M.Sc. SEM-I 2021

SUBJECT: GEOGRAPHY

Paper: Geo 103 Unit: GEO103.1(Climatology)

Topic: Climate Change & Global Warming

- **Climate change** means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods (100 years).
- Climate change is usually measured in major shifts in temperature, rainfall, snow, and wind patterns lasting decades or more.
- Humans are creating climate change by burning large amounts of fossil fuels (coal, oil, natural gas), **deforestation (when forests are cut down or burned, they can no longer store carbon, and the carbon is released to the atmosphere)**.

Greenhouse effect and Global Warming

- A greenhouse is a structure whose roof and walls are made chiefly of transparent material, such as glass, in which plants requiring regulated climatic conditions are grown.
- In a greenhouse, the **incident solar radiation (the visible and adjacent portions of the infrared and ultraviolet ranges of the spectrum)** passes through the glass roof and walls and is absorbed by the floor, earth, and contents, which become warmer and **re-emit the energy as longer-wavelength infrared radiation (heat radiation)**.
- **Glass and other materials used for greenhouse walls do not transmit infrared radiation**, so the **infrared cannot escape via radiative transfer**.
- As the structure is not open to the atmosphere, heat also **cannot escape via convection**, so the temperature inside the greenhouse rises. This is known as the 'greenhouse effect'.

Importance of Natural Greenhouse Effect

- The green-house effect is a natural phenomenon and has been occurring for millions of years on the earth.
- Life on the earth has been possible because of this natural greenhouse effect which is due to water vapour and small particles of water present in the atmosphere.
- Together, these produce more than 95 percent of total greenhouse warming.
- Average global temperatures are maintained at about 15°C due to natural greenhouse effect.
- Without this phenomenon, average global temperatures might have been around –17°C and at such low temperature life would not be able to exist.

Greenhouse Gases (GHGs)

- Atmospheric gases like **carbon dioxide, methane, nitrous oxide (N_2O), water vapour, and chlorofluorocarbons** are capable of **trapping the out-going infrared radiation** from the earth's surface thereby causing **greenhouse effect**.

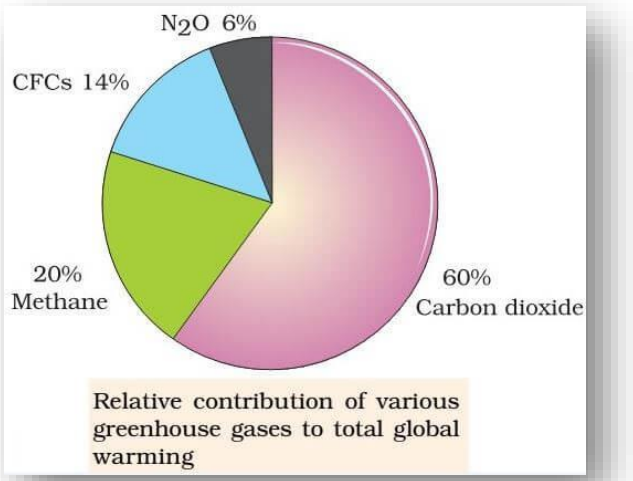
- Hence these gases are known as **greenhouse gases** and the heating effect is known as **greenhouse effect**.

Oxides of Nitrogen with general formula ***NO_x – NO, NO_2 – Nitrogen oxide, Nitrogen dioxide etc. are global cooling gasses while Nitrous oxide (N_2O) is a greenhouse gas.***

- If greenhouse gases are not checked, by the turn of the century the temperature may rise by 5°C.
- Scientists believe that this rise in temperature will lead to deleterious changes in the environment and resulting in odd climatic changes (e.g. increased incidence of El Nino), thus leading to increased melting of polar ice caps as well as of other places like the Himalayan snow caps.

Cryosphere: ***The cryosphere is the frozen water part of the Earth water system. Polar regions, snow caps of high mountain ranges are all part of cryosphere.***

- Over many years, this will result in a rise in sea level that can submerge many coastal areas and lead to loss of coastal areas and ecosystems like swamps and marshes (most important ecosystems from the point of ecological services), etc.



Relative contribution of various greenhouse gases to total global warming

Gas	Sources and Causes
Carbon dioxide (CO_2)	Burning of fossil fuels, deforestation
Chlorofluorocarbons (CFCs)	Refrigeration, solvents, insulation foams, aero propellants, industrial and commercial uses
Methane (CH_4)	Growing paddy, excreta of cattle and other livestock, termites, burning of fossil fuel, wood, landfills, wetlands, fertilizer factories.

Nitrogen oxides (N_2O)	Burning of fossil fuels, fertilizers; burning of wood and crop residue.
Carbon Monoxide (CO)	Iron ore smelting, burning of fossil fuels, burning e-waste.

Carbon dioxide

- Carbon dioxide is meteorologically a very important gas as it is **transparent to the incoming solar radiation but opaque to the outgoing terrestrial radiation**.
- It absorbs a part of terrestrial radiation and reflects back some part of it towards the earth's surface. It is **largely responsible for the greenhouse effect**.
- Its **concentration is greater close to the earth's surface as it is denser than air**.

Ozone

- Ozone is another important greenhouse gas. But it is in **very small proportions at the surface**.
- Most of it is confined to the **stratosphere** where it **absorbs the harmful UV radiation**.
- At ground level, pollutants like **NO_2 react with volatile organic compounds** in the **presence of sunlight** to **produce ozone (tropospheric ozone)**.

Water vapour

- Water vapour is also a variable gas in the atmosphere, which decreases with altitude.
- Water vapour also decreases from the equator towards the poles.
- In the warm and wet tropics, it may account for **four per cent** of the air by volume, while in the dry and cold areas of desert and polar regions, it may be less than one per cent of the air.
- One unique feature about this greenhouse gas is that it **absorbs both incoming (a part of incoming) and outgoing solar radiation**.

Methane

- Methane is the **most important greenhouse gas after carbon dioxide**.
- It is produced from **decomposition of animal wastes and biological matter**.
- The emission of this gas can be restricted by using animal wastes and biological matter to produce **gobar gas (methane)**.

Nitrous Oxide (N_2O)

- **N_2O or Nitrous Oxide is a greenhouse gas**.

- **NO and NO_2** (nitric oxide or nitrogen oxide and nitrogen dioxide) emissions cause **global cooling** through the formation of (OH) radicals that **destroy methane molecules**, countering the effect of GHGs.

Carbon Monoxide

- Carbon monoxide is a **short-lived greenhouse gas (it is less dense than air)**.
- It has an **indirect** radiative forcing effect by **elevating concentrations of methane** and **tropospheric ozone** through chemical reactions with other atmospheric constituents (e.g., the hydroxyl radical, OH.) that would otherwise destroy them.
- Through natural processes in the atmosphere, it is eventually **oxidized to carbon dioxide**.

Fluorinated gases

Chlorofluorocarbons (CFCs)

- **CFCs were phased out via the Montreal Protocol** due to their part in **ozone depletion (explained in Geography > Climatology > Polar Vortex)**.
- This anthropogenic compound is also a greenhouse gas, with a much **higher potential to enhance the greenhouse effect** than CO_2.

Hydrofluorocarbons

- Hydrofluorocarbons are used as **refrigerants, aerosol propellants, solvents, and fire retardants**.
- These chemicals were developed as a **replacement for chlorofluorocarbons (CFCs)**.
- Unfortunately, HFCs are potent greenhouse gases with **long atmospheric lifetimes**.

Perfluorocarbons

- Perfluorocarbons are compounds produced as a **by-product in aluminium production** and the **manufacturing of semiconductors**.
- Like HFCs, PFCs generally have **long atmospheric lifetimes** and **high global warming potential**.

Sulphur hexafluoride

- Sulphur hexafluoride is also a greenhouse gas.
- Sulphur hexafluoride is used in **magnesium processing and semiconductor manufacturing**, as well as a **tracer gas for leak detection**.
- Sulphur hexafluoride is used in electrical transmission equipment, including circuit breakers.

Black Carbon or Soot

- Black carbon (BC) is a solid particle or aerosol (though not a gas) that contributes to warming of the atmosphere. Black carbon, commonly known as soot.
- Soot is a form of **particulate air pollutant**, produced from **incomplete combustion**.
- Black carbon warms the earth by absorbing heat in the atmosphere and by **reducing albedo** (the ability to reflect sunlight) when deposited on snow and ice.
- BC is the **strongest absorber of sunlight and heats the air directly**.
- In addition, it darkens snow packs and glaciers through deposition and leads to melting of ice and snow.
- Regionally, **BC disrupts cloudiness and monsoon rainfall**.
- Black carbon stays in the atmosphere for **only several days to weeks**.
- Thus, the effects of BC on the atmospheric warming and glacier retreat disappear within months of reducing emissions.

Brown Carbon

- Brown carbon is a ubiquitous and unidentified component of organic aerosol.
- Biomass burning (possibly domestic wood burning) is shown to be a major source of brown carbon
- Brown carbon is generally referred for greenhouse gases and black carbon for particles resulting from impure combustion, such as soot and dust.