VISIONIAS
INSPIRING INNOVATION

CLIMATE CHANGE & GLOBAL WARMING

QUICK REVISION MODULE

[UPSC PRELIMS 2024] ENVIRONMENT

AHMEDABAD | BENGALURU | BHOPAL | CHANDIGARH | DELHI | GUWAHATI | HYDERABAD | JAIPUR | JODHPUR | LUCKNOW | PRAYAGRAJ | PUNE | RANCHI

What is Climate Change?

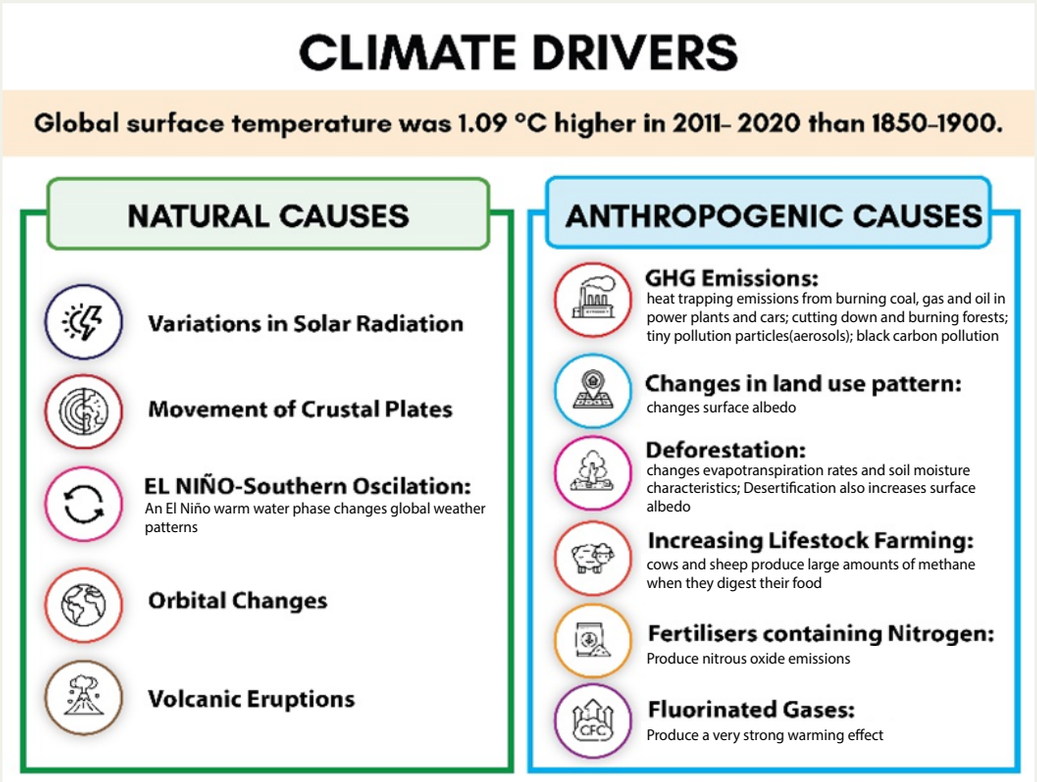
The **United Nations Framework Convention on Climate Change (UNFCCC)** defines climate **change as a change of climate which is attributed directly or indirectly to human activity that** alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

Theories of Climate Change

Theories of Climate Change

- Astronomical or Orbital Theory
  - The **Earth's orbit around the sun changes overtime.** It leads to variations in the amount of solar radiation received, thereby affecting the climate.
- Theories of continental drift
  - The continental drift theory of **Wegner,** the sea floor spreading **by H.H. Hess,** and the plate tectonics **by Morgan** reveal that the continents and ocean basins are under constant movement. Changes in the distribution of continents and ocean basins also lead to changes in climate.
- Theories about the changes in the Atmospheric Composition
  - Variation in the composition of the atmosphere (Co_2, NO_2, CH_4, H_2O etc.) can affect climate.
  - The **carbon dioxide theory** about climate change was put forward by T.C. Chamberlin.
- The Volcanic Dust Theory
  - The **volcanic dust deflects light of short wavelengths** coming from the sun, but allows the long wave terrestrial radiation to easily pass through, thus cooling the Earth's temperature.
  - The volcanic dust is considered to be responsible for the **'Little Ice Age'.**
- Sunspots Theory
  - The number of **sunspots increases and decreases** over **an 11-year cycle.**
  - There is a close relationship between the sunspots and the heat and energy received at the earth's surface.

