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INDIA'S CONTRIBUTION IN GLOBAL WARMING

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ABSTRACT Global warming occurs when carbon dioxide (CO2) and other air pollutants and greenhouse gases collect in the atmosphere and absorb sunlight and solar radiation that have bounced off the earth's surface. India is also very vulnerable to climate change, notably due to the melting of the Himalayan glaciers and changes to the monsoon. Although India as a developing country does not have any commitments or responsibilities at present for reducing the emissions of greenhouse gases such as CO2 that lead to global warming, pressure is increasing on India and other large, rapidly developing countries such as China and Brazil to adopt a more pro-active role. India's population and emissions are rising fast, and its ability to tackle poverty without massive fossil fuel use will decide the fate of the planet

KEYWORDS : Global Warming, India, Weather.

INTRODUCTION

Global warming has emerged as one of the most important environmental issues ever to confront humanity. This concern arises from the fact that our everyday activities may be leading to changes in the earth's atmosphere that have the potential to significantly alter the planet's heat and radiation balance. It could lead to a warmer climate in the next century and thereafter, portending a potpourri of possible effects – mostly adverse.

Over the past 50 years, the average global temperature has increased at the fastest rate in recorded history. And experts see the trend is accelerating: All but one of the 16 hottest years in NASA's 134-year record have occurred since 2000.

Global warming occurs when carbon dioxide (CO2) and other air pollutants and greenhouse gases collect in the atmosphere and absorb sunlight and solar radiation that have bounced off the earth's surface. Normally, this radiation would escape into space—but these pollutants, which can last for years to centuries in the atmosphere, trap the heat and cause the planet to get hotter. That's what's known as the greenhouse effect.

Scientists agree that the earth's rising temperatures are fueling longer and hotter heat waves, more frequent droughts, heavier rainfall, and more powerful hurricanes. In 2015, for example, scientists said that an ongoing drought in California—the state's worst water shortage in 1,200 years—had been intensified by 15 percent to 20 percent by global warming. They also said the odds of similar droughts happening in the future had roughly doubled over the past century.

India is also very vulnerable to climate change, notably due to the melting of the Himalayan glaciers and changes to the monsoon. India is embarking on one of the fastest rural-to-urban transitions in human history, with 200 million more city dwellers expected by 2030, all using new buildings, roads and cars. The country has pledged a 33-35% reduction in the “emissions intensity” of its economy by 2030, compared to 2005 levels. In this context, keeping the rise in emissions to just a doubling would be truly remarkable, says Stern, and leave India's emissions per person well below the current global average.

Causes of Global Warming

Greenhouse gases are a hot topic (pun intended) when it comes to global warming. These gases absorb heat energy emitted from Earth's surface and reradiate it back to the ground. In this way, they contribute to the greenhouse effect, which keeps the planet from losing all of its heat from the surface at night. The concentrations of various greenhouse gases in the atmosphere determine how much heat is absorbed by the atmosphere and reradiated back to the surface. Human activities—especially fossil-fuel combustion since the Industrial Revolution—are responsible for steady increases in the concentration of greenhouse gases in the atmosphere. The five most significant gases are presented here.

Carbon Dioxide

Of the greenhouse gases, carbon dioxide (CO_2) is the most prominent. Sources of atmospheric CO_2 include volcanoes, the combustion and decay of organic matter, respiration by aerobic (oxygen-using) organisms, and the burning of fossil fuels, clearing of land, and production of cement by humans. These sources are balanced, on average, by a set of physical, chemical, or biological processes, called "sinks," that tend to remove CO_2 from the atmosphere. Plant life, which takes up CO_2 during the process of photosynthesis, is an important natural sink. In the oceans, marine life can absorb dissolved CO_2, and some marine organisms even use CO_2 to build skeletons and other structures made of calcium carbonate ($CaCO_3$).

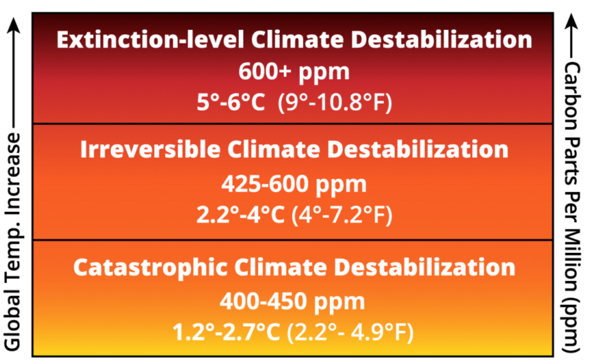
Carbon dioxide is currently the most important greenhouse gas related to global warming. For the longest time, our scientists believed that once in the atmosphere, carbon dioxide remains there for about 100 years. New research shows that is not true. 75% of that carbon will not disappear for thousands of years. The other 25% stays forever. We are creating a serious global warming crisis that will last far longer than we ever thought possible.

