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Review Article

Global Climate Change: The Present Scenario

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Abstract: The term climate change is growing in preferred use to 'Global warming' because it helps to convey that there are other changes in addition to rising temperature. Climate change refers to any significant change in measures of climate (such as temperature, precipitation or wind) lasting for an extended period (decades or longer). Climate change may result from: a) Natural factors, such as changes in the sun's intensity or slow changes in the Earth's orbit around the sun. b) Natural process within the climate system (such as changes in ocean circulation) c) Human activities that change the atmosphere's condition (such as burning fossil fuels) and deforestation, urbanization and industrialization. Climate change is primarily attributable to rise in the atmospheric temperature of the earth. Our atmosphere traps solar radiation and raises the temperature due to the major greenhouse gases such as carbon dioxide, CFCs, nitrous oxide and methane. In some regions of Asia and Africa, the frequency and intensity of droughts have been observed to increase in recent decades. Episodes of EL Nino which creates great storms, have been more frequent persistent and intense since the mid-1970s compared with the previous 100 years. All these are signs that the Earth is ailing. Its climate is changing making it more difficult for mankind to survive. The Earth is losing its equilibrium due to the imbalances created by human activities. Climate change related impacts on human health could lead to displacement of a large number of people creating environment refugees and lead to further health issues. Climate change is an intricate problem which although environmental in nature has consequences for all spheres of existence on planet. It either impacts on or is impacted by global issues including poverty economic development population growth sustainable development and resource management.

Keywords: Climate Change, Environment, Greenhouse Gases, Carbon Dioxide

1. Introduction

A planet's climate is decided by its mass, its distance from the sun and the composition of its atmosphere. Earth's climate is unstable and rather unpredictable as compared to other planets. Over the last 4,00,000 years the Earth's climate has been unstable, with very significant temperature changes, going from a warm climate to an ice age in as rapidly as a few decades. According to recent reports of the Intergovernmental Panel on Climate Change, the global average surface temperature over the 20th century has increased by around 0.60°C. This value is about 0.15°C more than the previous estimates. Global average land and sea surface temperatures in May 2003 were the second highest since 1880.

Till date, the 10 hottest years in the 143 year old global temperature record have all been after the 1990, with the three hottest being 1998, 2002 and 2001. Extreme weather events also increased during this period. There were 63 weather-related disaster declarations in 1998, far more than the average 21.7 disaster announcements made per year during the 1980s. For instance there were 26 flood disasters worldwide in the 1990s, but just 21.7 per year during the 1980s. The frequency and intensity of extreme weather invents increased due to a change in the distribution of heat, which disrupts the flow of energy through the climate system, altering the circulation patterns of the atmosphere and oceans, and modifying the Earth's hydrological cycle. Higher temperatures increase evaporation and transpiration and raise the air's capacity to hold moisture, making more of it available to fall as rain and snow.

In the last two decades, the term 'environment' has gained enormous importance and almost everyone is aware of the term. Along with it, terms like ozone depletion [1-4], greenhouse effect [5-7] and acid rain [8;9] have also surfaced and are often the topics of discussion among the socially and educationally advanced.

2. Greenhouse Effect

As the name suggests, the term had its origin from the practice in cold countries of encasing vegetation in the glass chambers to protect them from frost. It was observed that there was a continued rise in the temperature in such chambers even when the outside temperature remained low. This enabled the warming up of vegetation inside the chamber, resulting in good plant growth. In a typical greenhouse, the transparent glass roof and walls of the greenhouse allow the sun's rays to pass through and strike the ground (surface of the chamber). The reflected radiation is of longer wavelength than the incident radiation. A significant portion of the former is absorbed by the glass. As long wavelength radiation (infrared radiation) generates heat, this resulted in a rise in temperature inside the greenhouse.

An effect similar to the greenhouse effect is responsible for keeping the earth's surface warmer than it would otherwise be [10]. The sun's rays strike the surface of the earth and the long wavelength radiation emitted by the earth are absorbed by atmospheric gases thereby contributed to the rise in temperature.

