DOI: https://doi.org/10.36094/sc.v89.2024.Global_Warming_Due_to_Generation.Ganguly_Gupta.107

ARTICLE

Sci. and Cult. 90 (3–4) : 107-113 (2024)

GLOBAL WARMING DUE TO GENERATION OF GREENHOUSE GASES PRODUCING OZONE HOLES: ROLE OF EARTH SCIENTISTS AND ECONOMISTS IN SOLVING THE DETRIMENTAL EFFECT OF CLIMATE CHANGE

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Since 1860, systematic rise of heat on the earth's surface and depletion of O_3 in ozone layer in the Earth's stratosphere by 4 %, has caused emissions of greenhouse gases such as CO_2,CO, CH_4, NO_2, along with chloro-fluoro carbons since the industrial revolution in developed nations. Increase in cattle and human population, together with deforestation, urbanization, and use offossil fuels for vehicles, etc., has had catastrophic effect on climate change.El Nino, a climatic phenomenon that originates in the tropical pacific regions leads to upwelling of warm ocean waterin the central and eastern pacific region up to, Indonesia and beyond which causes drastic changes in the weather patterns for several years. This has caused terrestrial storms in Bangladesh and Sri Lanka (such as Bhola) causing destruction of a lot of properties. The cause of El Nino generation has to be determined carefully, by the weather scientists so that they can learn to control the emission of greenhouse gases and the climate change. The role of environtal scientist and economists have also been discussed elaborately.

Introduction

Increase in the average Earth's surface temperature[1,8] over the last140 years has been 0.6, as it has been summarized in (Fig. 1, schematic)

Observations have been available from many satellites orbiting around the earthsince last 39 years from 1979. The excellent advantage of the use of satellites is that they provide data with global coverageextensively, which helps to understand climatic changes. It is never the less expected that the lower atmospheric measurements and the occurrence of Ozone hole should be related and careful study has to be carried out in keepingthe two recordsin interpreting the difference.

Since 1979 meteorological satellites sent by the National oceanic and Atmospheric Administration of the U.S., carried out by attaching microwave sounding instrumentsalong with thousands of balloons (Fig.2) for the remote observation of the average temperature of the lower part of the atmosphere. Time series of observation of global average temperature in !, relative to average from 1979 to 90 (a) has also been carefully done.

Fig.3a summarizes the time series of observations of global average temperature (relative toaverage for1979-90 for the lower temperatures, based on measurements withballoons and satellites in the troposphere, whereas Fig 3b shows the time series temperature observations for the lower stratosphere with respect to 1979-90.

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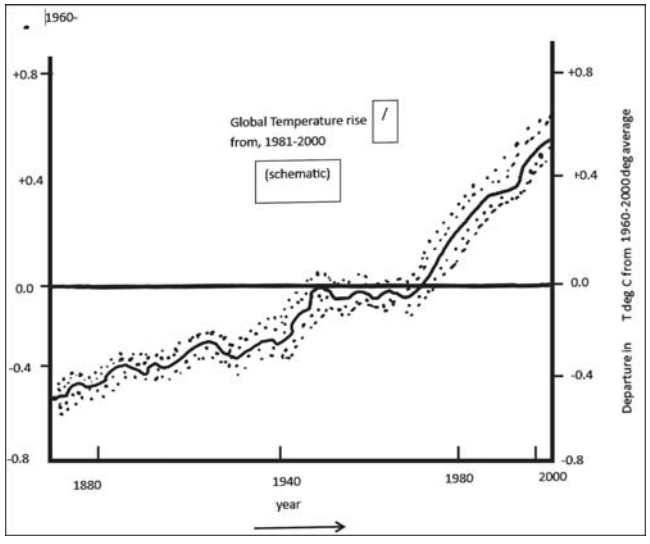

Fig. 1. The dark bars are the yearly averaged values, the grey line is a smoothed annual curve to show that decadal variations. Uncertainties in the data are also shown. The graph is drawn on the basis of original publications (Gail Herman, 2018, also see anthropogenic treatment in global temperature rise, Lean and Rind, 2008, with permission)

Some of the recent regional patterns of temperature changes are reflected in different phases of ocean-atmosphere oscillations. An increase in temperature during the last few decades has shown that, in the daily cycle of temperature minima over land have increased about twice as much as maximum temperatures.