"The lifetime of fossil fuel CO2 in the atmosphere is a few centuries, plus 25 percent that lasts essentially forever. The climatic impacts of releasing fossil fuel CO2 to the atmosphere will last longer than Stonehenge, longer than time capsules, longer than nuclear waste, far longer than the age of human civilization so far." —“Carbon is forever,” Mason Inman.

Atmospheric carbon from fossil fuel burning is the main human-caused factor in the escalating global warming we are experiencing now. The current level of carbon in our atmosphere is tracked using what is called the Keeling curve. The Keeling curve measures atmospheric carbon in parts per million (ppm).

Each year, many measurements are taken at Mauna Loa, Hawaii to determine the parts per million (ppm) of carbon in the atmosphere at that time. At the beginning of the Industrial Revolution around 1880, before we began fossil fuel burning, our atmospheric carbon ppm level was at about 270. Here is the current Keeling curve graph for where we are today:

Three Degrees of Climate Destabilization



No matter what you hear in the media, if the total carbon ppm level is not going down or carbon's average ppm level per year is not falling or at least slowing its steep increase, we are not making any significant progress on resolving the escalating global warming emergency. Total atmospheric carbon and carbon's average ppm level per year are the most dependable measurements of our progress and a predictor of what will be happening with global warming and its many consequences.

The concentrations of other greenhouse gases such as methane and nitrous oxide have also been rising at a fairly rapid rate. The effect is that the atmosphere retains more of the sun's heat, warming the earth's surface. Of course, not all man-made additions to the atmosphere increase warming. For example, aerosols, tiny particles of solid or liquid suspended in the air, which result from the emissions of soot and sulphur dioxide from power plants tend to reflect heat and diminish warming. But aerosols are mostly shortlived while the CO2 released into the atmosphere will stay there for decades.

Sources of Carbon Dioxide

Processes or regions that predominately produce atmospheric carbon dioxide are called sources. Carbon dioxide is added to the atmosphere naturally when organisms respire or decompose (decay), carbonate rocks are weathered, forest fires occur, and volcanoes erupt. Carbon dioxide is also added to the atmosphere through human activities, such as the burning of fossil fuels and forests and the production of cement.

Respiration and Decomposition

You are probably familiar with respiration and the respiratory system. One definition of respiration is the exchange of oxygen and carbon dioxide between the blood of an animal and the environment. Carbon dioxide is also released when organisms breathe.

Respiration also takes place at the cellular level. All plants and animals return both carbon dioxide and water vapor to the atmosphere. Every cell needs to respire to produce the energy it needs. This process is known as cellular respiration. The process of respiration produces energy for organisms by combining glucose with oxygen from the air. During cellular respiration, glucose and oxygen are changed into energy and carbon dioxide. Therefore, carbon dioxide is released into the atmosphere during the process of cellular respiration.

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + H_2O + \text{energy}$$

glucose + oxygen → carbon dioxide + water + energy

Respiration is also the process by which once-living (organic) organisms are decomposed. When organisms die, they are decomposed by bacteria. Carbon dioxide is released into the atmosphere or water during the decomposition process.

Weathering of Carbonate Rocks

The **carbonate**–silicate geochemical cycle, also known as the inorganic carbon cycle, describes the long-term transformation of silicate **rocks** to **carbonate rocks** by **weathering** and sedimentation, and the transformation of **carbonate rocks** back into silicate **rocks** by metamorphism and volcanism.

There are also four microbial weathering mechanisms of carbonate rocks:

(1) microorganisms grow on rock surface or in crevices, resulting in bio-corrosion, bio-erosion, and boring, and accelerate rock decomposition and weathering;
(2) boring meshes produced by microbial colony could increase the efficient superficial area of chemical denudation of rocks and could lead to the intensification of rock surface weathering to promote mechanical erosion, and the microbial destruction and loosing of cementation structure of rock particles would also accelerate the decomposition of mineral particles;
(3) rock weathering can be intensified by the effects of microbial water-keeping, acidification of organic acids secreted by microorganisms, and the release of CO_2 induced by microbial respiration onto rock surface;
(4) microorganisms obtain nutrition from rock surface to produce complicated organic ligands and promote the release of mineral elements in the growing process of microorganisms.