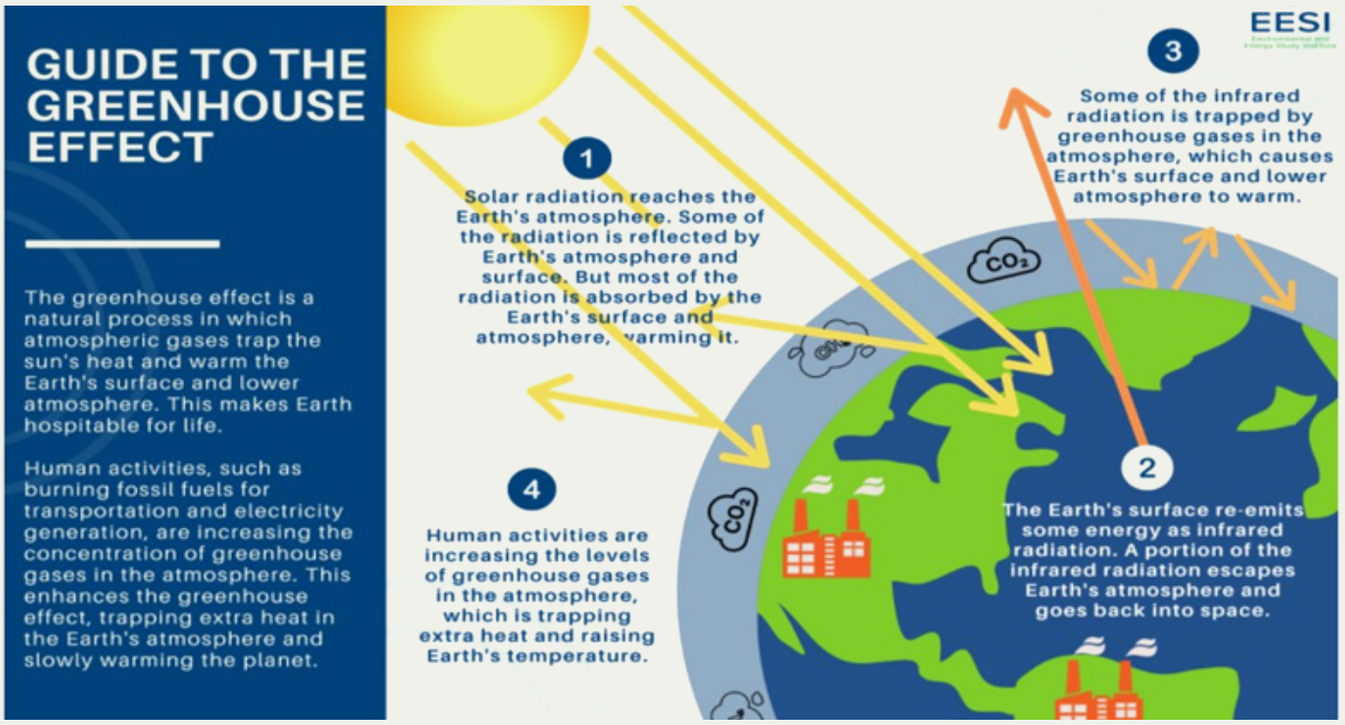
Climate Change Drivers



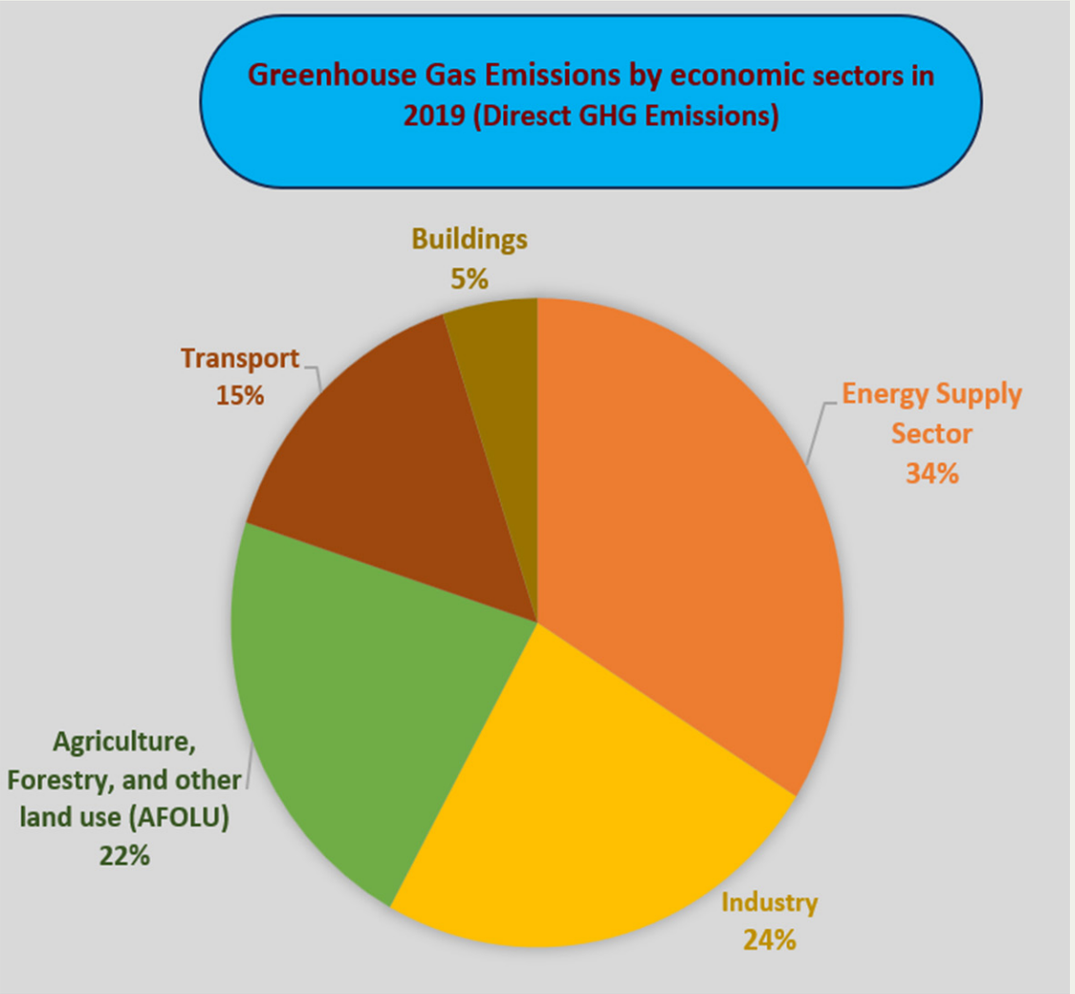
Greenhouse Gases and Global warming: Green House Effect, Sources & Causes and Evidences

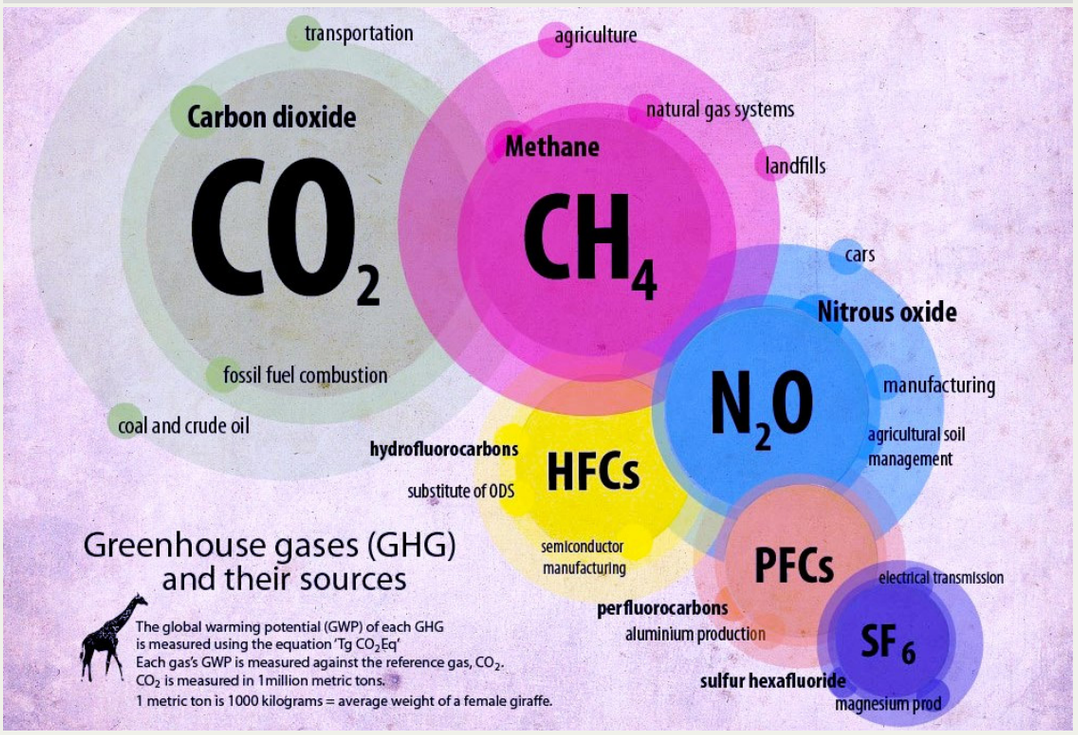
What is Global warming?

Global warming refers to the increase in average global temperature since the Industrial Revolution. The average global temperature has increased by more than one degree Celsius since 1880. Global warming is an ongoing process; scientists expect the average global temperature to rise an additional 0.3 to 0.7 degrees Celsius through 2035.

