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GLOBAL WARMING AND ITS CONSEQUENCES

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Abstract

The increased concentration of various greenhouse gases mostly due to anthropogenic causes in today's world is responsible for global warming. Global warming in turn is causing various climatic changes. The rising temperature leads to various changes in our environment, ecosystem, hydrosphere, social- economic life, flora and fauna etc. This study is an attempt to identify the various natural and man-made factors causing global warming and their consequences. At the end of the study some remedial measures are being suggested to tackle the global climatic crisis.

Key words: Greenhouse gases, Anthropogenic factors, Global warming, Global environmental crisis, Ecological communities, Afforestation programmes, Non-conventional sources of energy, Collective global efforts.

Introduction

Climate change, driven by increased greenhouse gas emissions, is a critical global environmental crisis. India, too, is experiencing profound environmental, economic, and social transformations due to extreme climatic patterns. The country faces a wide range of climate-related issues, like increased unpredictable monsoon seasons, frequent incidence of severe heat waves, and heightened risk of droughts and floods across various regions. All these are having a profound impact on Indian agriculture, water resources, public health, and overall economic stability.

Since the geological past, the world's climate has undergone glacial and interglacial periods. The glacial periods were marked by cold climates, whereas the interglacial periods were marked by warmer climates. The warmer periods were the result of natural factors, mainly with no human role. However, the current rapid global warming, several times faster than past ice -age warming, is driven by human- produced greenhouse gases. (National Aeronautics and Space Administration, Science, 2006)

Global warming, due to increased concentration of greenhouse gases in the lower layers of the atmosphere, leads to melting of glaciers and polar ice caps, rising sea levels, increased frequency of extreme weather events like devastating floods, catastrophic storms, prolonged heat waves, etc., intense droughts, water scarcity, severe fires, declining biodiversity, etc. The ongoing changes in the global climate are intensifying risks across ecological systems, public health, and economic stability.

FACTORS OF GLOBAL WARMING

A) Anthropogenic Factors: The IPCC Fifth Assessment Report (AR5), finalized in 2014, unequivocally confirmed that human influence is the dominant cause of observed global warming since 1950. The various anthropogenic factors responsible for the increase in emissions of carbon dioxide are discussed below:

i) Burning of fossil fuels

According to the Intergovernmental Panel on Climate Change (IPCC), human activities- particularly fossil fuel burning are the dominant cause of the global warming observed since the mid-20th century. Large amounts of carbon dioxide and other greenhouse gases are released into the atmosphere due to the burning of fossil fuels to generate electricity, run industries, and power vehicles. The power plants, the transportation sector, and the manufacturing units are the major users of fossil fuels.

ii) Deforestation

Deforestation contributes to global warming by increasing the amount of carbon dioxide in the atmosphere and reducing the earth's ability to absorb greenhouse gases. Large-scale felling of trees can also alter the rainfall cycles and increase surface temperature. For example, the indiscriminate clearing of the Amazon rainforest significantly contributes to the rising carbon dioxide levels (Nepstad et al., 2008).

iii) Industrialization and manufacturing

The factories and the manufacturing units release vast amounts of carbon dioxide, methane, and nitrous oxides – the powerful greenhouse gases. Increased concentration of these harmful gases in the atmosphere significantly intensifies the greenhouse effect. Moreover, the conversion of forest lands to manufacturing grounds reduces the forest cover. This reduces the planet's capacity to absorb carbon dioxide (Sejian et al., 2015).

iv) Agriculture and livestock

By releasing large amounts of various greenhouse gases, such as methane, nitrous oxide, and carbon dioxide, agriculture and livestock play a dominant role in global warming. Livestock production contributes approximately 14.5% to 18% of global greenhouse gas emissions (Sejian et al., 2015).

v) Transportation

Emissions from land, water, and air transport systems account for a significant portion of global energy-related carbon dioxide emissions. In 2016, global CO_2 emissions from transport were 7.9 billion tonnes, accounting for roughly 21% of global emissions. (Wang & Ge, 2019; World Resources Institute, 2014).The largest sources of transportation-related greenhouse gas emissions include passenger cars, trucks, minivans, public buses, etc. Commercial aircraft, ships, boats, and trains also contribute significantly.