Over geologic time, limestone may become exposed (due to tectonic processes or changes in sea level) to the atmosphere and to the weathering of rain. The carbonic acid that forms when carbon dioxide dissolves in water, in turn, dissolves carbonate rocks and releases carbon dioxide.

Burning of Fossil Fuels and Forests

A fossil fuel is a fuel formed by natural processes, such as anaerobic decomposition of buried dead organisms, containing energy originating in ancient photosynthesis. Such organisms and their resulting fossil fuels typically have an age of millions of years, and sometimes more than 650 million years.

Carbon dioxide is added to the atmosphere by human activities. When hydrocarbon fuels (i.e. wood, coal, natural gas, gasoline, and oil) are burned, carbon dioxide is released. During combustion or burning, carbon from fossil fuels combine with oxygen in the air to form carbon dioxide and water vapor. These natural hydrocarbon fuels come from once-living organisms and are made from carbon and hydrogen, which release carbon dioxide and water when they burn.

For more than a century, burning fossil fuels has generated most of the energy required to propel our cars, power our businesses, and keep the lights on in our homes. Even today, oil, coal, and gas provide for about 80 percent of our energy needs.

And we're paying the price. Using fossil fuels for energy has exacted an enormous toll on humanity and the environment - from air and water pollution to global warming. That's beyond all the negative impacts from petroleum-based products such as plastics and chemicals. Here's a look at what fossil fuels are, what they cost us (beyond the wallet), and why it's time to move toward a clean energy future.

Deforestation

Forests store large amounts of carbon. Trees and other plants absorb carbon dioxide from the atmosphere as they grow. This is converted into carbon and stored in the plant's branches, leaves, trunks, roots and in the soil.

When forests are cleared or burnt, stored carbon is released into the atmosphere, mainly as carbon dioxide. Averaged over 2015 – 2017, global loss of tropical forests contributed about 4.8 billion tonnes of carbon dioxide per year (or about 8-10% of annual human emissions of carbon dioxide) (WRI 2018).

Whilst forests are important carbon sinks, meaning they draw down carbon dioxide from the atmosphere, the carbon stored in these sinks is part of an active, relatively quick carbon cycle. As living things (including trees) die and decay, the carbon that they once stored is released back into the atmosphere.

Methane

Methane (CH_4) is the second most important greenhouse gas. It is more potent than CO_2, but exists in far lower concentrations in the atmosphere. CH_4 also hangs around in the atmosphere for a shorter time than CO_2 - the residence time for CH_4 is roughly 10 years, compared with hundreds of years for CO_2. Natural sources of methane include many wetlands, methane-oxidizing bacteria that feed on organic material consumed by termites, volcanoes, seepage vents of the seafloor in regions rich with organic sediment, and methane hydrates trapped along the continental shelves of the oceans and in polar permafrost. The primary natural sink for methane is the atmosphere itself; another natural sink is soil, where methane is oxidized by bacteria. As with CO_2, human activity is increasing the CH_4 concentration faster than it can be offset by natural sinks. Human sources (rice cultivation, livestock farming, the burning of coal and natural gas, biomass combustion, and decomposition in landfills) currently account for approximately 70 percent of total annual emissions, leading to substantial increases in concentration over time.

Global warming has often been described as one of the most serious environmental problems ever to confront humanity, as this problem is inextricably linked to the process of development and economic growth itself. Since greenhouse gases are generated by burning fossil fuels as in power plants, factories and automobiles, it is not easy to reduce emissions, since virtually every facet of our lives is intimately tied to the consumption of energy. Climate change is an unusually difficult issue for the people who make the decisions in democratic governments. First of all, the science is uncertain while governments have to make firm policy decisions, if only the decision to do nothing, long before these uncertainties can be resolved.

Each year, scientists learn more about the consequences of global warming, and many agree that environmental, economic, and health consequences are likely to occur if current trends continue. Here's just a smattering of what we can look forward to:

- Melting glaciers, early snowmelt, and severe droughts will cause more dramatic water shortages and increase the risk of wildfires in the American West.

