute to rising global temperatures. This warming trend has the potential to impact sea levels, crop yields, and precipitation patterns, and may also intensify and increase the frequency of natural disasters such as tornadoes, hurricanes, floods, and droughts.

Greenhouse Gases:

Greenhouse gases are compounds in the Earth's atmosphere that trap heat by absorbing and emitting infrared radiation. This process, known as the greenhouse effect, helps regulate the planet's temperature by preventing heat from escaping into space. Key greenhouse gases include:

- **Carbon Dioxide (CO2):** Produced by burning fossil fuels, deforestation, and various industrial processes.

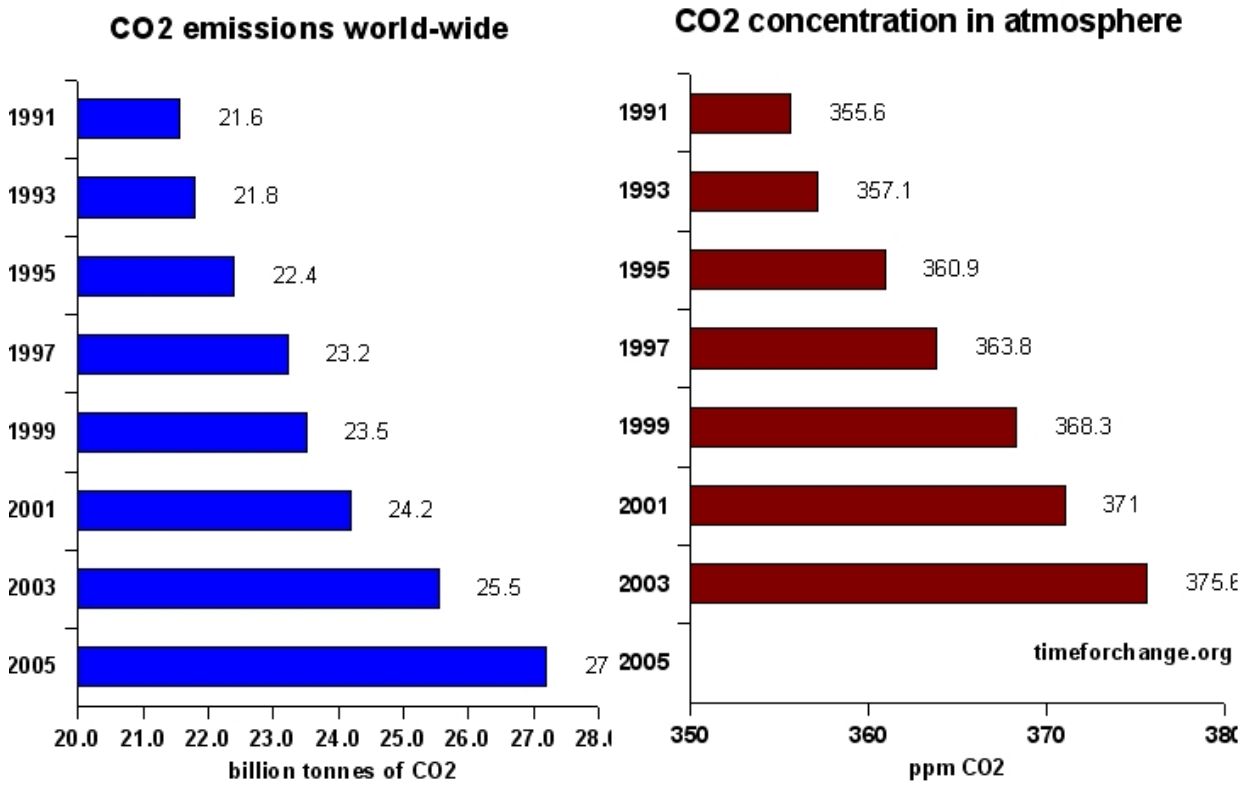

Figure 1 Carbon dioxide emission and concentration in atomsphere

Figure 1

Methane (CH4): It is emitted during the production and transport of coal, oil, and natural gas, as well as from livestock and other agricultural practices.