B) Natural Factors: Natural factors of global warming are processes that occur without human intervention and influence earth's climate system over long periods. The various natural factors contributing to global warming are discussed below:

i) Volcanic eruption

Volcanic eruptions release substantial amounts of carbon dioxide and aerosols. The released carbon dioxide gets mixed up with the gases in the atmosphere and stays there for a long time. It prevents the terrestrial long-wave radiation, thus contributing to global warming in the long run.

ii) Insolation

In the early 20th century, Milutin Milankovitch, a Serbian astronomer, proposed that the occurrence of ice ages on earth was closely related to the shape of earth's orbit around the sun.

The Milankovitch cycle, which encompasses these orbital shifts, influences the seasonal and latitudinal distribution of incoming solar radiation (Sham, 2017).

When earth's orbit is at its most elliptic, about 23 percent, more incoming solar radiation reaches earth at our planet's closest approach to the sun each year compared to its farthest departure from the sun (Hays et al., 1976; National Aeronautics and Space Administration, 2017).

The melting of ice sheets is associated with warmer summers as a consequence of more incidence of insolation. During cooler summers, the ice sheets expand. As ice sheets grow, the atmospheric carbon dioxide concentrations decrease, reducing the greenhouse effect and causing further cooling. During warming phases, melting ice releases carbon dioxide stored in oceans, further elevating temperatures (Sham, 2017).

iii) Solar activity

Sunspot activities significantly influence the amount of solar radiation reaching the earth's surface. This activity follows an approximately 11-year solar cycle that directly influences the amount of solar radiation, or insolation, reaching earth. Higher sunspot numbers correspond to increased solar magnetic activity, which actually increases the total solar irradiance (energy output) by about 0.1% (Wilson and Hudson, 1991). Solar variation in solar output has contributed to past climate changes. Increased incidence of insolation on the earth's surface leads to higher temperatures (Sham, 2017).

iv) Natural release of greenhouse gases like water vapour

The rate of evaporation is directly related to temperature. Increasing temperature increases the rate of evaporation, whereby a larger amount of water vapour is added into the atmosphere. Water vapour, being an important greenhouse gas, further contributes to trapping heat.

v) Melting of ice

Climate change has caused profound impacts on natural and human systems globally, including rising sea levels (19 cm increase from 1900 to 2010), increased ocean acidification, and widespread melting of ice (Intergovernmental Panel on Climate Change, 2013, 2014).

Rising temperatures lead to the melting of ice sheets. Excessive melting of ice reduces the reflectivity of the planet, and hence, more heat is retained (ice being a good reflector).

When ice sheets expand during periods of lower summer insolation, they reflect more sunlight (high albedo), causing further cooling. Conversely, when ice sheets shrink due to increased solar energy, land and ocean surfaces absorb more heat (low albedo), reinforcing warming.

GREENHOUSE GASES: THE MAIN CULPRITS

Most atmospheric gases are largely transparent to incoming sunlight. Sunlight warms the ocean and land surfaces, and those sun-warmed surfaces radiate heat back into the atmosphere. The most abundant atmospheric gases, oxygen and nitrogen, are transparent to this outgoing heat (thermal infrared radiation), allowing it to travel freely out to space (Tuckett, 2018).

In contrast, greenhouse gases are not transparent to heat. They continually absorb heat energy and radiate it back into their surroundings. Greenhouse gas concentrations are currently at their highest levels in the past two million years and continue to rise. According to datasets from the National Aeronautics and Space Administration (NASA) and the National Oceanic and Atmospheric Administration (NOAA), the earth is approximately 1.1°C warmer than it was in the late 1800.

The five most abundant greenhouse gases in the earth's atmosphere, listed in decreasing order of average global mole fraction, are: water, carbon dioxide, methane, nitrous oxide, ozone. Other greenhouse gases of concern include chlorofluorocarbons (CFCs) hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6), and nitrogen trifluoride ((NF_3). Water vapour is responsible for approximately half of the greenhouse effect, primarily acting as a climate change feedback in response to other gases. (Hodnebrog et al., 2019; U.S. Environmental Protection Agency, 2016).