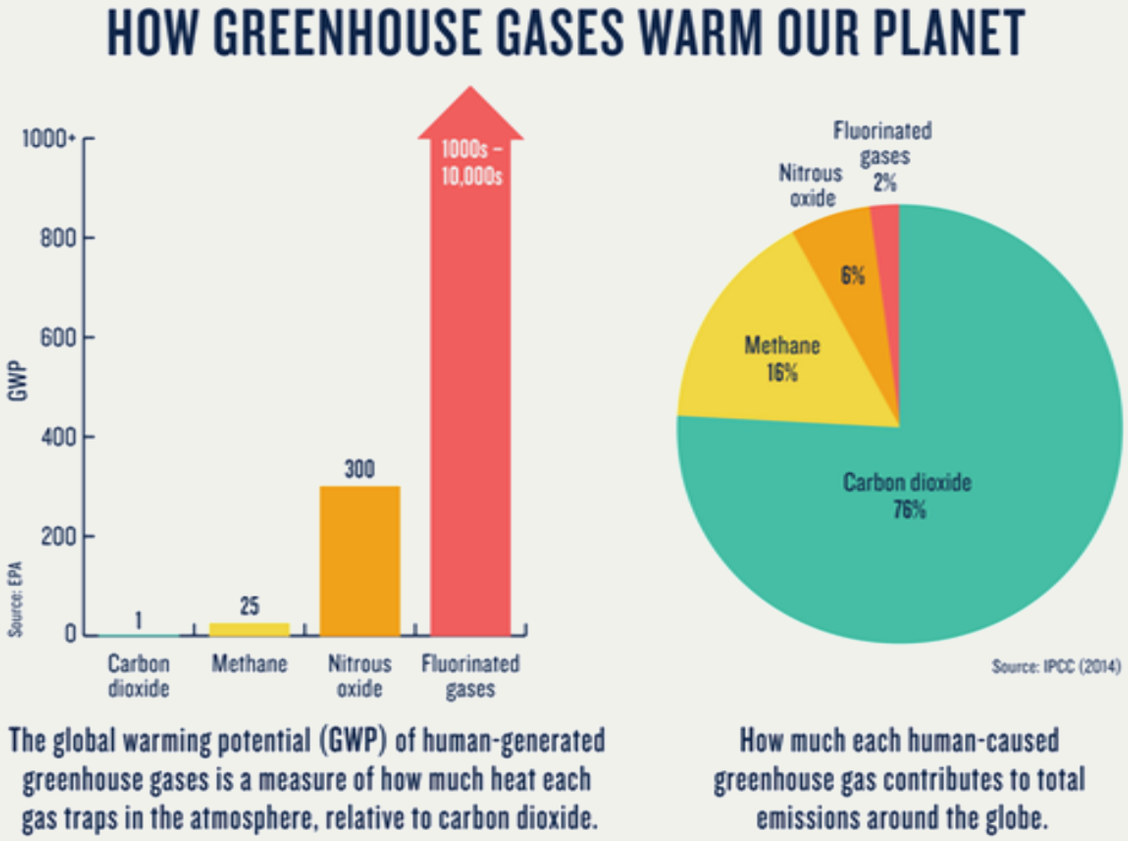


Greenhouse Gases: Sources and Causes





Global Warming Potential (GWP):



The Global Warming Potential (GWP) was developed to allow comparisons of the global warming impacts of different gases.

It is a measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to the emissions of 1 ton of carbon dioxide (CO_2).

The larger the GWP, the more that a given gas warms the Earth compared to CO_2 over that time period. The time period usually used for GWPs is 100 years.

Greenhouse Gases	Atmospheric lifetime (yrs)	GWP	Sources/Causes
Carbon Dioxide (CO_2)	50-200	1	Burning of fossil fuels, deforestation
Methane (CH_4)	12±3	21	Growing paddy, excreta of cattle and other livestock, termites, burning of fossil fuels, wood, landfills.
Nitrous Oxide (N_2O)	120	310	Burning of fossil fuels, fertilizers; burning of crop residue
Hydrofluorocarbons (HFCs)	1.5 to 209	150 to 11700	Primarily produced for **use in refrigeration, air-conditioning,** insulating foams and aerosol propellants
Perfluorocarbons (PFCs)	2600 to 50000	6500 to 9200	The **aluminum smelting** industry has been a major source of atmospheric perfluorocarbons.
Sulfur Hexafluoride (SF_6)	3200	23900	SF6 is a substance which originates **only from anthropogenic sources** used primarily in the electricity and electronics supply industries, e.g., the semiconductor industry, where it is used as an electronic insulator due to its inertness.

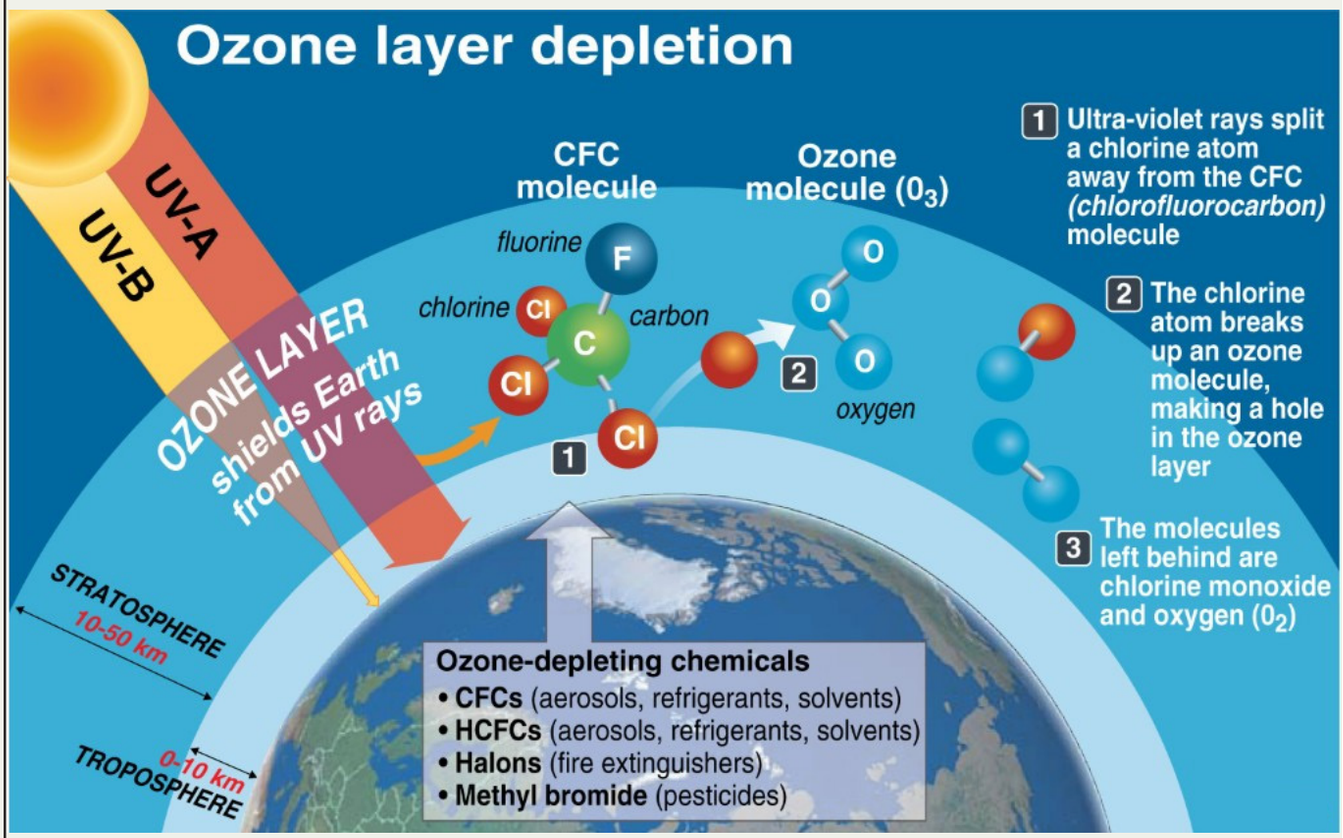
Global warming evidences

Evidence of Global Warming

- **Higher CO_2 concentrations in 2019** than at any time **in at least 2 million years.**
- **Unprecedented Global nature of glacier retreat since the 1950s** in at least the **last 2000 years.**
- **Global surface temperature has increased** faster since 1970 than in any other **50-year period over at least the last 2000 years**.
- **Increase in Global mean sea level** by 0.20 m between 1901 and 2018**, faster than** over any preceding century in at least the **last 3000 years.**
- **Lowest Annual average Arctic Sea ice area** in 2011–2020 **since at least 1850.**
- **Faster warming of Global ocean** over the past century than since the **end of the last deglacial transition** (around 11,000 years ago).
- **Unusually low Surface open ocean pH** in recent decades in the **last 2 million years.**