Chlorofluorocarbons (CFCs) and Hydrofluorocarbons (HFCs): Synthetic compounds used in refrigeration and air conditioning, with a high global warming potential.

Nitrous Oxide (N2O):

Released from agricultural and industrial activities, as well as during the combustion of fossil fuels. These gases contribute to global warming and climate change by enhancing the natural greenhouse effect, leading to a rise in average global temperatures.

Global Warming Triggers: Anthropogenic and Environmental

Carbon dioxide (CO2) is a major contributor to global warming, surpassing the impact of other greenhouse gases such as methane, nitrous oxide, and chlorofluorocarbons (CFCs), as well as the combustion of fossil fuels like coal and oil. While these man-made factors are significant drivers of global warming, it is also essential to recognize the existence of "natural" causes for which humans are not directly responsible. Many people view global warming primarily as a result of human-induced pollution and the increase in greenhouse gases. This perspective may stem from a lack of awareness regarding the natural causes of global warming, which include:

Volcanic Eruptive Phenomena

Volcanic eruptions or explosions are the natural causes of global warming for which humans are not directly accountable. These eruptions release substantial quantities of
carbon dioxide (CO_2) and methane into the atmosphere.

Forest Wildfires
When addressing global warming and climate change, it is crucial to consider forest fires. Forests function as "carbon sinks," absorbing significant amounts of carbon dioxide (CO_2) and releasing oxygen through photosynthesis. Thus, a greater forest cover would help reduce atmospheric CO_2 levels.

Peat Decomposition and Methane Emissions:
Another natural cause of global warming involves regions such as Indonesia and Siberia. These areas contain substantial deposits of peat, which consists of decomposed plant material and is considered an early stage in coal formation. When peat decomposes or is disturbed, it releases large quantities of methane gas into the atmosphere. Methane is a potent greenhouse gas, approximately 20 times more effective at trapping heat than CO_2.

Permafrost Warming
In the polar regions, both the Arctic and Antarctic, permafrost is melting on a large scale, which significantly exacerbates global warming. Factors such as fluctuations in solar activity, volcanic eruptions, and natural forest fires can disrupt natural carbon storage systems and contribute to the extensive thawing of permafrost. This melting leads to the substantial release of greenhouse gases into the atmosphere.

"What Potential Impacts Could Global Warming Have in the Future?"
If global warming is not addressed seriously on a worldwide scale, the following impacts are likely to emerge:

1) Coastline
2) Storms and floods
3) El Nino-Southern oscillation
4) Health
5) Biodiversity
6) Agriculture

Coastline:
According to the IPCC, the sea level could rise by 20 to 80 cm over the next century due to the ongoing increase in fossil fuel consumption. This rise will exacerbate the instability of cliffs and beaches and reduce the effectiveness of coastal defenses against storms and floods, posing a significant threat to all coastal regions. In response, developed countries such as Britain and the USA are taking measures including raising the height of sea walls around coastal properties and halting the reclamation of poor-quality agricultural land from the sea.

Storms and Floods:
From 1951 to 1999, storms and floods, which are major natural hazards, caused 58% of economic losses, 76% of global insured losses, and 52% of fatalities from natural disasters. It is crucial to consider future possibilities, as historical records indicate that rapid climate changes could lead to an increase in storm frequency and more erratic weather patterns.

El Nino-Southern Oscillation:

The periodic shifts in the direction and intensity of ocean currents and winds in the Pacific Ocean are crucial elements in global climate patterns. Known as El Niño, or more broadly as ENSO (El Niño-Southern Oscillation), this phenomenon typically occurs around Christmas and happens every three to seven years. The 1997-1998 El Niño event was particularly intense, leading to severe droughts in regions such as southern USA, Australia, East Africa, northeast Brazil, and northern India. ENSO significantly affects global weather by altering monsoon patterns, storm trajectories, and contributing to drought conditions around the world.