This rise of temperature has resulted in the increase of cloud covers obstructing day time sunshine, which ultimately leads to increase in average precipitation. This together with excessive use of cars by developed nations has resulted in the increase in the emission of greenhouse gases during this period.

Quite a bit of cooling of the lower stratosphere at altitudes between 10 and 30 km has been observed during the last twenty years. This is because of decrease in the concentration of zones (which absorbs sun's radiation and because increased CO2 concentration[6] leading to increased cooling at these levels.A source of information related to climate changes comes from the determination of sea level change. The sea level during the last 100 years has risen between 10 and 20 cm because of rise of the oceanic temperature. The general feeling among environmental scientists is related to anthropogenic climate change together with natural variation in temperatures.

It has been determined from the global average temperature, that is about half that in the polar regions. It has also been shown that the current CO_2 concentration has risen during the 21st century under various projections of the growth.

A great deal of information source is stored in the ice that caps Greenland and Antarctic continents[2]. These ice caps are several thousands of meters thick. The ice at the top of the layer must have been deposited very recently but the ice near the bottom should have fallen many hundreds of years ago. Ice often includes metal silicates and trapped air at certain definite time. The ages of the meta silicates and trapped air provides important cluesregarding the composition of earth's atmosphere. Further information on different oxygen isotopes e.g. O16 and O18 particularly the heavy isotopes contained in the ice. The ratios of these isotopes that are present depend on the sensitivity of temperatures at which evaporation and condensations took place for the water in the clouds from which the ice originated. A temperature record for thepolar regions may therefore, be constructed from the analysis of the ice cores as shows in Fig. 3 such reconstruction has been done by scientist from Vostok ice core for temperature and the carbondioxide content as shown in Figure 3, which includes ice age, 120,000 ago.

In addition, variation occurs in the orbit of the Earth around the Sun (Figure 5). The earth's orbit is in effect an ellipse. In has been noted by the astronomers that there is eccentricity of the ellipse (which is related to the ratios

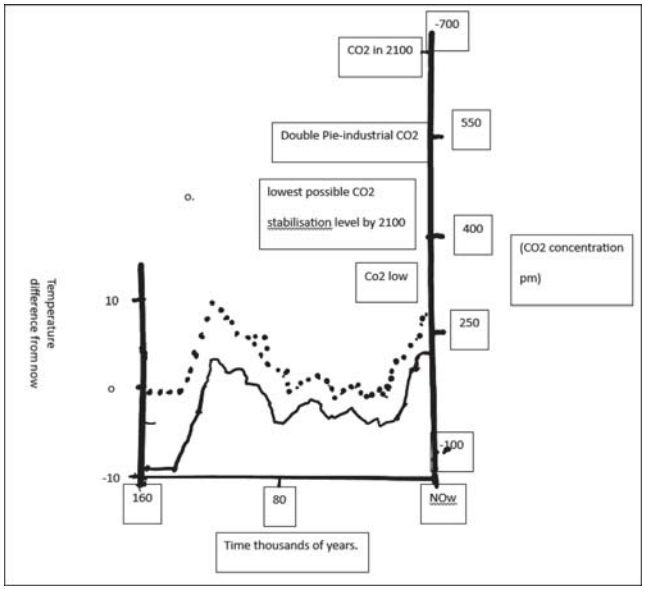

Fig. 2, Variation of polar temperature and atmospheric CO_2 concentrations derived from the Vostok ice core from Antarctica over the last160000 years (with permission, Gail Herman, 2018, Penguin academic press).

The sea level rise in future due to melting of Antarctic and Greenland ice cover (Figs. 3and 4) shows rise in sea level during 2050 and 2100 as decided by the scientists. They had to rely on the use in the sea level by direct and indirect methods to determine the sea level rise because of rise in heat and as a consequence of which there is sea level and change in the climatic condition (with permission from author).

of the greatest and least diameters, which varies within the period of 100,000 years. The earth also spins on its own axis; the axis of spin is tilted with respect to the axis of the Earth's Orbit, the angle varies between 21.5o and 24.5o (currently it is 23.5° within a period of 41,000 years.