Ozone Layer Depletion

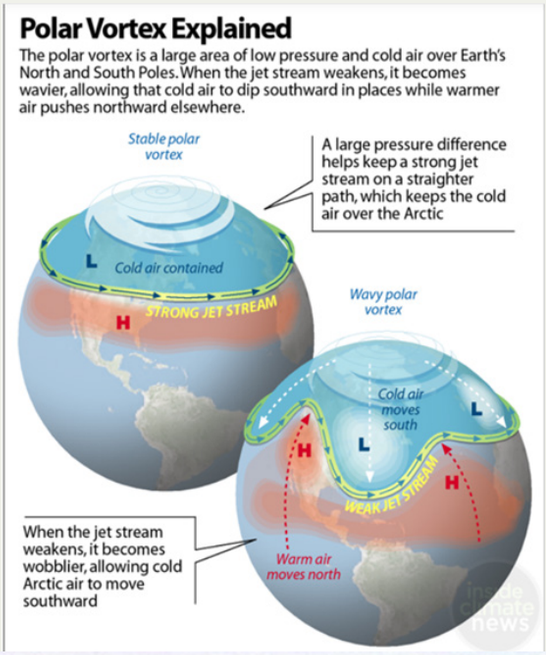
- The main reason of ozone layer depletion is believed to be the release of chlorofluorocarbon compounds (CFCs), also known as freons.
- Once CFCs are released in the atmosphere, they mix with the normal atmospheric gases and eventually reach the stratosphere. In stratosphere, they get broken down by powerful UV radiations, releasing chlorine free radical. The chlorine radicals are continuously regenerated and cause the breakdown of ozone.

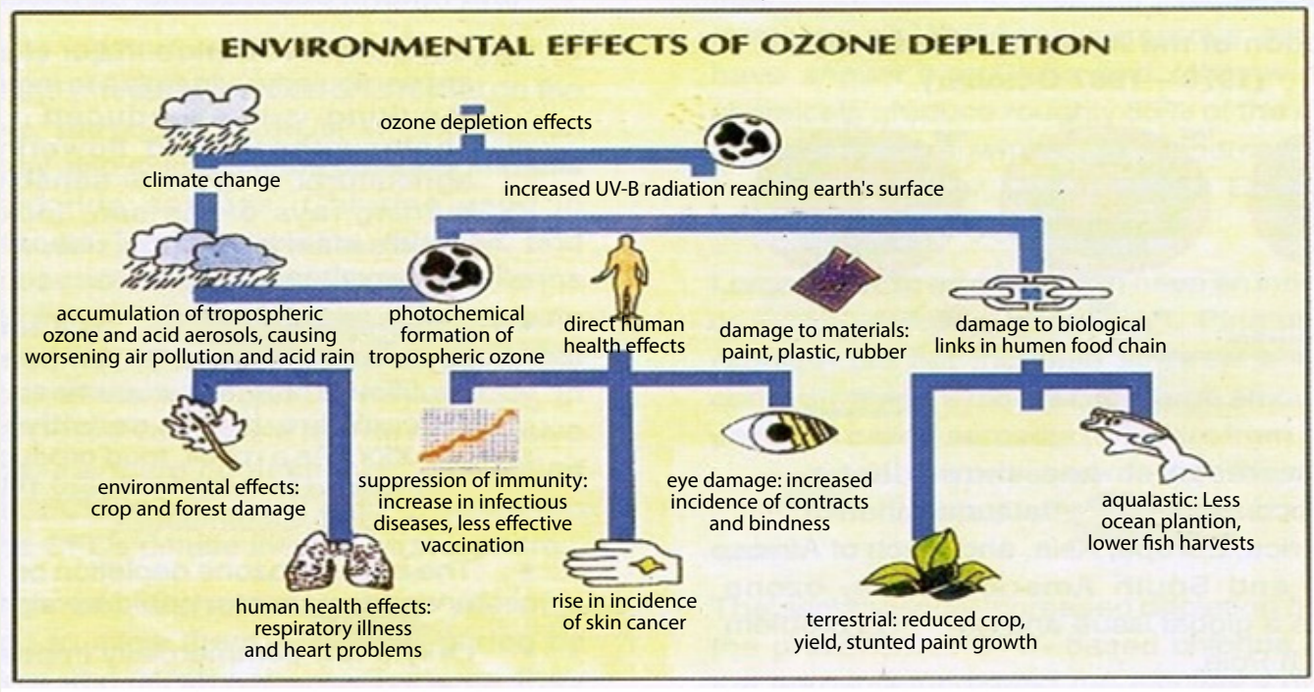


Ozone- Depleting Substances	Sources
Chlorofluorocarbons	Manufacturing of polyurethane, phenolic, polystyrene and polyolefin foam polymers, blowing agents
Halons	Used in portable fire extinguishers.
Hydrochlorofluorocarbons (HCFCs)	Used in the refrigeration, foam, solvent, aerosol and firefighting sectors as a transitional substance to substitute CFCs.
Methyl Bromide	Used as a fumigant in agriculture, for pest control in structures and stored commodities, and for quarantine treatments.
Carbon Tetrachloride	Used as chlorinated solvent in different industries, feedstock for different CFCs.
Methyl Chloroform	Used for cold cleaning, vapour degreasing, chemical processing, adhesives in industries.
Nitrogen Oxides	Explosions of thermonuclear weapons, industrial emissions and agricultural fertilizers.

Role of Polar Stratospheric Clouds

- **In 1980s** atmospheric scientists working in Antarctica **reported** about **depletion of ozone layer** commonly known as ozone hole over the South Pole. It was found that a unique set of conditions was responsible for the ozone hole.
- **In summer season, nitrogen dioxide and methane react** with chlorine monoxide and chlorine atoms forming chlorine sinks, preventing much ozone depletion.
- **In winter,** special type of clouds called **polar stratospheric clouds** are formed over Antarctica. These clouds provide surface on which chlorine nitrate formed gets hydrolysed to form hypochlorous acid. It also reacts with hydrogen chloride produced to give molecular chlorine.