Health:
Global warming will have mixed effects on human health, including an increase in mortality rates due to rising global temperatures.

Biodiversity:
Due to global warming caused by climate change, the species at threat as reported by the IPC are as follows:-

a. Amphibians
b. Forest birds of Tanzania,
c. The Bengal tiger
d. The mountain gorilla etc

These species are at risk because they are adapted to specific geographical locations and are unable to cope with the changes brought about by climate change.

Agriculture:
Another significant concern arising from global warming and climate change is its impact on agriculture, both globally and regionally.

Global Warming and Climate Change:
The climate system is intricate, and forecasting the effects of global warming challenges the boundaries of scientific knowledge. Nevertheless, numerous aspects remain unresolved. Scientific uncertainty is an inherent and evolving part of the global warming discourse. Global warming and climate change denote the rise in average global temperatures, influenced by both natural phenomena and human activities. A significant driver of this warming is the increase in greenhouse gases such as Carbon Dioxide (CO2). A warming planet indicates a shift in climate that can alter weather patterns in multiple ways.

Distinction Between 'Global Warming' and 'Climate Change'
The term "global warming" is commonly used by the media and the general public, while scientists typically refer to "global climate change." Climate change encompasses any variations in climate resulting from various factors, such as deforestation or increased greenhouse gas concentrations. Global warming is a specific aspect of climate change, referring to the rise in Earth's surface temperatures. According to NASA, the term "global warming" became widely used following a 1975 paper by geochemist Wallace Broecker, titled *Climatic Change: Are We on the Brink of a Pronounced Global Warming?*

Human Contributions to Rising Carbon Dioxide Levels
Human activities are responsible for a significant rise in atmospheric carbon dioxide, contributing to a 30% increase. This substantial growth is closely linked to the increased burning of fossil fuels and other related activities, for which humans are accountable.

Global Endeavors to Curb Global Warming

Global Endeavors to Curb Global Warming refer to the collective international efforts aimed at reducing greenhouse gas emissions and mitigating the effects of climate change. These initiatives have been briefly discussed below:

United Nations Framework convention on climate change:

The Framework Convention on Climate Change (FCCC) represents the international community's response to the challenge of global warming, which is driven by increasing concentrations of greenhouse gases in the Earth's atmosphere. Signed by 155 countries at the United Nations Conference on Environment and Development in June 1992, the treaty emerged after four years of rigorous scientific evaluation and political negotiation. It provides a foundational framework for addressing global warming but defers specific implementation details to subsequent treaties or protocols.

While the Convention's language is intentionally broad and sometimes vague to avoid political disagreements, its primary goal is clear: to "stabilize greenhouse gas concentrations... at a level that would prevent dangerous anthropogenic interference with the climate system" within a timeframe that allows ecosystems to adapt naturally, ensures food production is not threatened, and supports sustainable economic growth.

The treaty places the primary responsibility for addressing global warming on the developed countries of the North. This reflects the fact that these countries have historically been the major contributors to greenhouse gas emissions and possess the resources to take action. However, the Convention does not fully endorse the "polluter pays" principle. For developing countries to contribute effectively, they will need additional financial and technological support.

UNFCCC Commitments:

Although the Framework Convention emphasizes the responsibilities of developed nations in addressing global warming, developing countries also have a significant list of obligations. They are required to develop and submit national plans that include actions to mitigate climate change by addressing greenhouse gas emissions and enhancing greenhouse gas removal from the atmosphere. This involves maintaining national inventories of emissions from sources and removals by sinks.

In addition to these obligations, developing countries must:

- Collaborate in the development, application, and dissemination of technologies that control, reduce, or eliminate greenhouse gas emissions.
- Promote the sustainable management of carbon sinks and reservoirs, such as forests and oceans.
- Work together on adaptation strategies to address the impacts of climate change, including integrated plans for coastal and air management, water resources, and agriculture, as well as the protection and restoration of areas affected by scarcity and desertification.
- Conduct environmental impact assessments of strategies and projects that may affect climate change.
- Support and participate in research, methodology development, and efficient monitoring to reduce uncertainties about the causes, effects, extent, and timing of climate change.
- Facilitate and engage in the open exchange of relevant information.
- Promote and participate in education, training, and public awareness efforts.
- Report to the Conference of the Parties on implementation progress.