Table 1

Major Greenhouse Gases and Their Dominant Sources

Greenhouse gases	Dominant sources
Carbon Dioxide	Fossil fuel combustion, deforestation, cement production
Methane	Landfills, oil and natural gas systems, agricultural activities, coal mining, stationary and mobile combustion, wastewater treatment, and certain industrial processes
Ozone	Internal combustion engines and power plants, automobile exhaust and industrial emissions.
Nitrous Oxide	Fertilizer application, fossil fuel and biomass combustion, industrial processes.
Water vapour	Evaporation from earth’s water bodies
Fluorinated gases (F-gases) Hydro fluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6)	Refrigerants, aluminium smelting industry, electrical industry etc.

(Archer & Rahmstorf, 2010; Tuckett, 2018)

EFFECTS OF GLOBAL WARMING

The Environmental Protection Agency declared that carbon dioxide and other greenhouse gases are harmful to people and the environment. The effects of greenhouse gases can be summarized as follows

i) Effects on global climate

Increased concentration of greenhouse gases would cause a rise in temperature. The rising temperature would adversely affect the precipitation pattern. The increased temperature due to the increased greenhouse effect would cause a decrease in precipitation and soil moisture content in the most developed agricultural regions of the world. Heat waves will be common soon. (Intergovernmental Panel on Climate Change**,** 2014).

The impact of greenhouse gases, primarily carbon dioxide, is also expected to influence, rather than intensify, the depletion of the ozone layer, which would cause a further rise in the temperature of the earth's surface. It may be possible that the concentration of carbon dioxide may increase to such an extent that the total atmospheric pressure would be increased. This increase in the atmospheric pressure would broaden the absorption bands and increase the opacity of the atmosphere to the outgoing long-wave terrestrial radiation, which would in turn increase the surface temperature to such an extent that all the atmospheric processes essential for the sustenance of life in the biosphere would come to a grinding halt. It would lead to an increased incidence of extreme weather events. Disasters from destructive storms (cyclones, hurricanes, and typhoons), drought, floods, etc., often destroy homes and communities, causing deaths and huge economic losses.

ii) Effects on the ecosystem

Global warming significantly disrupts ecosystems by altering ecological communities, habitats, natural processes, and food chains. The rising temperature would largely affect plants and animal communities. They will face challenges to adjust to the changing environmental conditions caused by the rise in air temperature. As a result, the entire ecosystem may be adversely impacted. The degraded ecosystems will create adaptive problems leading to biodiversity loss at an unprecedented rate (Tewari et al., 2017).

iii) Effects on the hydrosphere

Greenhouse gases also have immense effects on the hydrosphere. If the concentrations of carbon dioxide continue to increase, the oceans will be required to absorb more and more carbon dioxide. More absorption and decomposition of carbon dioxide in the oceans would raise their normal level of acidity, thus endangering marine life and coral reefs. Increased oceanic acidity would decrease the biological productivity of the marine ecosystem, and the decreased plant cover in the oceanic areas would change the albedo of the ocean surface (Tuckett, 2018).

The increased surface temperature would cause melting of continental and mountain glaciers and polar ice caps. The resultant melt water would raise sea-level and thus would cause flooding and erosion of coastal areas of lowland countries. In cases of severe saltwater intrusion due to flooding, often the entire communities need to be relocated. The number of people displaced by weather-related events is expected to rise in the near future.

iv) Effects on the socio-economic sphere

Climate change affects the physical and emotional well-being of residents, including health effects, food and water scarcity, livelihood impacts, and displacement. Economic losses from climate events reduce resources available to address social issues.

Water is becoming scarcer, mainly in arid and semi-arid regions, due to scanty rainfall. The deserts are expanding due to extreme dryness, reducing land for growing food. The farmers who rely on agricultural production as their sole source of income face the brunt of multiple crises. The decline in production in the agricultural sector due to decreased precipitation will hard hit the farmers in general and the economy of the country as a whole, where agriculture is the main livelihood. Moreover, the occurrence of extreme events like floods, droughts, etc., also jeopardises agricultural livelihoods.

Global warming is having a profound influence on winter recreation activities. The Ski industry mainly is. experiencing shorter seasons, receding glaciers, and a reliance on energy-intensive artificial snow, with some regions already forced to repurpose or close lower-altitude resorts (Gilaberte-Búrdalo et al., 2014).