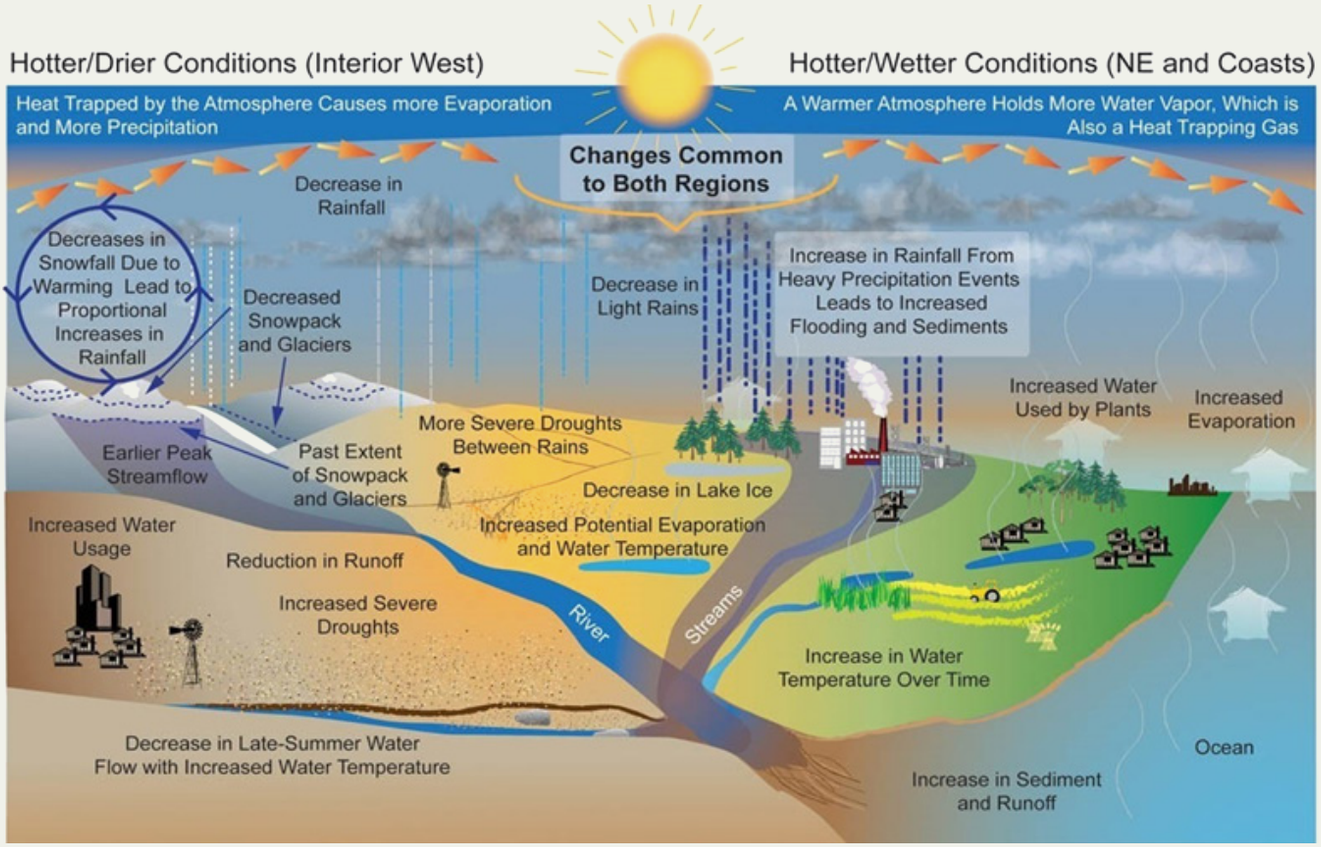




Consequences/ Impacts of climate change:

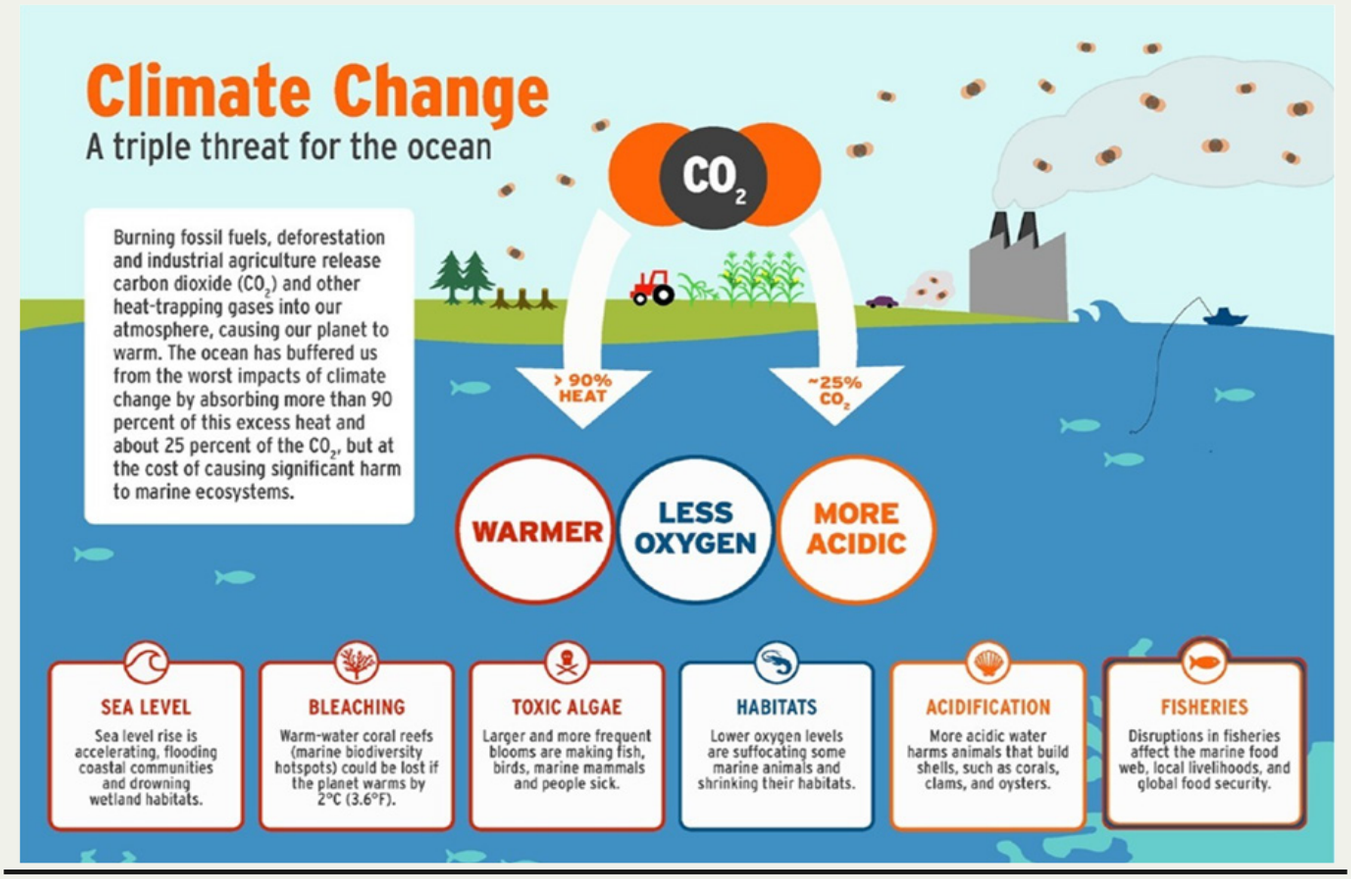
Impact on Hydological Cycle

1. **Water:** Reduced availability of water resources/ Serious threat to water security.
2. **Agriculture:** Water demand for crops and livestock will be affected. Affecting the crop yield in both irrigated and rainfed regions.
3. **Energy Production:** Climate change increases streamflow variability thus affecting the hydropower generation.
4. **Municipal Services:** Increased temperature can also encourage presence of algal bloom and cyanotoxins thus needing additional and new treatment methodologies.
5. **Freshwater Ecosystem:** Between 1970 and 2000, populations of freshwater species included in the **Living Planet Index** declined on average by 50%.