There is variation in the earth's orbit (Fig 4) in its eccentricity and the orientation of its spin axis between 21.6° and 24.5° and longitude of perihelion (that isthe time of the year, when the earth is closest to the Sun) cause change in the average amount of summer sunshine in millions of joules per square meter per day near the poles. These changes appear in cycles in the climate reward in terms of volume of ice in the ice caps.

Use of Fossil Fuels and Removal of Forests Causes Generation of Greenhouse Gases

Excessive use of fossil fuels like coal and gasoline by the population of present generation, and removal of forests have resulted in the addition of 5.5 ×109 tons of carbon dioxide in the atmosphere[7]. It has been stated already that in the presence of sunshine during the use of coal, gasoline and diesel, up to 2×109 tons of carbon-dioxide enter into the atmosphere. Generation of glucose is useful to the trees and liberation of O_2 helps mankind for their survival. Excessive liberation of carbon dioxide, CH_4, nitrous oxide and chloro-fluoro carbon absorbs heat and later release of this heat results in global warming. Chloro-fluoro carbon liberated at–86° in the atmosphere of antarctica releases an extra chlorine atom, which reacts with 'O_3' to form molecular (O_2). This is why, since the year, 1976 a hole in the Ozone layer has been created. Thus, use of chloro-fluoro carbon in the industrial belt has now been restricted and portion of the liberated CO_2 results in the deposition of sedimentary carbonates in the ocean basins, as confirmed by the geologists.

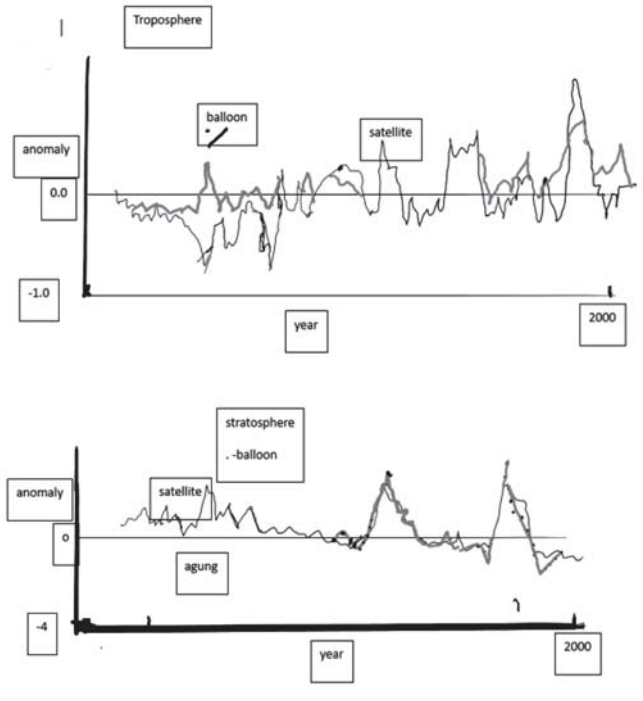

Fig. 3.(a) and (b): Time series of observations of global average temperature, ! (relative to average for 1979-1990), for the lower troposphere. Figure drawn at the top and 3b) time series of observations of global temperatures in !, for the stratosphere.

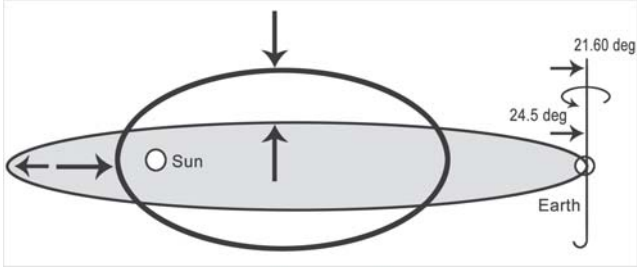

Fig. 4, The earth rotates around the sun along an elliptical orbit. The figure also shows that the earth also rotates on its own orbit at an angle of 21.6 and 24.5 tilted towards the Sun (with permission from author, Gail Herman, Penguin academic press)

Increase in the CO_2 Content and the Way to Control the Same

The moisture in the stratosphere reacts with CO_2 (Carbon Dioxide) to form glucose ($C_{612}O_6$) in presence of sunshine, resulting in the generation of additional O_2 (oxygen) Please note the reaction.

$$6\ CO_2 + 6H_2O = C6H_{12}O_6(\text{glucose}) + 6O_2$$

It has been observed that since 1996, in the United States of America, the CO_2 content has been steadily increased from 2.8 to 3.9% in the recent years. This has resulted in the increase of CO_2 by 1.1%. In case of Europe the CO_2 content has been found to be 2.2%.