Globally, there is consensus on the need to address global warming and climate change. The initial challenge was to establish a framework for action. In 1988, the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) established the Intergovernmental Panel on Climate Change (IPCC) to assess the scientific and technical knowledge on global warming. By 1990, the IPCC confirmed broad international agreement on the human-induced nature of climate change. The IPCC, composed of a group of scientists, meets periodically to review the latest scientific findings and produce reports summarizing the state of knowledge on global warming. Each report reflects a consensus among hundreds of leading scientists.

Kyoto Protocol: An Overview

The Kyoto Protocol is an international treaty negotiated in December 1997 in Kyoto, Japan. It stipulated that the Protocol would not take effect until it had been ratified by at least fifty-five countries. Additionally, these ratifying countries needed to account for at least fifty-five percent of the world's total carbon dioxide emissions from 1990.

The Kyoto Protocol came into force on February 16, 2005, after meeting two key conditions:

1. Iceland became the fifty-fifth country to ratify the Kyoto Protocol on May 23, 2002, fulfilling the first condition.
2. Russia's consent to the agreement met the second condition, enabling the international treaty to take effect.

Countries that signed the Kyoto Protocol committed to reducing emissions of six greenhouse gases that contribute to global warming: carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs). The Protocol aimed to reduce global greenhouse gas emissions by 5.2% below 1990 levels during the period from 2008 to 2012.

The Kyoto Protocol set specific emissions reduction targets for industrialized nations while excluding developing countries. To achieve these targets, most ratifying countries would need to employ various strategies, such as:

- Implementing restrictions on their major polluters
- Managing transportation to reduce emissions from automobiles
- Enhancing the use of renewable energy sources, such as solar power, wind power, and biodiesel, instead of fossil fuels

Additionally, the Kyoto Protocol introduced three mechanisms to help stabilize or reduce greenhouse gas emissions:

a. Clean Development Mechanism (CDM):

Through this mechanism, developing countries can implement emission reduction projects and earn Certified Emission Reductions (CERs), also known as carbon credits. These projects enable developing nations to benefit from investments and technology transfers. The Clean Development Mechanism (CDM) promotes both emission reduction and sustainable development by offering industrialized countries flexibility in meeting their emission reduction targets.

b. Emission Trading

Article 17 of the Kyoto Protocol allows parties to trade their surplus credits through a process known as the "carbon market."

c. Joint Implemenetation (JI):

Article 6 of the Kyoto Protocol offers a flexible, transparent, and cost-effective method for parties to meet their carbon emission reduction targets. This approach allows for investments and technology transfers, which in turn benefit the host country of the project.

Aims of Kyoto Protocol:

The primary objective of the Kyoto Protocol is to promote sustainable development by enhancing energy efficiency, supporting sustainable agriculture and forest management, and encouraging technological innovation for greenhouse gas reduction (Article 2, Kyoto Protocol). According to Article 2, Annex I countries are required to participate in greenhouse gas reduction efforts not covered by the Montreal Protocol.

Article 3 of the Protocol sets a target for reducing greenhouse gas emissions to at least 5% below 1990 levels, with the year 1990 serving as the reference point. The reduction period is established from 2008 to 2012. Achieving these greenhouse gas goals can be accomplished either through improved emission reduction technologies or by creating carbon sinks to absorb environmental waste.

Article 6 of the Kyoto Protocol introduces Joint Implementation, which allows industrialized countries to collaborate on emission reduction projects to earn Emission Reduction Units (ERUs). Unlike the CDM, Joint Implementation projects occur in countries that need to reduce emissions.