The possibility that the absorption of long wavelength radiation by atmospheric gases would influence ground temperature was recognized by Fourier as early as 1827. Fourier maintained that the atmosphere acts like the glass of a greenhouse by letting through the incident light rays of the sun and retaining the infrared rays which are reflected back to the ground. This greenhouse effect warms the lower atmosphere. If the atmosphere would be transparent to the outgoing long wavelength radiation emanating from the earth's surface the mean equilibrium temperature of the earth's surface would be considerably lower and probably below the freezing point of water. According to one estimate in the absence of natural concentrations of greenhouse gases the average temperature of the earth's surface would be -19°C instead of the present value of 15°C and the earth would be a frozen lifeless planet. The Swedish chemist Svante Arrhenius was able to show in 1896 that it was the carbon dioxide (CO_2) present in the earth's atmosphere which help the atmosphere retain the long wavelength radiation and thus warm up the earth.

3. The Earth's Radiation Balance

Scientists, until 1896, had been unable to explain how the earth's atmosphere could maintain the planet's relatively warm temperature, when oxygen and nitrogen, which constitute 99 per cent of the atmosphere, do not absorb heat from the infra-red radiation emitted from the earth back into space. The emission spectrum of the sun roughly resembles that of the blackbody, radiating at a temperature of 6000°K. In the visible portion of the spectrum (0.4 to 0.7 µm wavelength range), where the maximum influx of solar energy takes place, the radiation can penetrate, almost without loss, down to the earth's surface except where clouds are present. High in the atmosphere, ordinary oxygen (O_2) and ozone (O_3) molecules absorb an estimated 1-3% of the incoming radiation. The absorption occurs in the ultraviolet portion of the spectrum and effectively limits the penetrating radiation of wavelengths longer than 0.3 µm. Although this effect is relatively small, it is important because it is the main source of energy for circulation of gases in the atmosphere above 30 kilometres. Moreover, the absorption at these levels shields the biosphere from the damaging effects of ultraviolet radiation.

In spite of certain long term climate changes, meteorological records do not show an appreciable net heating of the earth and its atmosphere. Therefore, the earth must be radiating as much radiation as absorbed. However, since the earth radiates at an effective blackbody temperature of 255°K, a very low temperature compared to the sun's blackbody temperature of 6000°K, the earth's emission occurs over a broad range of wavelengths from 2 to 40 microns with a flat maximum at about 12 microns. In this range the atmosphere is no longer transparent.

Arrhenius discovered that carbon dioxide, which makes up only a tiny fraction of the atmosphere, could trap enough of the escaping heat (wavelength of 12-16.3 microns) to warm up the surface of the planet [11]. Furthermore he realized that the burning of coal, oil and natural gases was raising the concentration of carbon dioxide and he predicted that a doubling of the gas could warm the planet by more than 10°F, a prediction that is considered reasonable by modern-day scientists.

4. Greenhouse Gases

The greenhouse gases of greatest concern are carbon dioxide, water vapour, methane, chlorofluorocarbons, nitrogen oxides and troposphere ozone.

4.1. Carbon Dioxide (CO_2)

In 1958, Charles Keeling and Roger Revalle studied the atmosphere's carbon dioxide concentrations. On the slopes of Mauna Loa in Hawaii, far from any sources of industrial pollution, Keeling was able to measure the subtle, seasonal ups and downs in the concentration of the CO_2 as the plants in the Northern Hemisphere varied their consumption and release of the gas. In addition to this annual cycle, he documented a steady rise in carbon dioxide due to human activities from 315 ppm (parts per million) thirty years ago to 350 ppm today. Using these data as well as evidences from tree rings and ice cores, climatologists estimate that the level of carbon dioxide before the dawn of the Industrial Revolution was above 280 ppm. Humans have already increased the levels of CO_2 by 25 per cent and are expected to double the CO_2 levels by the year 2075.

Table 1. *Estimated sources and sinks of CO_2.*

Sources	Sources/Sinks	Range (TgC/Year)
1.	Ocean	102700-106500
2.	Land	8700-120000
3.	Fossil fuel	4500-5500
4.	Land use conversion	0-2600
Sinks		
1.	Oceans	106000-108000
2.	Land	100000-140000