Estimated Sea Level Rise During the Last 120,000 Years Ago

In the history of the Earth, there has been a lot of evidencethat the sea level has undergone a lot of changes, during the Earth's history. It is a well-known fact that before the beginning of the ice age (about 120,000) years ago[1,2]. The global average temperature was warmer than today (Fig.5).

It is estimated that the contribution related to sea level rise in the 21st century can be identified. Outside Antarctica and Greenland, if all glaciers melted the sea level, is estimated to rise about 40-60 cm. The projections in figure 6 apply to the next 100 years. During that period because of the slow mixing that occurs throughout much

of the ocean, only a small part of t it would have warmed significantly.

During the subsequent centuries as the rest of the oceans warm up, sea level will continue to rise at about the same rate. The estimated average sea level would rise as shown in (Fig. 5 and Fig. 6) provide a general guide as to what can be expected during the 21st century. The estimate of sea level rise, is shown in fig.6. The global average sea level changes between 2000-3000 AD as estimated is shown in fig. 6. The portion of the Antarctic ice sheet that is most concern is that in the west of Antarctica around 90° west longitude.

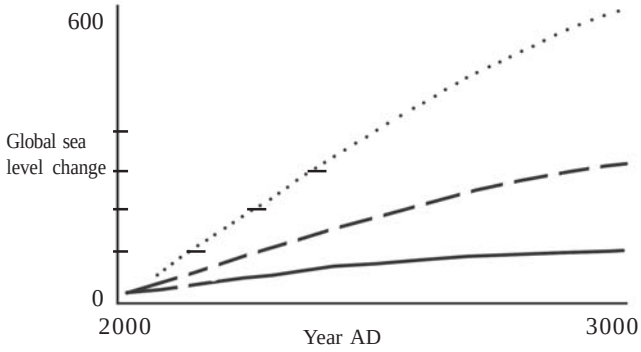

Fig. 5: It has been observed that the average sea level was 5-6 m higher than it is today. When the ice cover was maximum, towards the end of the ice age, the sea level was 100 m lower than today. That is sufficient for Britain to be joined to the continent of Europe. It is thought that the main cause of the sea level changes was the growth of the large ice sheets that cover the polar regions (With permission from the author).

The Impact of Sea Level Rise

It is estimated that a rise in the average sea level of 10 cm by 2030 and above ½ a metre by the end of next century (Fig 6, and 7) may not appear to be very high. Global average level of rise between 1990 and 2100 for the special emission scenarios (SRES) has been calculated by scientists[2,11]. Many people usually leave sufficiently above the sea level. About half of humanity lives in the coastal zone around the world. Within these the lowest lying areas are some of the very fertile and densely populated zones. Those people living in these areas, even a fraction of meter increase in the sea level can add tremendously to their problems. Many areas are vulnerable, firstly there are large river delta areas, as an example Bangladesh; secondly there are areas close to sea level where there are sea defenses that are already present, for example, Netherland, and thirdly many low-lying islands in the pacific and other oceans. Let us take examples one by one: Bangladesh. It is a densely populated country of 120 million people who are confined to complex delta regions of the Ganges, Brahmaputra and Meghna rivers (Fig. 7). About 10% many countries habitable lands (with about 6 million people) would be lost if there is half a meter of sea level rise, and about 20% would be lost if there is a 1 m rise of sea level. If it is estimated that if the sea level rise is about 1 m, by the year 2050, due to the subsidence of land movement and removal of ground water by about 30 cm due to global warming there would be tremendous loss in both the population as well as property. Global warming and climate change is the subject of many discussions of many scientists[9], also see IPCC fifth assessment report and IPCC special report on global warming[8,9]. The real concern for scientists related to climate change andglobal warming.