Under Article 12 of the Protocol, the Clean Development Mechanism (CDM) allows industrialized countries, including the United States, to invest in projects that reduce emissions in developing countries as an alternative to more costly reductions at home. Countries implementing CDM projects receive Certified Emission Reduction (CER) credits, which can be sold or used to meet their emission reduction targets. While the CDM aims to stimulate sustainable development and emission reductions, it has been criticized for not producing additional reductions in greenhouse gases beyond what would have occurred without it (UNFCCC, 2009).

Article 17 of the Kyoto Protocol states that "countries with Assigned Amount Units (AAUs) that are not used may sell their AAUs to countries that have exceeded their limits." This provision essentially turns greenhouse gas emissions into a tradable commodity. There is debate over whether emission trading effectively addresses overall pollution issues, as it may merely allow developed countries to meet their targets by purchasing AAUs rather than reducing emissions domestically.

Most industrialized countries support the Kyoto Protocol, with the notable exceptions of the United States and Australia, both of which are among the largest emitters of greenhouse gases and collectively account for over 25% of global human-generated emissions.

According to the UNFCCC, industrialized nations were required to "stabilize their greenhouse gas emissions at 1990 levels by the year 2000" (UNFCCC, 2009). The Kyoto Protocol extended this requirement, mandating that these nations "reduce their greenhouse gas emissions from 1990 levels by an average of 5 percent over the period 2008 to 2012" (EUROPA, 2002). However, not all countries were obligated to make cuts; some, such as New Zealand, the Russian Federation, and Ukraine, were allowed to maintain their existing emission levels, while Iceland, Norway, and Australia were permitted to increase theirs (EUROPA, 2002).

These flexible mechanisms, along with carbon sinks, have faced criticism from environmentalists who argue that they may delay necessary changes in the energy and transportation systems of wealthy industrialized countries. Critics contend that the focus on financial mechanisms rather than direct environmental impacts may undermine the effectiveness of the Protocol (Air Pollution & Climate Secretariat, 2003).

The success of the Kyoto Protocol has been questioned, particularly because the United States and Australia, the largest emitter of greenhouse gases, did not ratify it. The lack of ratification by major greenhouse gas emitters like the United States and Australia substantially undermined the Protocol’s goals, illustrating the difficulties in meeting its ambitious targets. This absence highlighted a crucial shortfall in the Protocol’s ability to address global emissions comprehensively. The Protocol faced challenges not only in reducing global warming but also in fostering the development of additional policies and strategies needed to combat climate change and adapt to its inevitable impacts.

What is Emission Trading System (ETS) and How Does It Work?

The emission-trading scheme (ETS) has established by the European Union for providing an efficient support to meet the targets of the Kyoto protocol. Its provisions include the flexible mechanisms of the Kyoto protocol such as clean development mechanism (CDM), Emission trading and joint implementation (JI).

Emission trading scheme is strongly interrelated with flexible mechanisms of the Kyoto protocol and its emissions cap.

Functions of ETS:

The European Union committed to reducing its greenhouse gas emissions to 8% below 1990 levels. This target is divided among the original 15 EU member states (EU-15) through a system known as "burden sharing." Specific reduction targets vary: for example, Germany and Denmark face reductions of up to 21% below 1990 levels, while Portugal has an allowable increase of 27%. The 10 new member states that joined the EU in May 2004 have their own individual Kyoto targets.

To achieve these goals, EU member states have implemented two main types of policies. Each state is responsible for its emissions reduction strategies, tailored to national requirements, except for

energy-intensive installations, which fall under the EU Emissions Trading System (ETS). Member state governments must make three key decisions:

1. **Assess Emissions Reductions**: Governments need to determine the total emissions reductions required to meet Kyoto targets and decide how many credits (from Joint Implementation (JI) and Clean Development Mechanism (CDM)) they plan to acquire through the flexible mechanisms of the Kyoto Protocol domestically.
2. **Set Sectoral Targets**: Governments must establish emissions targets for other sectors, particularly for energy-intensive installations.
3. **Allocate Emissions Rights**: Since the ETS allocates emissions rights primarily based on historical emissions (grandfathering), national governments are responsible for distributing these rights among approximately 12,000 installations.