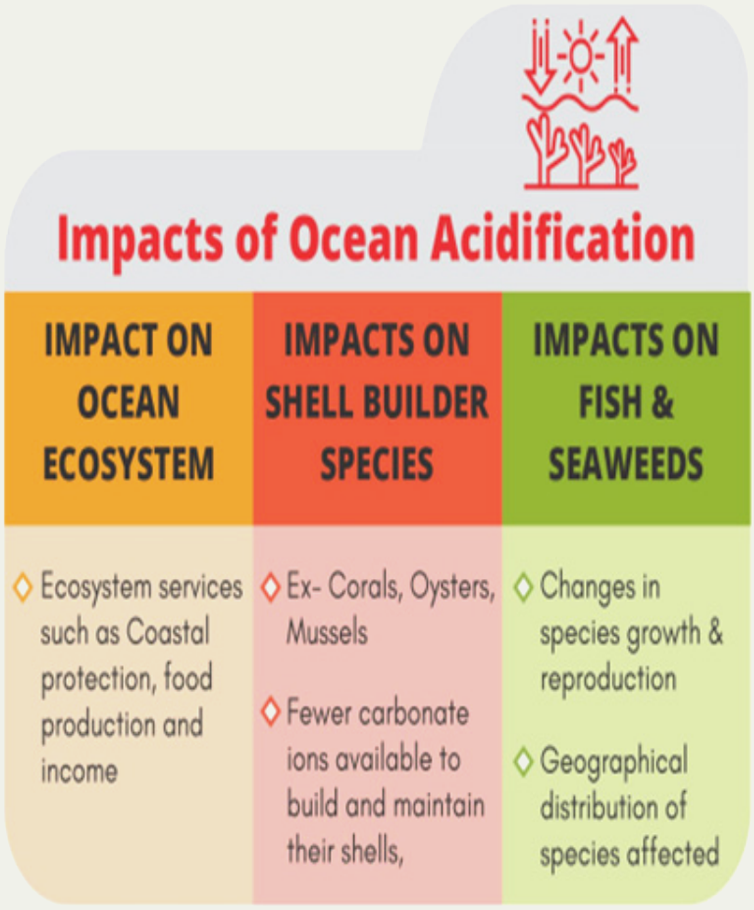


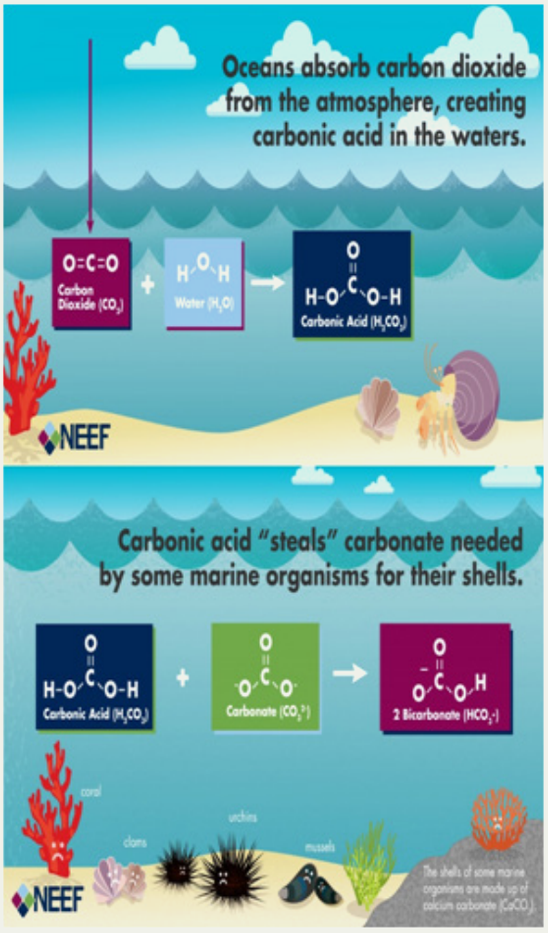
Impact on Oceans

- Ocean warming: Climate Change leads to more stable stratification of layers by density. Which promotes more Oxygen Minimum Zones (OMZs)

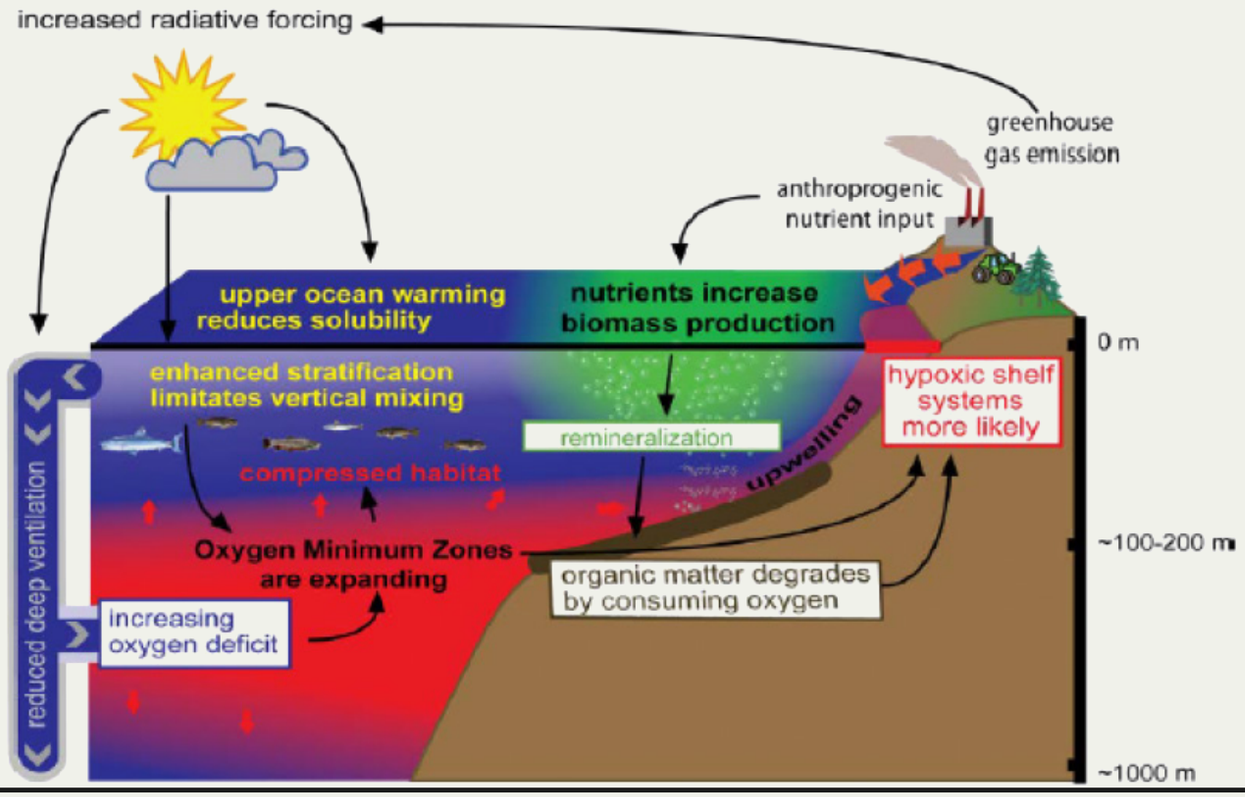


- Ocean Acidification: Anthropogenically emitted CO2 gets dissolved in the sea water. It forms Carbonic Acid in the process, reducing the pH of water.

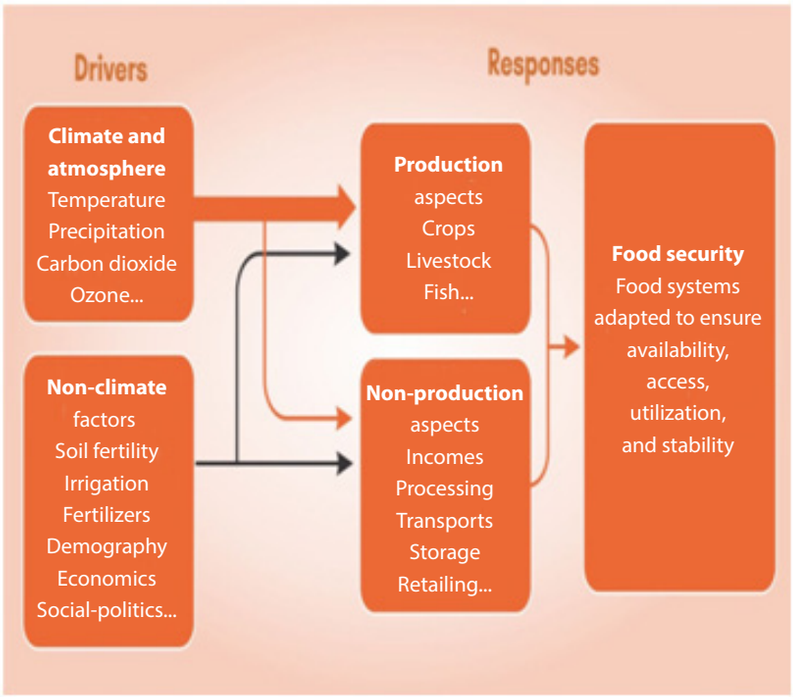




- Ocean Deoxygenation: Volumes of areas depleted of oxygen, known as **"anoxic waters.** Major causes include - degassing due to warming of sea water and less intermixing due to stable stratification of layers e.g. Baltic Sea and Black Sea.