Many other examples of vulnerable delta regions especially in southeastAsia and Africa can be given where the problems will be similar to Bangladesh and Egypt. For instance, several large and low- lying alluvial planes are distributed along the eastern coast line of china. A seas level rise of ½ m would inundate and area of about 40,000 km square (1/2 the area of the Netherlands), where over 30 million people currently live. Some of the low- lying

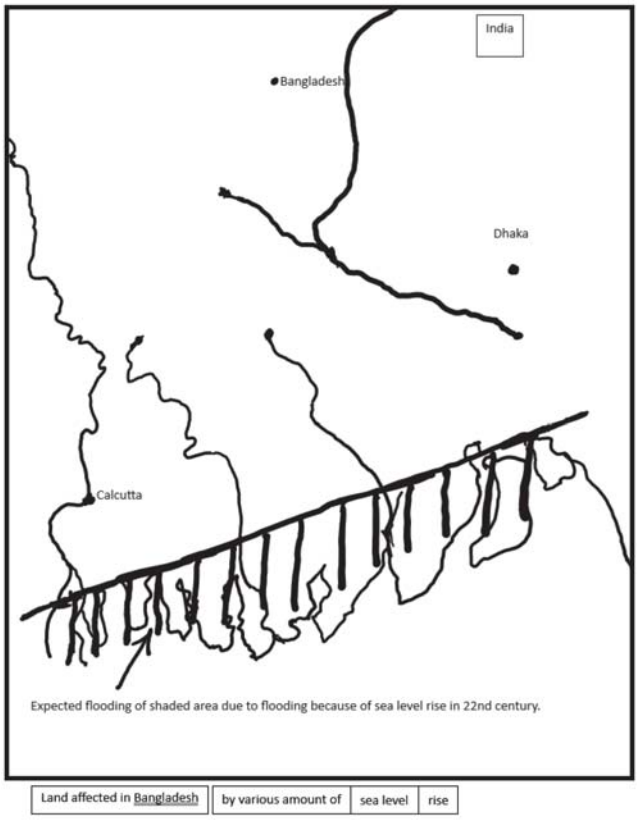

Fig. 6: It is definitely true that the reason for the drop in sea level, 180000 years ago was the amount of water locked up with polar ice sheets. In the northern hemisphere these ice sheets extended in Europe as far south as southern England and in North America to south of the great lakes. The reason for 5 or 6 m high sea level during the last interglacial period, was a reduction in the Antarctic or Greenland ice sheets (With permission from the authors).

Islands of Maldives in the Arabian sea consisting of 1190 individual islands about 1-2° rise in sea level would cause disappearance of many important cities due to global warming.

Fig 6 shows the land affected areas in Bangladesh by various amounts of sea level rise, but the loss of land in Bangladesh is not only the effect of sea level rise but also every year, on an average atleast one major cyclonic attacks Bangladesh, during the past 25 years, there have been two large disasters with extensive flooding and loss of life.

There is a further effect of sea level rise on the productivity of agricultural lands that is the intrusion of salt water into fresh groundwater resources. Many other examples of vulnerable delta regions, especially in Southeast Asia and Africa has already been discussed. Man made interference related to global warming has been the subject of many discussions[12,13].

Elimination of Forests

We know for Certain that in Brazil, French Guyana, Surinam, Guyana, Venezuela, Costerica, Nicaragua, Panama, Columbus, Equador, Peru and Bolivia, the forests have been eliminated and therefore, the Content of CO_2 has been increased by 4.7%.

Exclusive liberation of CO_2[6], CH_4, nitrousoxide and chloro-fluoro carbon liberated at-86°in the atmosphere of antarctica releases, an extra chlorine atom which reacts with 'O_3' to from molecular O_2. This is why since 1976 a hole in the O3on layer has been created. Thus, use of chloro-fluro Carbon in the industrial belt has been restricted.

Conferences Related to Global Warming

There were three conferences on global climate change, organized by the U.N.O. The first one took place between June 3 and 14, 1992 in Rio de Ganeiro. This conference was attended by 192 members. Here it was decided to consider an alternative to fossil fuels like coal and petroleum and instead use H2 fuel. It was also suggested to employ electricallyoperated vehicles, because fossil fuels were responsible for increase in the greenhouse gases (GHG)

The second Climate change international meeting was held in Kyoto, Japan. There were 192 members attended the meeting on 11th December, 1997. In Kyoto it was decided to reduce the green house gas production by 5% over next 5 years. In this Conference all parties were committed to reduce GHG by 18% compared to the 1992 level.