The ETS has operated in two trading periods: the first from 2005 to 2007, which set initial emissions limits to meet 2012 targets, and the second from 2008 to 2012, aligning with the EU's burden-sharing agreement. During these periods, EU countries were required to adhere to their emissions caps, with the option to convert CDM credits, Certified Emission Reductions (CERs), and JI credits into allowances within the ETS.

While the ETS is considered an effective tool for emission reduction, it covers only about half of the EU's greenhouse gas emissions. The remaining emissions must be controlled through other measures. A significant issue is that national governments have allocated numerous allowances to the ETS sector, resulting in a greater reduction burden on non-ETS sectors.

Intergovernmental Panel on Climate Change (IPCC):

The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) to address the potential impacts of global warming. In December 1990, the UN General Assembly created the Intergovernmental Negotiating Committee (INC) to draft a treaty for the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in June 1992.

The primary objective of the IPCC is to evaluate various aspects of climate change, including its scientific, environmental, and socio-economic effects, and to develop response strategies. The IPCC is regarded as the most authoritative and effective scientific and technical body on climate change. Its assessments significantly influence the negotiations of the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol.

The IPCC's success can be attributed to several factors:

- The IPCC reports are relevant to policy but do not prescribe specific policies.
- Emphasis is placed on scientific reliability, transparency, objectivity, and fairness.
- The reports undergo a rigorous review process involving numerous experts worldwide and are open to scrutiny by all member governments.
- The IPCC's success is also due to the collaboration of thousands of experts globally who contribute to the preparation of its reports each year.

CONCLUSION

Addressing the issue of global warming cannot be accomplished on an individual basis; it requires global cooperation. Human activities significantly contribute to global warming, primarily through the use of fossil fuels. However, there are also natural causes, such as volcanic eruptions, natural forest fires, and melting permafrost, which are not directly attributable to human actions.

To safeguard future generations, it is crucial to tackle global warming through international collaboration, as it is a collective and universal issue. Among the key international efforts to combat global warming is the Kyoto Protocol, which represents a significant milestone in this regard. The Intergovernmental Panel on Climate Change (IPCC) also plays a vital role in addressing global warming.

The United Nations Framework Convention on Climate Change (UNFCCC) introduces two fundamental principles of environmental law: "common but differentiated responsibilities." This

means that while all states share a common responsibility to reduce greenhouse gas emissions, industrialized or developed nations bear a greater responsibility compared to developing countries. Collectively, these treaties and initiatives are essential in the global effort to combat global warming.