Changes in the climate and increases in extreme weather events are disrupting food chains, endangering global fisheries, and jeopardizing livelihoods for the communities that depend on them. (United Nations, 2019) Fisheries, crops, and livestock are on the verge of being destroyed or becoming less productive. A sharp decline in livestock is noticeable as a consequence of water shortages and the shrinkage in grasslands. Increasing acidification of the oceans is causing harm to the extensive marine resources that feed billions of people. This crisis disrupts food chains, endangers global fisheries, and jeopardizes livelihoods for the communities that depend on them.

v) Effects on human health

Climate change has a profound influence on human health, either directly through changing weather patterns or indirectly through changes in water, air, food, ecosystems, livelihoods, and infrastructure

The occurrence of diseases, death, disability, suffering, etc. are rising sharply as a consequence of declining water supplies, reduced food production, heightened hunger and malnutrition, extreme events, air pollution, etc. Environmental factors, including pollution, climate change, and unsafe environments, are responsible for approximately 13 million deaths annually, accounting for nearly one-quarter of all global deaths (World Health Organization, 2016).

Changing weather patterns are facilitating the spread of diseases, while extreme weather events increase deaths and make it difficult for health care systems to respond.

vi) Effects on plants and organisms

Altered weather patterns resulting from the greenhouse effect intensify drought, directly affecting plant growth and productivity**.** Less productive plants mean fewer sources of food for all animal species. Acid rain causes trees to die, reducing natural habitat for animals and prompting animals to migrate to new areas. The earlier snowmelt and higher temperatures—and resulting drier soils from increased evaporation—in addition to greater water loss from vegetation ,have all contributed to lengthening fire seasons in western regions.

According to recent research, global warming threatens the breeding grounds of the emperor penguins. If the current global warming trend continues, more than 80% of Emperor penguin colonies will disappear by 2100 (Jenouvrier, 2019).

The boreal forests appear increasingly vulnerable to indirect effects of rising temperatures, including temperature-induced drought stress, increased frequency of fires, heightened risk of insect outbreaks and more frequent climate extremes.

Climate change poses significant risks to the survival of terrestrial and marine species. Exacerbated by climate change, the world is losing species at a rate 1,000 times greater than at any other time in recorded human history (Dell'Amore, 2014).

One million species are at risk of becoming extinct within the next few decades. Forest fires, extreme weather, and invasive pests and diseases are among the many threats related to climate change. Some species will be able to relocate and survive, but others will not.

A 2019 United Nations-backed report from the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) warned that roughly one million animal and plant species are threatened with extinction, many within decades. This unprecedented decline, driven by human activities like land-use change, climate change, pollution, and overexploitation, is occurring 10 to 1,000 times faster than the natural rate. (United Nations, 2019)

Conclusion:

Global warming is primarily caused by the increased concentration of greenhouse gases from human activities such as burning fossil fuels, deforestation, and industrial processes. Its effects include rising global temperatures, changing rainfall patterns, melting ice caps, and more frequent extreme weather events. These changes severely impact ecosystems, human health, agriculture, and overall economic stability.

The unprecedented rate of global warming can be slowed by reducing the emission of greenhouse gases and by adopting various afforestation programmes. These include substituting the use of fossil fuels with non-conventional sources of energy, using energy- efficient gadgets, restoring wetlands, and forests etc. which act as carbon sink.

Since anthropogenic factors dominate in the global rise of temperature, the success depends on both large-scale governmental policies (like carbon pricing) and individual behavioural changes. The fossil fuels should be judiciously used, reducing misuse. The world should be made greener to tackle with the global climate issues and make it more habitable.

Addressing global warming requires a coordinated international effort through agreements, policies, and shared climate goals to reduce greenhouse gas emissions. Collective action by governments, industries, and individuals is essential to transition toward sustainable energy and protect the planet for future generations.

The Paris Agreement is a legally binding international treaty adopted by 195 parties at COP21 in December 2015, aiming to limit global temperature increases to well below 2°C—preferably to 1.5°C—above pre-industrial levels. It requires countries to submit updated national climate plans. The Nationally Determined Contributions (NDCs) are updated every five years to reduce greenhouse gas emissions and achieve net-zero emissions by mid-century (United Nations Framework Convention on Climate Change, 2015).

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