4.2. The Carbon Cycle

The carbon cycle in the biosphere is fundamentally an overall global interference of living organisms and their physical and chemical environment. Carbon dioxide is the most abundant and the single most important greenhouse gas in the atmosphere. Its concentration has increased by about 25 percent since the industrial revolution. Carbon dioxide concentrations are currently increasing at a rate of about 0.4% per year, which is responsible for about half of the current increase in global warming caused by greenhouse gases. Deforestation and consumption of fossils fuels have contributed to this rise. Current emissions are estimated at 5.5 billion tons of carbon from fossil fuel combustion and 0.4-2.6 billion tons of carbon from deforestation. This carbon dioxide remains in the atmosphere, or is absorbed by the oceans. Even though only half of the current emission remains in the atmosphere, available models of CO_2 uptake by the ocean suggest that substantially more than a 50 percent cut in the emissions is required to stabilized concentration at current levels. CO_2 levels vary in the atmosphere not only diurnally or seasonally but spatial variations-latitudinal and altitudinal- have also been observed. The average global CO_2 concentration is about 320ppm by volume. Palaeoclimatological studies show that during the last glacial maximum the CO_2 concentration was only 180-220ppm. But one of the most unexpected discovery of recent years was that the CO_2 concentration could change by a factor of 1.5 during a time span of only a few hundred years. The fact that the changes are real is confirmed by the last observation that they are accomplish by corresponding changes in the $^{18}O/^{16}O$ ratio which reflects the decrease in temperature in this period, evidently due to the decrease of atmospheric greenhouse effect. This fact shows that we are still far from understanding many important factors determining the carbon cycle in nature.

4.3. Methane (CH_4)

Fewer studies have been conducted on the impact of methane [12] as a greenhouse gas compared to CO_2 due to the greater uncertainties about the sources and sinks of methane. Table 2 presents the estimated sources and sinks of methane. Apart from its role in global warming, methane can also affect the tropospheric ozone distribution. A model named IMAGE (Integrated Model to Assess Greenhouse Effect) predicts that a 10 percent cut in CH_4 emission besides stabilizing CO_2 emission by the year 2025 can lead to stable CH_4 levels in the atmosphere. CH_4 is currently increasing at a rate of 1 percent per year and is responsible for about 20 percent of current increases in the commitment to global warming. Scientists from development countries have blamed paddy fields, existing predominantly in tropical developing countries yielding about 90 percent of global rice production for contributing vast quantities of methane to the global methane flux.

Table 2. *Global methane emission estimates.*

Sources/Sinks	Best estimates ($106ta^{-1}$)	Range
1. Natural wetlands	115	100-200
2. Rice paddies	110	25-170
3. Enteric fermentations (animals)	80	65-100
4.Gasdrilling,venting,transmission etc.	45	25-50
5. Biomass burning	40	20-80
6. Termites	40	10-100
7. Landfills	40	20-70
8. Coal mining	35	19-50
9. Oceans	10	5-20
Sinks		
1.Removal by soils	30	15-45
2.Raction with OH	500	400-600

ta^{-1}: tones per annum

These allegations have been hotly contested by the developing countries and this has persistently been a bone of contention in the North-South dialogue on global warming. The extent of divergence of views on this subject can be gauged from the widely differing estimates of methane contribution from rice paddies. For example, an Indian scientist Sinha has claimed that the estimates of IPCC (Inter Governmental Panel on Climate Change) on methane production in developing countries are as much as 15 times higher than actual.

The emissions from landfills and coal seams also to contribute to the methane levels all over the world. CO_2 and CH_4 are known to be produced during bacterial decomposition of flooded peat and forest biomass. Hydroelectric reservoirs are also considered an important source of methane. Of the major greenhouse gases, the concentration of methane can be stabilized relatively easily by modest cuts in anthropogenic emissions. A 10-20 percent cut would suffice to stabilize concentrations at current level due to methane’s relatively short atmospheric life-time, assuming that this life-time remains constant and that the natural emission does not change. Whether this does actually happen will depend on how the tropospheric chemistry is influenced by emission of hydrocarbons and carbon monoxide among others and on whether change of global climate, itself affects methane emission.

4.4. Nitrous Oxide (N_2O)

The concentration of nitrous oxide has increased by 5-10 percent since pre-industrial times. The exact cause cannot be pinpointed but the use of nitrogenous fertilizers, land-clearing, biomass-burning and fossil fuel combustion may all have contributed. Each additional molecule of N_2O has over 200 times as much impact on climate as an additional molecule of CO_2 Nitrogen oxide also contributes to the stratospheric ozone depletion. N_2O is currently increasing at a rate of 0.25 percent per year. Table 3 below represents the global N_2O emission estimates. N_2O increase is responsible for roughly 6 percent of the current increases in the commitment to global warming. Assuming that the observed increase in N_2O concentration is due to anthropogenic sources and that natural emission have not changed, then an 80-85 percent cut in anthropogenic, emissions would be required to stabilize N_2O at current levels.

Table 3. *Global N_2O emission estimates.*

Sr. No.	Sources/sinks	Range (106ta^{-1})
Sources		
1	Oceans	1.4-2.6
2	Soils (tropical forest)	2.2-3.7
3	Soils (temperature forest)	0.7-1.5
4	Fossils (Fuel combustion)	0.1-0.3
5	Biomass burning	0.02-0.2
6	Fertilizers	0.01-2.2
Sinks		
1	Removal by soils	Unknown
2	Photolysis in the stratosphere	7-13
3	Atmospheric increase	3-4.5

ta^{-1}: tones per annum

4.5. Halocarbons

Chlorofluorocarbons (CFCs) are well-known as the depleters of stratospheric ozone but they are also significant as greenhouse chemicals. The most common species of CFCs are CFC-12 (CCI2F2) and CFC11 (CFI3F). Their atmospheric concentration in 1986 were 392 and 226 parts per trillion by volume. While these concentrations are tiny when compared with that of COD, CFCs have as much 20,000 times more impact on climate per additional molecule than CO_2. Further the atmospheric concentration of CFCs is increasing very rapidly more than four percent per year since 1978- representing about 15 percent of the current increase in the commitment to global warming. It is estimated that 75 percent and 85 percent cuts respectively, are required in the emissions of CFC-11 and CFC-12 to stabilize the atmospheric concentrations of their present level. However because of contribution from several other compounds, in order to stabilize the total greenhouse warming potential from all halocarbons, a phase out of fully halogenated compounds (those that do not contain hydrogen), a freeze on the use of methyl chloroform and a limit on the emissions of partially halogenated substitutes would be required.

4.6. Other Gases

Increasing emissions of carbon monoxide (CO) and nitrogen oxides (NO_X) [12; 13] are also adversely influencing the chemistry of the atmosphere. This change in atmospheric chemistry alters the distribution of ozone and the oxidizing power of the atmosphere, changing the atmospheric lifetime of the greenhouse gases. If the concentration of the long-lived gases were stabilized, it might only be necessary to freeze emissions of the short-lived gases at current levels to stabilize atmospheric composition.

Many of the greenhouse gases that induce tropospheric warming through the greenhouse effect are highly stable and may be retained in the atmosphere for decades or even century or more. Though the role of CO_2 in global warming appears substantial at present due to the high concentration of the gas, other greenhouse gases (GHGs) are a thousand to ten thousand times more effective than CO_2 and are consequently dangerous even at their present trace levels of concentration.

The concept of relative GWPs (Global Warming Potentials) has been developed to evaluate the relative radioactive effects (and, hence, the potential climate effects) of equal emissions of each of the GHGs. The GWPs take into account the differing residence times of gases in the atmosphere and define the time-integrated warming effect due to an instantaneous release of unit mass (1kg) of a given GHG in today's atmosphere, relative to that of CO_2. The relative cumulative effect of man-made emissions on the climate is summarized in the table 4.

Table 4. *The relative cumulative climate effects (1990) of man-made emissions.*

Sr. No.	Gases	GWP (100 yrs. Horizon)	1990 emissions (Tg)	Relative contribution over 100 yrs.
1	CO_2	1	26000	61%
2	Methane	21	300	15%
3	Nitrous oxide	290	6	4%
4	CFCs	Varies	0.9	11%
5	HCFC -22	1500	0.1	0.5%
6	Others	Varies	-	8.5%

GWP = Global Warming Potential; CFCs = Chloroflouro Carbons; HCFC = Hydro chlorofluorocarbons

5. Conclusion

Climate is the long term statistical expression of short term weather. In the entire context and with all these discussions, we can say that every time critical analysis of any matter is done and more so with in the ecological context; there is an utter need to emphasize the need for "green" as well as "development". We should make a set of guidelines that can make way for a smooth flow of green clearance. A certain amount of "green thought" within the objective framework is the need of the hour.

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