REFRENCES

1. Ackerman, K. V., and E. T. Sundquist. 2008. Comparison of two U.S. power-plant carbon dioxide emissions data sets. Environmental Science & Technology 42(15):5688-5693.
2. Adams, P. N., and D. L. Inman. 2009. Climate Change and Potential Hotspots of Coastal Erosion Along the Southern California Coast—Final Report. CEC-500-2009-022-F, Sacramento, California Energy Commission.
3. Adger, W. N., J. Paavola, S. Huq, and M. J. Mace, eds. 2006. Fairness in Adaptation to Climate Change. Cambridge, MA: MIT Press.
4. Adger, W. N., S. Agrawala, M. M. Q. Mirza, C. Conde, K. L. O'Brien, J. Pulhin, R. Pulwarty, B. Smit, and K. Takahashi. 2007. Assessment of adaptation practices, options, constraints and capacity. In Climate Change 2007: Impacts, Adaptation and Vulnerability: Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. M. L. Parry, O. F. Canziani, J. P. Palutikof, C. E. Hanson, and P. J. Van Der Linden, eds. Cambridge:M. L. Parry, O. F. Canziani, J. P. Palutikof, C. E. Hanson, and P. J. Van Der Linden, eds. Cambridge:Cambridge: Cambridge University Press.
5. Adger, W. N., I. Lorenzoni, and K. O'Brien. 2009a. Adaptation now. In Adapting to Climate Change: Thresholds, Values, Governance. W. N. Adger, I. Lorenzoni, and K. L. O'Brien, eds. Cambridge: Cambridge University Press.
6. Adger, W. N., S. Dessai, M. Goulden, M. Hulme, I. Lorenzoni, D. R. Nelson, L. O. Naess, J. Wolf, and A. Wreford. 2009b. Are there social limits to adaptation to climate change? Climatic Change 93(3-4):335-354.
7. Adler, M. D., and E. A. Posner. 2006. New Foundations of Cost-Benefit Analysis. Cambridge, MA: Harvard University Press. Agrawala, S. 2004. Adaptation, development assistance and planning: Challenges and opportunities. IDS Bulletin—Institute of Development Studies 35:50-54.
8. Agrawal, A. 2008. The role of local institutions in adaptation to climate change. In Social Dimensions of Climate Change Workshop. Washington, DC: Social Development Department, The World Bank.
9. Agrawal, A., and N. Perrin. 2008. Climate Adaptation, Local Institutions, and Rural Livelihoods. Ann Arbor, MI: International Forestry Resources and Institutions Program, University of Michigan.
10. AGU (American Geophysical Union). 2009. Geoengineering the Climate System. A Position Statement of the American Geophysical Union (adopted by the AGU Council on December 13, 2009). Washington, DC: AGU.
11. Airame, S., J. E. Dugan, K. D. Lafferty, H. Leslie, D. A. Mcardle, and R. R. Warner. 2003. Applying ecological criteria to marine reserve design: A case study from the California Channel Islands. Ecological Applications 13 (1):S170-S184.
12. National Academies of Sciences, Engineering, and Medicine. 2010. Advancing the Science of Climate Change. Washington, DC: The National Academies Press. https://doi.org/10.17226/12782.
13. American Association for the Advancement of Science. (2007). Atlas of Science Literacy, Volumes 1 and 2. Project 2061. Washington, DC: Author.
14. Ardoin, N.M., Falk, J., Heimlich, J.E., and Foutz, S. (2009). Behavior-change theories and free-choice environmental learning. In J.H. Falk (Ed.), Free-Choice Learning and the Environment (Ch. 4, pp. 57-76). Lanham, MD: AltaMira Press.
15. Bostrom, A., Morgan, M.G., Fischhoff, B., and Read, D. (1994). What do people know about global climate change? 1. Mental models. Risk Analysis, 14(6), 959-970.

16. Boyes, E., and Stanisstreet, M. (1993). The greenhouse effect: Children's perceptions of causes, consequences, and cures. International Journal of Science Education, 15, 531-552.
17. Boyes, E., and Stanisstreet, M. (1997). Children's models of understanding of two major global environmental issues (ozone layer and greenhouse effect). Research in Science and Technological Education, 15(1), 19-28.
18. Boyes, E., and Stanisstreet, M. (2001). Plus ca change, plus c'est la meme chose? School students' ideas about the "greenhouse effect" a decade on. Canadian Journal of Environmental Education, 6, 77-101.
19. California Academy of Sciences. (2008). "Altered State" Exhibit Addresses Climate Change in California and Around the World: An Ongoing Exhibit. San Francisco.
20. Chabot Space and Science Center. (2010). Bill Nye's Climate Lab Exhibit. Oakland, CA.
21. Coyle, K. (2005). Environmental Literacy in America: What Ten Years of NEETF/Roper Research and Related Studies Says About Environmental Literacy in the U.S. Washington, DC: National Environmental Education and Training Foundation.
22. Coyle, K. (2010). Training, Educating and Activating U.S. Hunters and Anglers and Other Constituencies on Climate Change. Reston, VA: Education and Training National Wildlife Federation.National Academies of Sciences, Engineering, and Medicine. 2011.
23. Climate Change Education: Goals, Audiences, and Strategies: A Workshop Summary. Washington, DC: The National Academies Press. https://doi.org/10.17226/13224.