- Rising sea levels will lead to coastal flooding on the Eastern Seaboard, especially in Florida, and in other areas such as the Gulf of Mexico.
- Forests, farms, and cities will face troublesome new pests, heat waves, heavy downpours, and increased flooding. All those factors will damage or destroy agriculture and fisheries.
- Disruption of habitats such as coral reefs and Alpine meadows could drive many plant and animal species to extinction.
- Allergies, asthma, and infectious disease outbreaks will become more common due to increased growth of pollen-producing ragweed, higher levels of air pollution, and the spread of conditions favorable to pathogens and mosquitoes.

For India, the climate change issue has several ramifications: First, although India does not currently have any obligations under the Convention to reduce its greenhouse gas emissions, international pressure will keep increasing in this regard. It is therefore important for us to develop a clear understanding of our emission inventory. We also need to document and analyse our efforts in areas such as renewable energy, wasteland development and afforestation – all of which contribute towards either reducing CO2 emissions or increasing CO2 removal from the atmosphere. Considering that these efforts may often be undertaken for a variety of reasons not directly related to global warming, but yet have benefits as far as climate change is concerned, we may be able to leverage such efforts in the international context.

India is the fourth highest emitter of carbon dioxide in the world, accounting for 7 per cent of global emissions in 2017, a study said on Wednesday. India's emissions look set to continue their strong growth by an average of 6.3 per cent in 2018, with growth across all fuels — coal (7.1 per cent), oil (2.9 per cent) and gas (6.0 per cent), the study said. The top 10 emitters were China, the US, the EU, India, Russia, Japan, Germany, Iran, Saudi Arabia and South Korea. The study also said that the Indian emissions were projected to grow 2 per cent in 2017, compared to 6 per cent per year averaged over the previous decade, due to significant government interventions in the economy.

In India, emissions are expected to grow by a solid 6.3 per cent in 2018, pushed by strong economic growth of around 8 per cent per year. "Coal is still the mainstay of the Indian economy, and as in China, it will be a challenge for solar and wind to displace coal, given the strong growth in energy use," it said.

It also said that although global coal use is still 3 per cent lower than its historical high, it is expected to grow in 2018, driven by growth in energy consumption in China and India.

India is the world's second largest coal consumer after China, having overtaken the US in 2015. Coal has fuelled the rapid growth in Indian electricity use and its coal fleet has more than tripled in size since 2000. In 2017, coal generated 76% of India's electricity, as shown in the chart below (black area).

The IIT research has crucial implications for the fight against air pollution. "The findings suggest that there could be a sharper increase in warming as we reduce air pollution," AchutaRao said. According to the models used by AchutaRao and other authors, the warming contributed by natural factors was just 0.005 degree C, while GHGs caused about 1.85 degree C warming. The pollution and land use change was seen to have led to a cooling of 1.2 degrees C, resulting in about 0.65. The IIT research has crucial implications for the fight against air pollution. "The findings suggest that there could be a sharper increase in warming as we reduce air pollution," AchutaRao said.

According to the models used by AchutaRao and other authors, the warming contributed by natural factors was just 0.005 degree C, while GHGs caused about 1.85 degree C warming.The pollution and land use change was seen to have led to a cooling of 1.2 degrees C, resulting in about 0.65 degree C net warming. This compared well with the observed warming of about 0.5 degree C. The IIT study found the sharpest rise in temperatures in the western Himalayas, specifically J&K and adjoining areas. It found that GHGs accounted for a warming of as much as 3 degrees Celsius during the 50-year period. "Other anthropogenic factors" (pollution, land use change) offset this rise by 1.5 degrees C, resulting in a net rise of 1.5 degrees. Western Himalayas was among the seven homogeneous temperature regions in the country the researchers looked at. The others were east coast, west coast, interior peninsula, northwest India, northeast and north-central India. Northeast and north-central India were the only regions that showed no significant warming during the period under study. They estimated the contribution of natural and anthropogenic (human-caused) influences through a two-signal optimal fingerprinting analysis. The study further isolated the anthropogenic influences due to GHGs from other human-induced factors to arrive at their results.

Surface Level Ozone

The next most significant greenhouse gas is surface, or low-level, ozone (O_3). Surface O_3 is a result of air pollution; it must be distinguished from naturally occurring stratospheric O_3, which has a very different role in the planetary radiation balance. The primary natural source of surface O_3 is the subsidence of stratospheric O_3 from the upper atmosphere toward Earth's surface. In contrast, the primary human-driven source of surface O_3 is in photochemical reactions involving carbon monoxide (CO), such as in smog.