Impact on Food Security



The multiple adverse impacts of global warming and climate change on food production

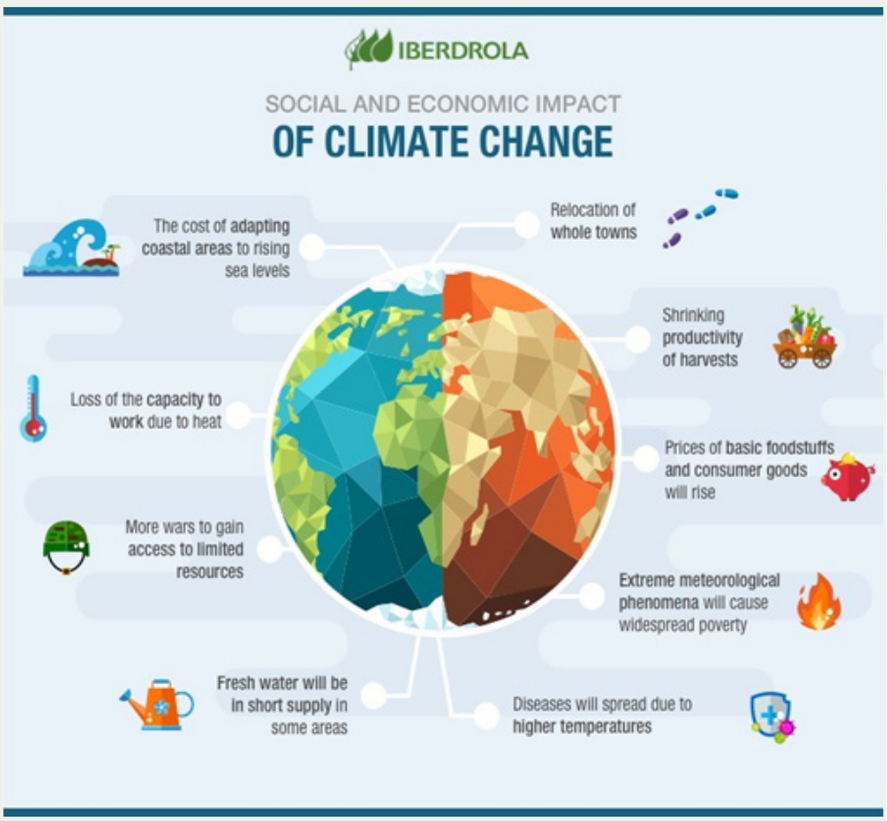
Global warming
- Heat waves
- Drought
- Soil erosion
- Tropospheric/ ground level ozone (toxic to plants)
- Weeds (more and resistant)
- Pests (more and resistant)
- Plant diseases
- Soil salinization - from sea level rise

Combined

Cumulative

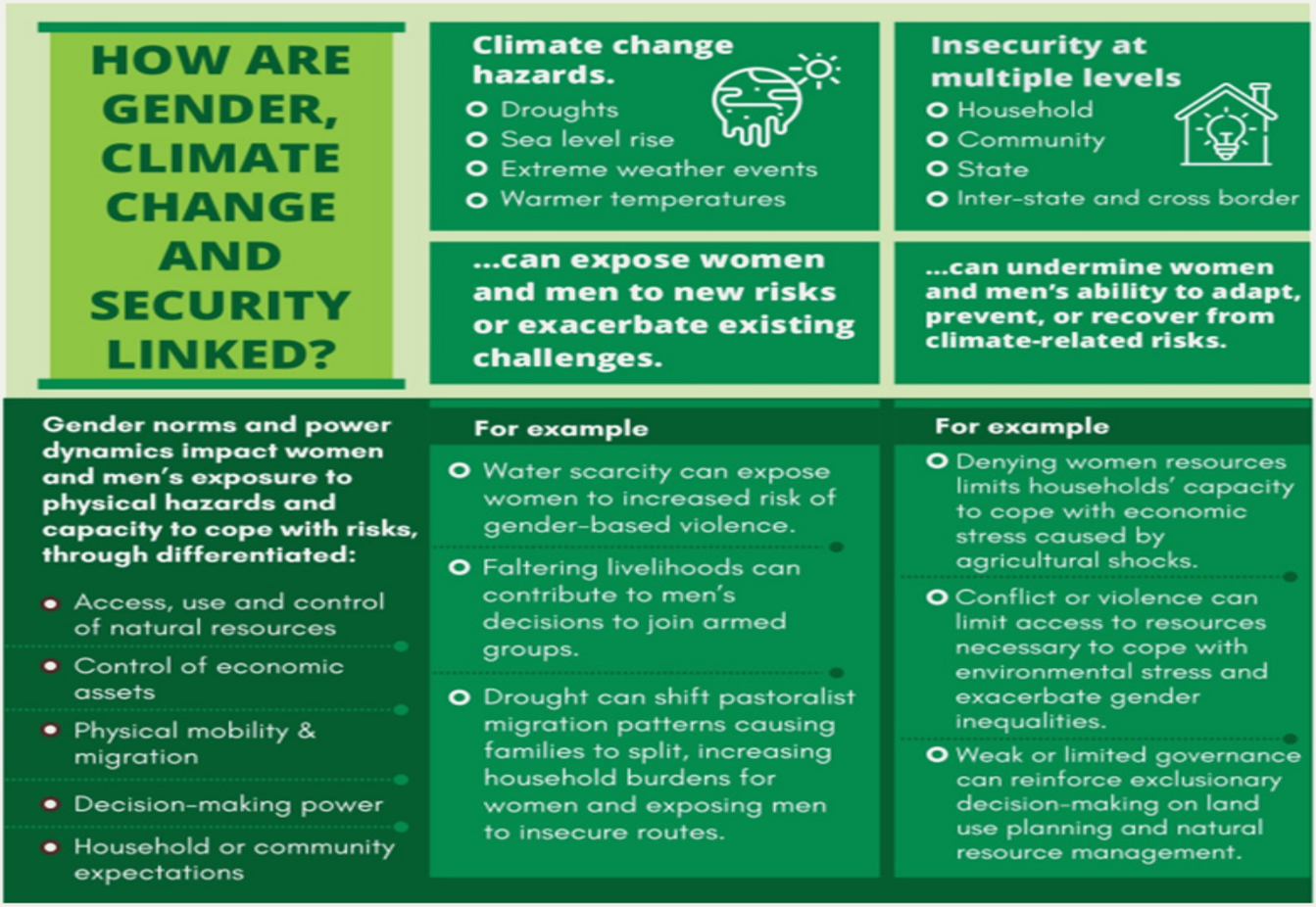
Climate change
- Seasonal variation
- Powerful storms
- Torrential rains
- Floods
- Waterlogged land
- Soil erosion