The Paris the Climate Change conference took place on 12th December, 2015. The Conference was attended by 196 members from all over the world. There it was decided to keep the temperature increase to below 2°C, (3.6°F) line, i.e. the preindustrial levels and preferably limit the increase to 1.5°c (2.6°F). The agreement was lauded by the world leaders but was criticized by environmentalists and analysts about the effectiveness of the goal. In these three conventions, top class economists from various countries attended the meeting and tried to find out which countries failed to meet the promises they made in earlier conventions. Those countries that failed to keep their promises had to pay substantial amounts in dollars to those developed countries that lived upto their promises.

El Nino

El Niño is a climate phenomenon that originates in the tropical Pacific Ocean and has far-reaching impacts on weather patterns around the world. El Niño begins with the warming of ocean waters in the central and eastern tropical Pacific Ocean. This warming is caused by a weakening of the typical easterly trade winds that blow across the Pacific (National Geographic Magazine). These winds usually push warm surface waters westward towards Indonesia, allowing cold, nutrient-rich waters to up well off the coast of South America. El Niño events occur irregularly, typically every two to seven years, and can last for several months. They are part of the larger phenomenon known as the El Niño-Southern Oscillation (ENSO), which also includes its opposite phase, La Niña, characterized by cooler ocean temperatures.El Niño's warming of the ocean disrupts normal weather patterns. Some of the major effects include: El Niño can lead to increased rainfall and flooding in some regions, such as South America, the western United States, and parts of Australia. Conversely, it can bring drought to regions like Southeast Asia and eastern Australia. Some areas experience warmer temperatures during El Niño events.El Niño tends to suppress the formation of tropical cyclones in the Atlantic but can increase their frequency in the Pacific.The warming ocean disrupts marine ecosystems, affecting fisheries. In some cases, it can lead to the collapse of fish stocks.Agriculture can be severely impacted. Excess rainfall can damage crops, while droughts can lead to crop failures.

El Niño is a global phenomenon. Its effects can disrupt economies, lead to food shortages, and even influence global commodity prices. For example, a severe El Niño can result in reduced agricultural production,

affecting the prices of crops like rice, wheat, and soybeans.

Scientists monitor sea surface temperatures in the tropical Pacific and other atmospheric variables to predict El Niño events. These predictions help governments, businesses, and communities prepare for the potential impacts.

Some of the most severe El Niño events in history include the 1982-1983 and 1997-1998 events, which caused widespread devastation, including floods, droughts, and economic losses.

El Niño is a natural climate phenomenon characterized by the warming of Pacific Ocean waters, which disrupts global weather patterns, leading to various environmental, economic, and social impacts. It requires careful monitoring and study due to its potential to cause significant disruption and hardship.

Terrestrial Storms in South Asia

Terrestrial storms, such as cyclones or tropical storms, are not uncommon in South Asia, like Orissa, Andhra Pradesh, Madras, and countries like Bangladesh. These storms are a significant weather phenomenon in the region and can have devastating impacts. Here's more information about terrestrial storms in South Asia, particularly in Bangladesh: South Asia, including the Bay of Bengal, experiences a cyclone season, typically from April to December. During this period, warm ocean waters provide the energy needed for the formation and intensification of tropical storms. Cyclones are large, rotating storm systems characterized by low-pressure centers and strong winds. They can originate over the warm waters of the Bay of Bengal and can intensify rapidly. Bangladesh is particularly vulnerable to cyclones due to its low-lying geography and extensive coastline along the Bay of Bengal. The flat topography of the region makes it susceptible to storm surges, which can result in severe coastal flooding. Cyclones in Bangladesh can bring heavy rainfall, strong winds, and storm surges. These events can lead to widespread flooding, landslides, infrastructure damage, and loss of life. Coastal communities are often the hardest hit, and many are at risk due to their proximity to the sea[14].

Bangladesh has made significant progress in terms of cyclone preparedness and response. The government, along with international organizations, has implemented early warning systems, cyclone shelters, and evacuation plans to reduce the loss of life during these events. These efforts have been successful in saving many lives. Bangladesh has experienced several devastating cyclones in its history. Notable examples include Cyclone Bhola in 1970 and Cyclone Sridhar in 2007, both of which caused significant casualties and damage.

Climate change is a growing concern in the region, as rising sea levels and warming ocean waters can potentially increase the intensity and frequency of cyclones, making proactive measures even more critical. Terrestrial storms, particularly cyclones, are a recurring natural hazard in South Asia, with Bangladesh being especially susceptible due to its geographical location. Efforts in cyclone preparedness, early warning systems, and infrastructure development have helped mitigate the impacts, but the region remains at risk, necessitating ongoing vigilance and adaptation to changing climate patterns.

Instruments to Control Global Warming

In the U.S., Japan and Europe instruments have been used to Control generation of the green house gases in the car pipelines. These countries have also started to use hydrogen fuel to run the cars. The use of electrically-operated cars have now been extensively used to avoid release of the greenhouse gases.

We should employ strong guidelines for the protection of our forest resources. In the advanced countries there has now been zero population growth. China too has used to stringent rules to restrict the growth of their population. Once we active this, the use of cattle would also be limited. In India there should be proper spread of education so that Indians learn to follow the above guidelines and our atmosphere becomes free from pollution so that we can inhale clean air to our heart's content.

Let's explore the role played by economists in the three major protocols: the Kyoto Protocol, the Paris Agreement, and the Brazil Climate Action Pledge:

Kyoto Protocol: The Kyoto Protocol, adopted in 1997, was the first international agreement to set binding greenhouse gas reduction targets for developed countries. Economists played a crucial role in the design and implementation of the protocol in several ways: Emission Reduction Targets: Economists contributed to the development of the emissions reduction targets specified in the Kyoto Protocol. They analyzed the costs and benefits of different reduction scenarios and provided insights into the feasibility and economic implications of various targets. Economists' expertise in cost-benefit analysis and economic modeling helped inform negotiations and set realistic targets that balanced environmental effectiveness and economic considerations.

Role of Economists

Economists play a crucial role in developing cities and addressing the challenges posed by sea level rise. Their contributions are multifaceted and include the following key aspects:

Economists assess the economic feasibility of various adaptation and mitigation strategies in response to sea level rise. They conduct cost-benefit analyses to determine which projects or policies are most efficient in terms of reducing risks and minimizing economic losses. This involves comparing the costs of implementing measures like building seawalls, elevating infrastructure, or relocating assets against the potential benefits in terms of avoided damages and enhanced resilience.Economists help prioritize investments in infrastructure and urban development. They assist city planners and policymakers in allocating resources efficiently to address sea level rise challenges. By identifying high-risk areas and critical infrastructure, economists guide decision-makers in making informed choices about where and how to invest in protective measures.Economists assess the impact of sea level rise on property values and insurance markets. They develop models to estimate how rising sea levels can affect property prices and the availability and cost of insurance coverage. This information is valuable for homeowners, real estate developers, and insurers in making informed decisions.

Economists assist cities in developing long-term fiscal plans to manage the financial implications of sea level rise. This includes estimating the costs associated with adaptation and mitigation measures and exploring financing mechanisms such as bonds, grants, or public-private partnerships to fund these projects.Economists study the environmental and ecological impacts of sea level rise. They assess the economic value of coastal ecosystems like wetlands and mangroves in providing natural flood protection and carbon sequestration. This information can be used to advocate for the preservation and restoration of these ecosystems as part of a city's resilience strategy.Economists design incentive-based policies to encourage sustainable behavior and reduce greenhouse gas emissions, which contribute to sea level rise. Examples include carbon pricing mechanisms like cap-and-trade systems or carbon taxes, which provide economic incentives for emissions reduction. Economists analyze the distributional impacts of sea level rise and associated policies. They assess how vulnerable communities and low-income households are disproportionately affected and develop strategies to address these disparities, such as affordable housing initiatives and targeted assistance programs.Economists engage in international collaborations and research to share best practices and lessons learned from cities worldwide facing similar challenges. This collaborative effort fosters knowledge exchange and can lead to innovative solutions for addressing sea level rise.Economists often advocate for evidence-based policies that promote sustainability and resilience. They communicate their research findings to policymakers, businesses, and the public to raise awareness about the economic risks associated with sea level rise and the need for proactive measures. Economists play a pivotal role in helping cities adapt and develop in the face of sea level rise. They provide valuable insights into the economic aspects of resilience planning, resource allocation, property valuation, and policy development, ultimately contributing to the sustainable and resilient growth of urban areas in the context of a changing climate. ❐

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