Nitrous oxides and fluorinated gases

Additional trace gases produced by industrial activity that have Greenhouse properties include Nitrous Oxide (N_2O) and Fluorinated gases (Halocarbons). The latter includes Sulfur Hexafluoride, Hydrofluorocarbons (HFCs), and Perfluorocarbons (PFCs). Nitrous Oxides have small background concentrations due to natural biological reactions in soil and water, whereas the fluorinated gases owe their existence almost entirely to industrial sources.

The Indian Scenario

- **India's Carbon Dioxide emissions up 5% (The Hindu)**
- India is the fourth highest emitter of carbon dioxide in the world, accounting for 7 per cent of global emissions in 2017 (Business Line).
- India's coal use increased relatively slowly in the first part of 2019. Oil demand growth moderated, too, meaning CO2 emissions in the first eight months of the year increased by an estimated 2.0%.
- A group of researchers have concluded that there has been no increase in the levels of methane emissions in India between 2010 and 2015. This is the first time that an independent assessment of India's methane emissions has been carried out. The research team included Anita L. Ganesan (University of Bristol); Abhijit Chatterjee (Bose Institute, Kolkata); Yogesh K. Tiwari (Indian Institute of Tropical Meteorology, Pune); Matt Rigby, Mark F. Lunt, Robert J. Parker, Hartmut Boesch, N. Goulding from UK; Taku Umezawa from Japan; Andreas Zahn from Germany, Ronald G. Prinn from US, Marcel van der Schoot and Paul B. Krummel from Australia. (India's methane emissions stable: study by Monika Kundu Srivastave | Updated on January 08, 2018 Published on October 18, 2017)
- The monthly average maximum concentration in summer was found to be in the range of 62–95 ppb whereas, it was found to be 50–82 ppb in the autumn (October and November). The analysis of hourly averaged surface ozone data illustrates that on a large number of days the surface ozone values at Delhi exceed the World Health Organization (WHO) ambient air quality standards (hourly average of 80 ppb) for ozone.
- Surface ozone (O3) concentrations are obtained from measurements in rural, urban and free tropospheric environments in January 2001 and 2002 as a part of Mobile Lab Experiments (MOLEX) conducted in western India. Elevated O3 from 70 to 110 ppbv (nmole/mole) are recorded during afternoon hours at rural sites in downwind of major industrial region of Gujarat adjoining the Arabian Sea. Repeated observations during both the years indicate that this is a regular process in this region. The average background ozone is found to be 42±6 ppbv. The elevated ozone in the downwind site is about 60% higher than that in the major urban center and its surroundings and by a factor of 2 higher than the background levels of O3 in this region.
- The research by Jadavpur University, Kolkata and Thailand's Asian Institute of Technology scientists reveals that "nitrous oxide emission from nitrogen-fertiliser use increases by around 358 percent, growing at a "statistically significant rate of 5100 tonnes per year" from 1980-1981 to 2014-2015.
- The total non-carbon dioxide emission from cropland-based agricultural activities, mainly due to nitrous oxide, has gone up by approximately 49% in the past three decades, according to the analysis authored by Shreya Some, Joyashree Roy and Arpita

Ghose.

- India is globally the biggest source of ammonia emission, nearly double that of NOx emissions.
- But at the current rate of growth, NOx emissions will exceed ammonia emissions and touch 8.8 tonnes by 2055, the report says.
- Greenhouse gases include not just carbon dioxide but also methane, nitrous oxide and fluorinated gases, which constitute 28% of all GHG emissions and India contribute to over 30%. The top emitters of GHG remain China (26%), U.S. (13%), India (7%).

(Hindustan Times: India saw largest rise in GHG emissions in 2016 among major emitters)

CONCLUSION

To reduce the carbon footprint by following the steps like conserving energy a part of your daily routine and your decisions as a consumer. When one shops for new appliances like refrigerators, washers, and dryers, look for products with the government's Energy Star label; they meet a higher standard for energy efficiency than the minimum federal requirements. When one buys a car, look for one with the highest gas mileage and lowest emissions. One can also reduce the emissions by taking public transportation or carpooling when possible. There is concern in India over the health impact of coal plants. One in every eight deaths in India is due to air pollution, according to a recent report in the Lancet Planetary Health, while India is home to half of the world's 20 most polluted cities. India's climate pledge notes that around 70% of its population depends on traditional biomass energy, which is inefficient and causes high levels of indoor air pollution. Greenhouse gases have raised India's temperatures much more than what we have experienced but it has been offset substantially by aerosols and land use change. Importantly, there was no contribution to warming from natural causes.

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