Socio-Economic Impact of Climate Change

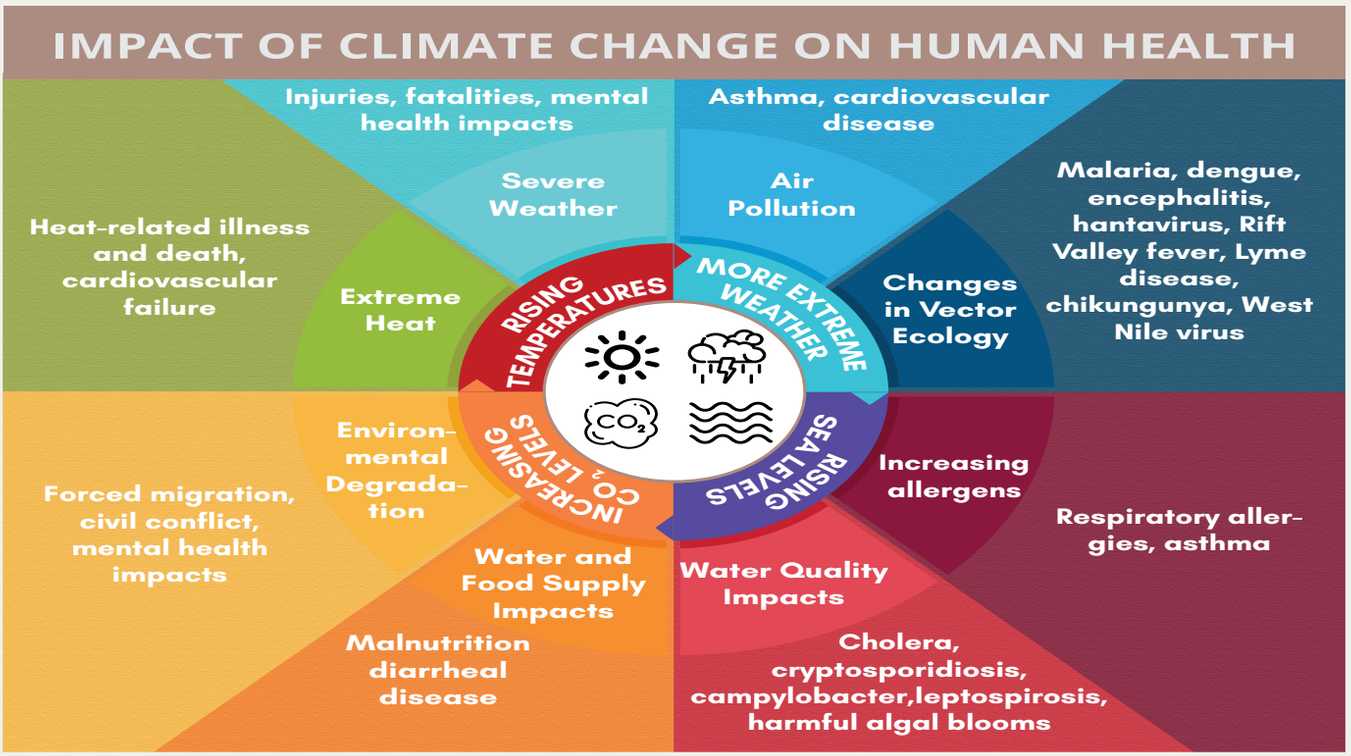


Sector	climate change drivers	Sensitivity to climate change	Sign	Other drivers
Cooling demand	• Temperature • Humidity • Hot spells		Positive for suppliers Negative for consumers	• Population • Income • Energy prices • Technology change
Health services	• Temperature • Precipitation		Positive for suppliers Negative for consumers	• Aging • Income • Diet/ lifestyle
Transportation	• Temperature • Precipitation • Starm Intensity • Seasonal Variability • Freeze/ Thaw cycles		Negative for all users Positive for transport construction industry	• Population • Income • Urbanization • Regulation • Mode Shifting • Consumer and commuter behavior

Impact of Climate change on Gender and Security



Impact on Human Health and Security



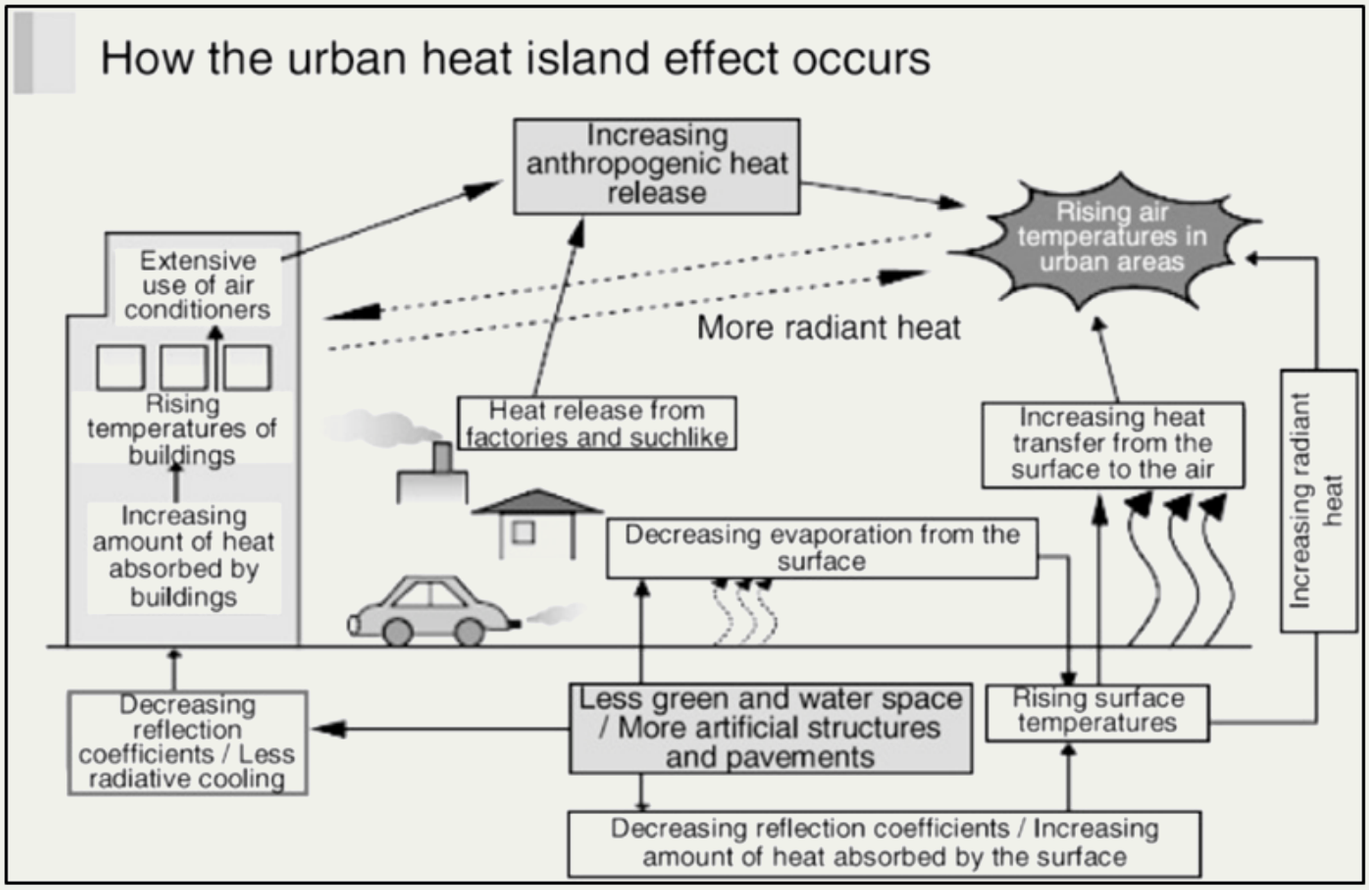
Impact On Urban and Rural Areas

On urban Areas

- **Urban temperature variation:** Increased frequency of hot days and warm spells will exacerbate urban heat island effects.
- Drought and water scarcity
- Coastal flooding, sea level rise
- Inland flooding
- Urban Heat Islands (UHI)

On urban Areas

- It will affect rural livelihood as they are dependent mostly on natural resources.
- Loss of land and disruption to transport.
- Increased migration
- Increased intensity of knowledge diffusion.



Changes in Climate in the Indian Region

The Ministry of Earth Sciences' (MoES) has come up with the report titled 'Assessment of Climate Change over the Indian Region'. As per the report, following are the observed and projected changes in various climatic dimensions over the Indian region: