2018

INTEGRATED LEARNING PROGRAMME, ILP-2018

IASBABA

[SET 5- ENVIRONMENT]

Integrated Learning Programme 2018 is a step towards 'Enabling a person located at the most remote destination a chance at cracking AIR 1 in UPSC/IAS'

Contents

CLIMATE CHANGE

Climate Change

- **Climate change** - a change in global or regional climate patterns, in particular a change apparent from the mid to late 20th century onwards and attributed largely to the increased levels of atmospheric carbon dioxide produced by the use of fossil fuels.

Global Warming (GW)

- Global Warming is the increase of Earth's average surface temperature due to effect of greenhouse gases, such as carbon dioxide emissions from burning fossil fuels or from deforestation, which trap heat that would otherwise escape from Earth.

Impact

- Increased extinction of many plant and animal species.
- Shifts in patterns of agriculture
- Rising sea levels.
- Increase in concentrations of carbon dioxide, methane, and nitrous oxides in the atmosphere.
- Increase in extreme events like floods, heat wave etc.
- Melting of glaciers
- Spread of disease
- Bleaching of coral reefs.

Difference between Climate Change and Global Warming

- **In simple words GW is just increase in temperature while Climate change means change in climate i.e. temperature + precipitation + winds etc.**
- Global warming is related to the more general phenomenon of climate change, which refers to changes in the totality of attributes that define climate.
- In addition to changes in air temperature, climate change involves changes to precipitation patterns, winds, ocean currents, and other measures of Earth's climate.
- Normally, climate change can be viewed as the combination of various natural forces occurring over diverse timescales
- The term global warming is used specifically to refer to any warming of near-surface air during the past two centuries that can be traced to anthropogenic causes.
- Climate change had led to the global warming (think) because first climate had changed and then it led to GW.

Global Dimming

Global dimming is defined as the decrease in the amounts of solar radiation reaching the surface of the Earth. The by-product of fossil fuels are tiny particles or pollutants which absorb solar energy and reflect back sunlight into the space. This phenomenon was first recognized in the year 1950.

Aerosols have been found to be the major cause of global dimming. The burning of fossil fuels by industry and internal combustion engines emits by-products such as sulfur dioxide, soot and ash. These together form particulate pollution—primarily called aerosols. Aerosols acts as precursor to global dimming in the following two ways:

- These particle matters enter the atmosphere and directly absorb solar energy and reflect radiation back into the space, before it reaches the planet's surface.

- Water droplets containing these air-borne particles form polluted clouds. These polluted clouds have heavier and larger number of droplets. These changed properties of the cloud – such clouds are called 'brown clouds' – makes them more reflective.

Vapors emitted from the planes flying high in the sky called contrails are another cause of heat reflection and related global dimming

Global Dimming and Global Warming

Global warming and global dimming are opposite phenomena.

Global warming is defined as the increase in the atmospheric temperature. This largely caused by greenhouse gases (GHGs). Greenhouse gases produced from the burning of fossil fuels traps the infrared radiations. This heats up the earth's atmosphere.

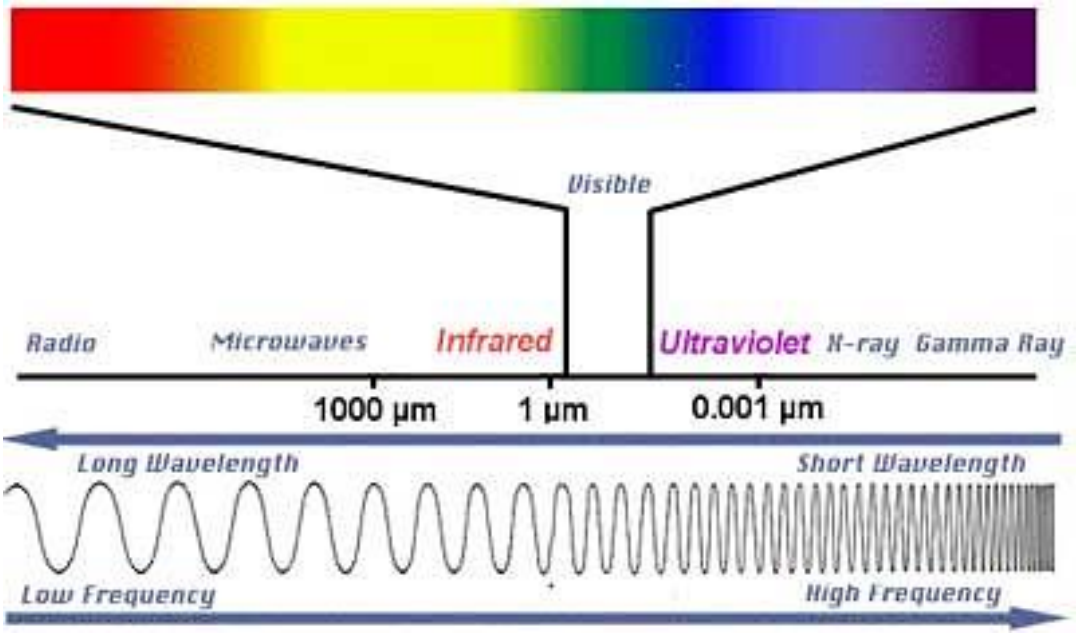
Global dimming is the exact opposite. Fine particles such as aerosols, also produced as the by-product of fossil fuels burning, reflect away sunlight. This decreases the amount of solar radiation entering our planet**. It produces a cooling effect.**

Causes of Global Warming

The Greenhouse Effect

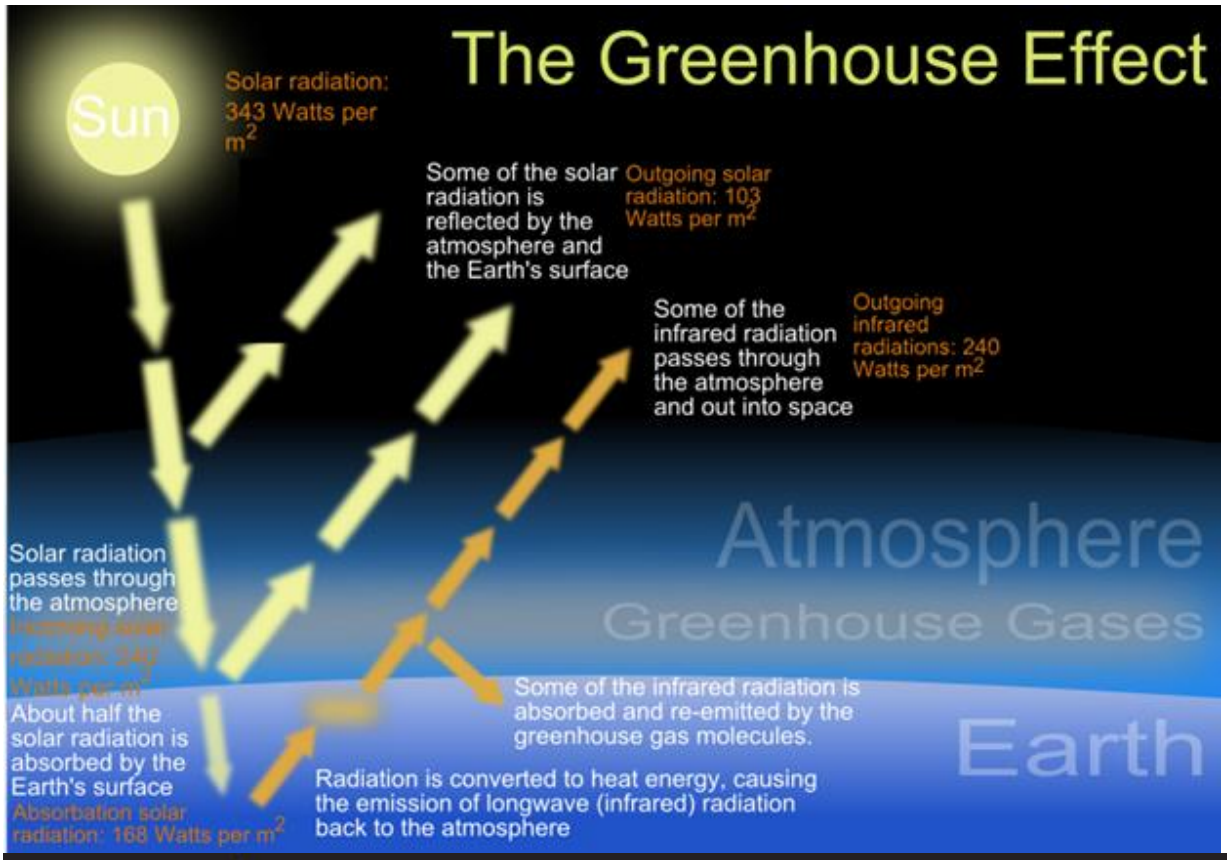
Greenhouse effect, a warming of Earth's surface and troposphere (the lowest layer of the atmosphere) caused by the presence of water vapour, carbon dioxide, methane, and certain other gases in the air. Of those gases, known as greenhouse gases, water vapour has the largest effect.

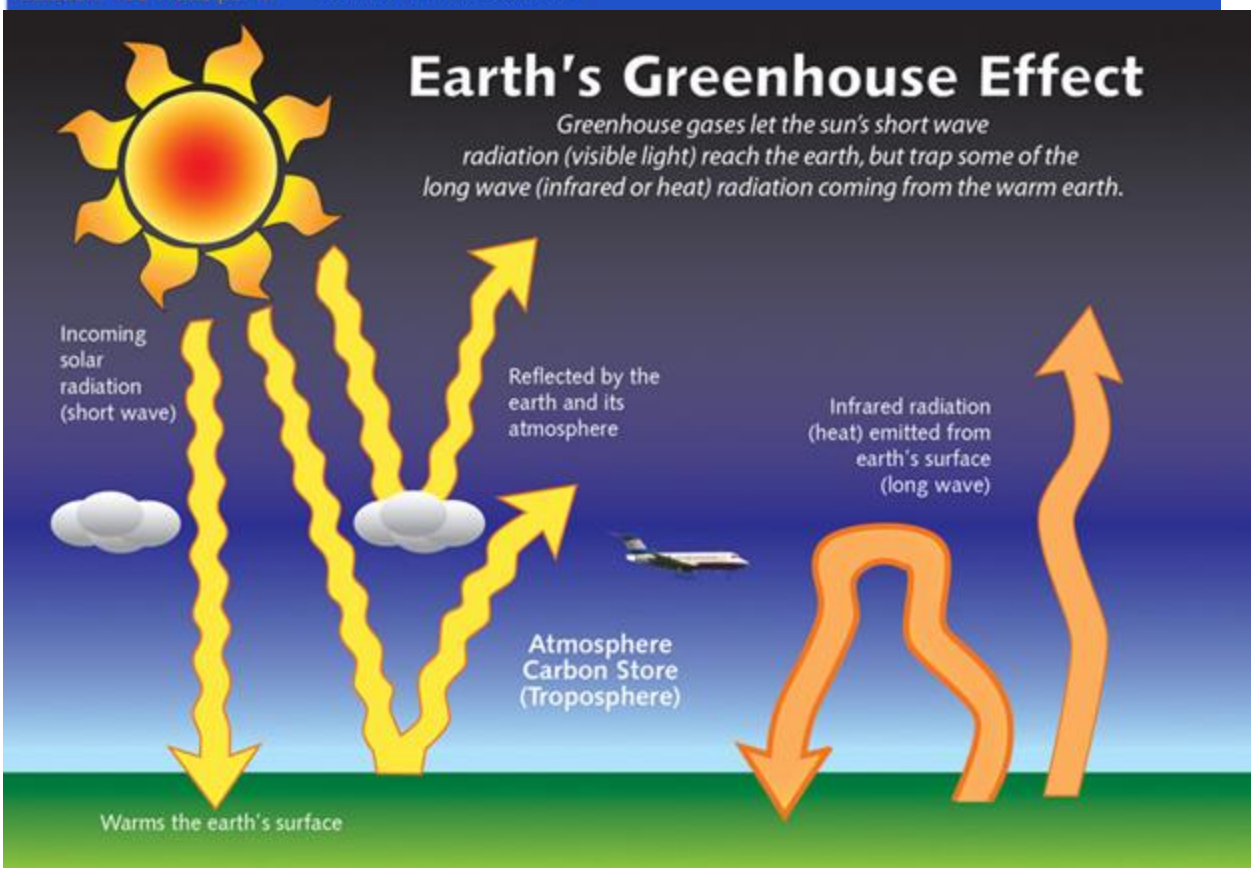
- **Greenhouse effect** - The trapping of the sun's warmth in a planet's lower atmosphere, due to the greater transparency of the atmosphere to visible radiation from the sun than to infrared radiation emitted from the planet's surface.
- **Solar radiation** is often called "**shortwave" radiation** because the frequencies of the radiation are relatively high and the wavelengths relatively short—close to the visible portion of the electromagnetic spectrum.
- **Terrestrial radiation**, on the other hand, is often called **"longwave" radiation** because the frequencies are relatively low and the wavelengths relatively long—somewhere in the infrared part of the spectrum.



- Just as greenhouses, that keeps the air warm inside its chamber, water vapor and greenhouse gases warms the Earth. **Greenhouse gases play an important role in the balance of Earth's cooling and warming.**
- In the absence of naturally occurring greenhouse effect, the average temperature of the earth surface would be -18°C instead of present value of 15°C and the earth would be a frozen lifeless planet.

- Human-generated greenhouse gas emissions had upset the natural balance and lead to increased warmth.


The Greenhouse Effect
Sun
Solar radiation: 343 Watts per m2
Some of the solar radiation is reflected by the atmosphere and the Earth's surface
Outgoing solar radiation: 103 Watts per m2
Some of the infrared radiation passes through the atmosphere and out into space
Outgoing infrared radiations: 240 Watts per m2
Atmosphere
Greenhouse Gases
Solar radiation passes through the atmosphere
Incoming solar radiation: 240 Watts per m2
About half the solar radiation is absorbed by the Earth's surface
Absorbation solar radiation: 168 Watts per m2
Some of the infrared radiation is absorbed and re-emitted by the greenhouse gas molecules.
Radiation is converted to heat energy, causing the emission of longwave (infrared) radiation back to the atmosphere
Earth


Earth's Greenhouse Effect
Greenhouse gases let the sun's short wave radiation (visible light) reach the earth, but trap some of the long wave (infrared or heat) radiation coming from the warm earth.
Incoming solar radiation (short wave)
Reflected by the earth and its atmosphere
Infrared radiation (heat) emitted from earth's surface (long wave)
Atmosphere Carbon Store (Troposphere)
Warms the earth's surface

Radiative Forcing

- **Radiative forcing or climate forcing** is defined as the difference of insolation (sunlight) absorbed by the Earth and energy radiated back to space. Typically, radiative forcing is quantified at the tropopause in units of watts per square meter of the Earth's surface.
- A positive forcing (more incoming energy) warms the system, while negative forcing (more outgoing energy) cools it.
- **Causes of radiative forcing** include changes in insolation and the concentrations of radioactively active gases, commonly known as greenhouse gases and aerosols.
- Atmospheric aerosols include volcanic dust, soot, particles from burning forests and mineral dust.

Greenhouse Gases

A greenhouse gas (often abbreviated as GHG) is a gas that both absorbs and emits radiation in the infrared range, commonly called thermal radiation or heat. When present in the atmosphere, these gases trap radiation in the form of heat, causing a warming process called the greenhouse effect.

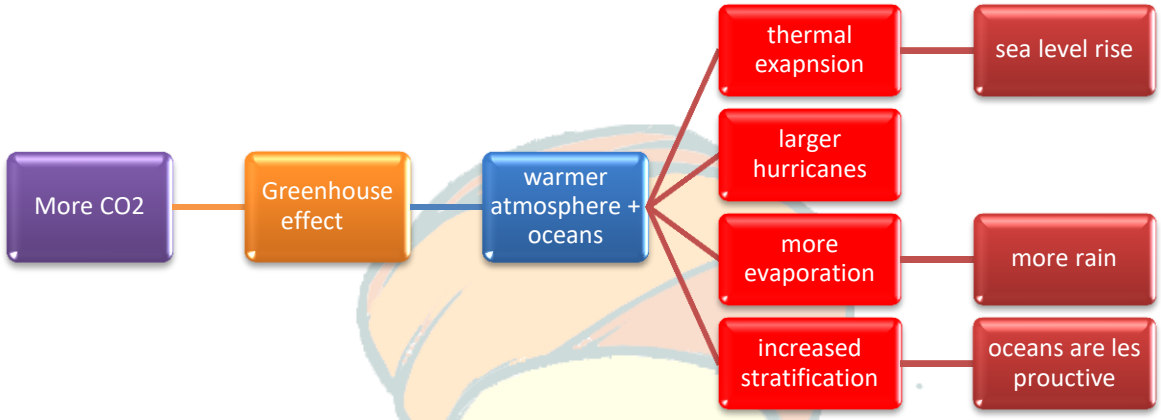
Water Vapor

- **Most potent of the greenhouse gases in Earth's atmosphere,** but its behavior is fundamentally different from that of the other greenhouse gases.
- **Primary role of water vapor** is - not as a direct agent of radiative forcing but rather as a **climate feedback**—that is, as a response within the climate system that influences the system's continued activity.
- This distinction arises from the fact that the amount of water vapour in the atmosphere cannot, in general, be directly modified by human behaviour but is instead set by air temperatures.
- The warmer the surface, the greater the evaporation rate of water from the surface. As a result, increased evaporation leads to a greater concentration of water vapour in the lower atmosphere capable of absorbing long-wave radiation and emitting it downward.

Carbon dioxide

- Primary greenhouse gas emitted through human activities.
- It is naturally present in the atmosphere as part of the Earth's carbon cycle.

- Human activities are changing the carbon cycle both by adding more CO_2 to the atmosphere and by reducing the ability of natural sinks, like forests, to remove CO2 from the atmosphere.



The main sources

- Combustion of fossil fuels
- Emission of CO2 by Thermal power plants and industries.
- Several processes also produce C02 emissions through chemical reactions that do not involve combustion. E.g. the production and consumption of mineral products such as cement, the production of metals such as iron and steel, and the production of chemicals, etc.

How to reduce CO2 emissions?

- Most effective way - reduce fossil fuel consumption.
- Other strategies include Energy Efficiency, Energy Conservation; Carbon Capture and Sequestration.

Methane

- Emitted by natural sources such as wetlands, as well as human activities such as leakage from natural gas systems and the raising of livestock.

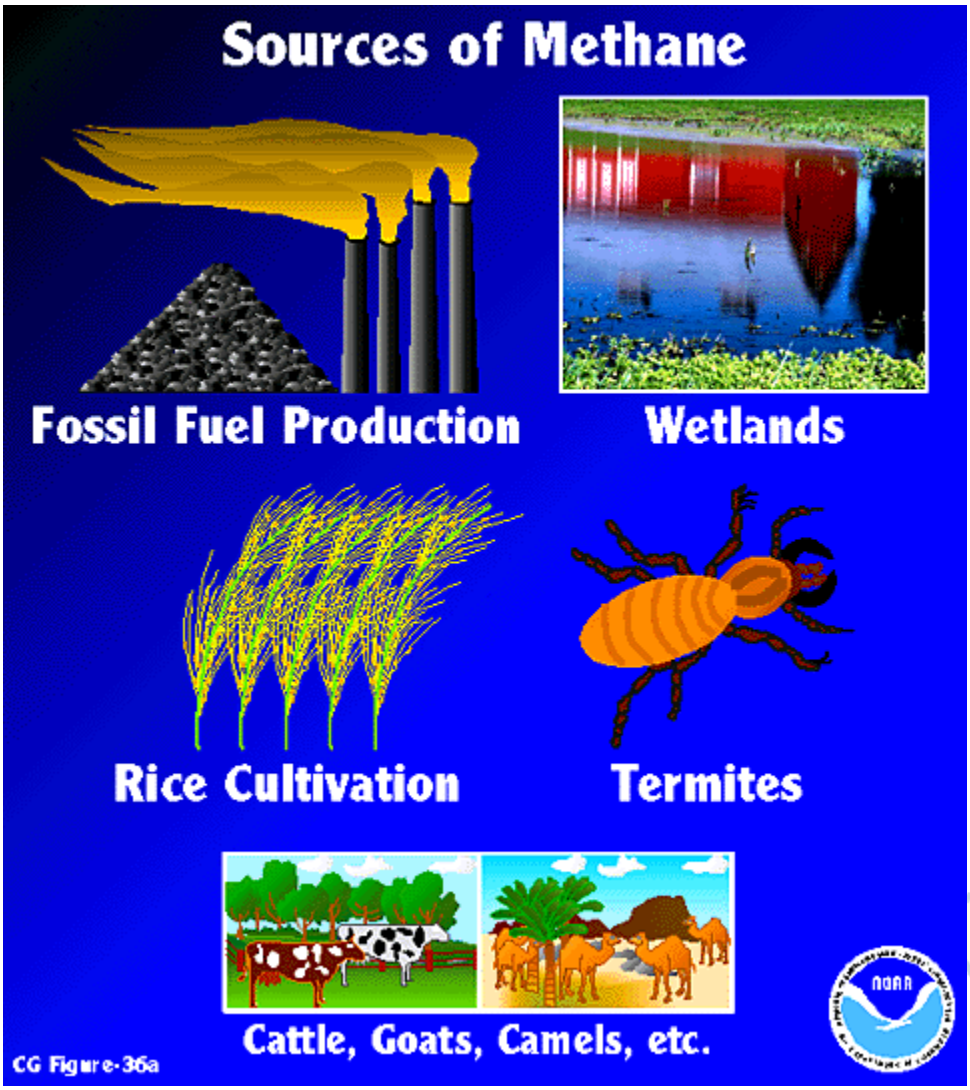
- Natural processes in soil and chemical reactions in the atmosphere help remove CH4 from the atmosphere.

Source

Natural sources

- Wetlands largest source
- Smaller sources - termites, oceans, sediments, volcanoes, and wildfires.

Human induced



- Agriculture - Domestic livestock such as cattle, buffalo, sheep, goats, and camels produce large amounts of CH4 as part of their normal digestive process. Also, when animals' manure is stored in tanks.
- Industry – primary component of natural gas. Some amount is emitted during the production, processing, storage, transmission, and distribution of crude oil and natural gas.
- Generated in landfills as waste decomposes and from the treatment of wastewater.

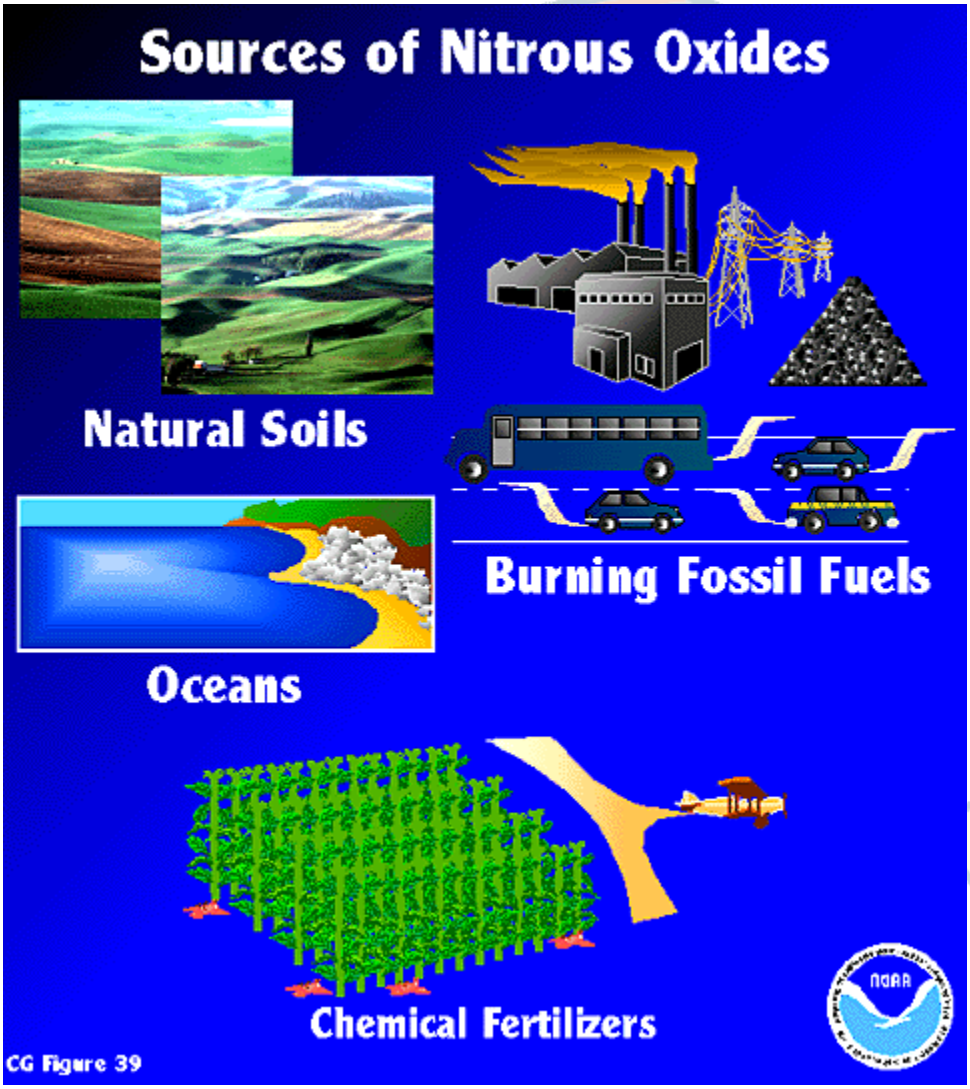
Nitrous Oxide (N2O)

Sources

Natural sources

- Atmosphere
- Emissions from breaking down of nitrogen in soils and oceans.

Human induced



- **Agriculture** – emission **during use of synthetic fertilizers**. It is also emitted during the breakdown of nitrogen in **livestock manure and urine.**
- **Transportation** – it is emitted when **transportation fuels are burned**.

- **Industry** - It is generated as a byproduct during the **production of nitric acid** (used to make synthetic commercial fertilizer), and in the **production of adipic acid** (used to make fibers like nylon, and other synthetic products)
- **Removal** - It is removed from the atmosphere when it is absorbed by certain types of bacteria or destroyed by ultraviolet radiation or chemical reactions.

Fluorinated Gases

- Emitted through a variety of industrial processes such as aluminum and semiconductor manufacturing & Substitution for Ozone-Depleting Substances.
- High global warming potentials (GWPs) + longest lasting type of greenhouse gases emitted by human activities.
- Removal - only when they are destroyed by sunlight in the far upper atmosphere.
- 3 main categories –
    - HFCs (Hydroflurocarbons)
    - PFCs (Perflurocarbons)
    - SF6 (Sulfur haxafluoride)

HFCs

- Substitution for Ozone-Depleting Substances
- They are used as refrigerants, aerosol propellants, solvents, and fire retardants.
- HFCs do not deplete the stratospheric ozone layer and so they were developed as a replacement for chlorofluorocarbons (CFCs) and hydro chlorofluorocarbons (HCFCs)

PFCs

- Compounds produced **as a by-product of various industrial processes** associated with aluminum production and the manufacturing of semiconductors.
- Long atmospheric lifetimes
- High GWPs

SF6

- It is used in magnesium processing and semiconductor manufacturing, as well as a tracer gas for leak detection.
- HFC-23 is produced as a by-product of HCFC-22 production.

Black Carbon

- It is a solid particle or aerosol, contributes to warming of the atmosphere.
- Commonly known as soot.
- It is a form of particulate air pollutant, produced from incomplete combustion.
- It consists of pure carbon in several linked forms.

Source

- Biomass burning,
- Cooking with solid fuels, and
- Diesel exhaust etc.

What does BC do?

- Warms the Earth by absorbing heat in the atmosphere and by reducing albedo, (the ability to reflect sunlight) when deposited on snow and ice.
- Strongest absorber of sunlight and heats the air directly.
- Leads to melting of ice and snow.
- BC disrupts cloudiness and monsoon rainfall and accelerates melting of mountain glaciers.

Life time

- Stays in the atmosphere for only several days to weeks.
- Effects of BC on the atmospheric warming and glacier retreat disappear within months of reducing emissions.

Project Surya – reduce black carbon by introducing efficient stove technologies, solar cookers, solar lamps and biogas plants.

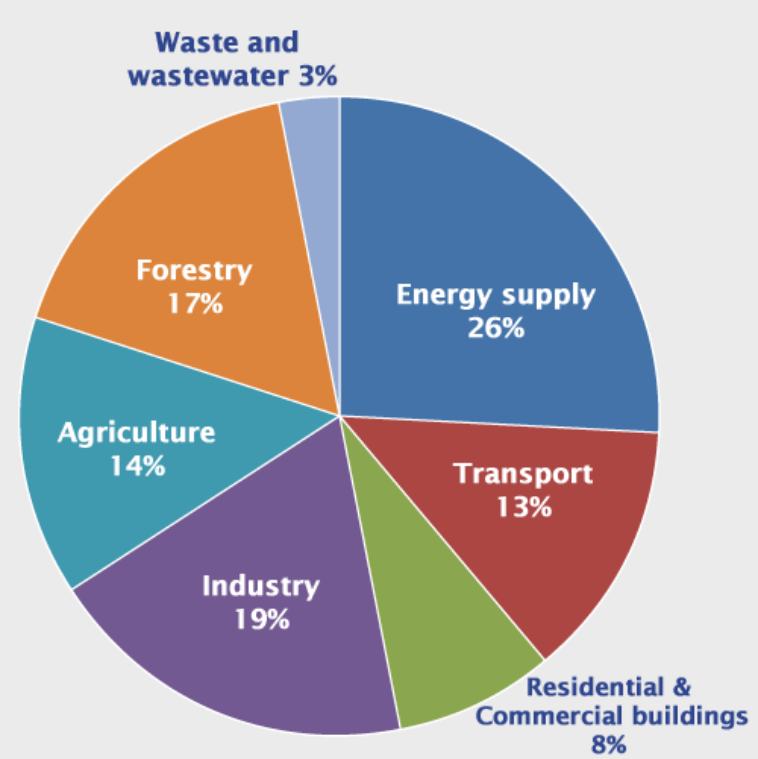
Global Warming Potential (GWP)

- **Global warming potential** describes the impact of each gas on global warming.
- Two most important characteristics of a GHG –
    - How well the gas absorbs energy
    - How long the gas stays in the atmosphere?
- The Global Warming Potential (GWP) for a gas is a measure of the total energy that a gas absorbs over a particular period of time (usually 100 years), compared to carbon dioxide.
- Higher GWP gases absorb more energy → Contribute more towards warming earth.
- Carbon dioxide (C02) has a GWP of 1 and serves as a baseline for other GWP values.
- The larger the GWP, the more warming the gas causes.
    - E.g. methane's 100-year GWP is 21, which means that methane will cause 21 times as much warming as an equivalent mass of CO2 over a 100-year time period.
- Note- CO2's Lifespan is thousands of years and hence it is taken as reference.

Greenhouse Gas	GWP	Lifetime (y)
Carbon Dioxide (CO2)	1	variable
Methane (CH4)	21	12.2
Nitrous Oxide (NO2)	206	120
Hydrofluorocarbons (HFC)	140-11700	1.5-264
Perfluocarbons (PFC)	6500-9200	3200-50000
Sulfur Hexafluoride (SF6)	23000	3200
Chlorofluorocarbons (CFC)	12000-16000	

Global Emissions

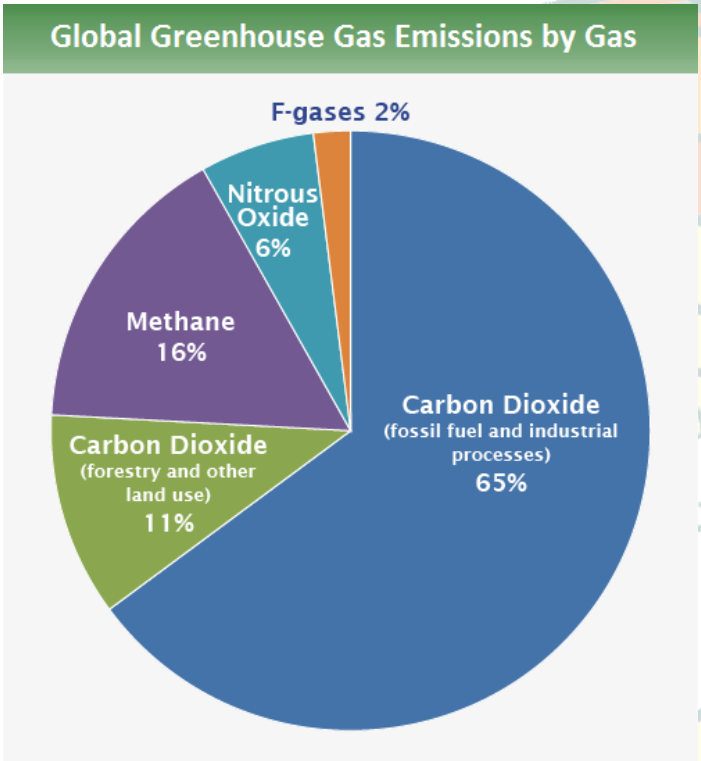
Global emissions by source



- Energy supply
  - 26% of GHG emissions
  - Source –burning of coal, natural gas, and oil
- Industry
  - 19% of GHG emissions
  - fossil fuels burned on-site for energy
  - Emissions from chemical, metallurgical, and mineral transformation processes not associated with energy consumption.
- Land Use, Land-Use Change, and Forestry
  - 17% of GHG emissions
  - deforestation, land clearing for agriculture, and fires or decay of peat soils.
- Agriculture
  - 14% of GHG emissions
  - Management of agricultural soils, livestock, rice production, and biomass burning.
- Transportation
  - 13% of GHG emissions

    - fossil fuels burned for road, rail, air, and marine transportation
- Commercial and Residential Buildings
    - 8% of GHG emissions
    - Burning of coals and wood for energy requirements.
- Waste and Wastewater
    - 3% of GHG emissions
    - Landfill methane, waste water methane, nitrous oxide.

Global Emissions by Gas



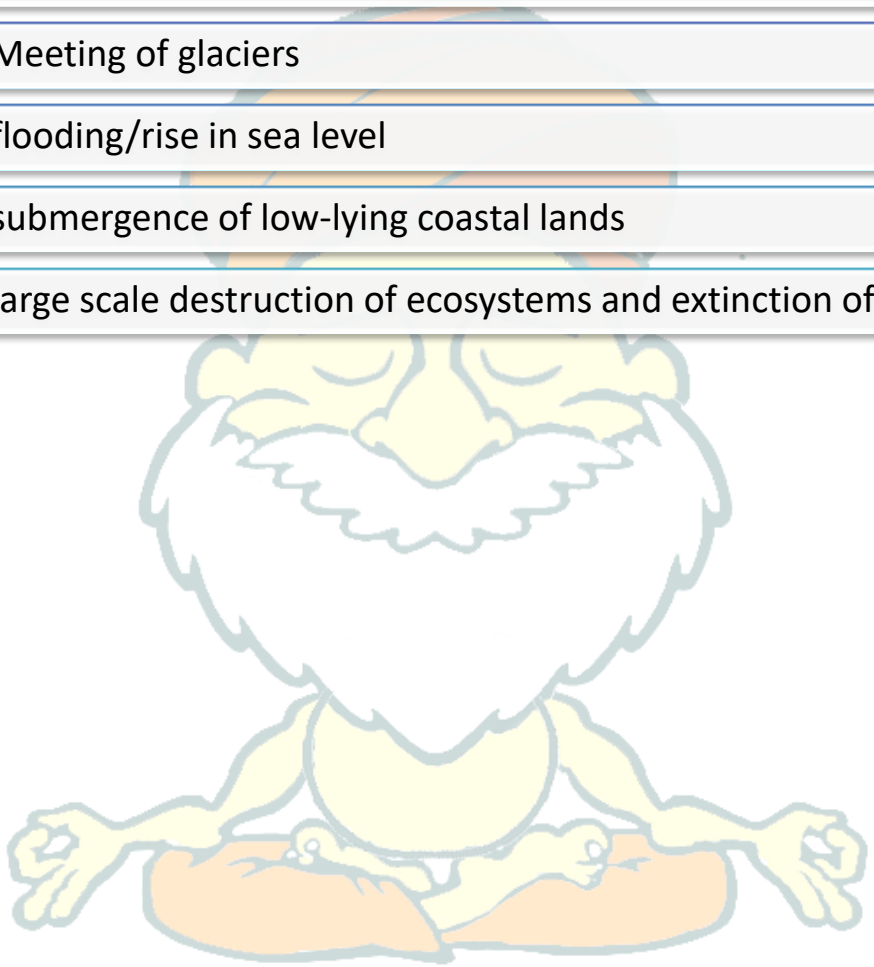
Receding glaciers - a symptom of global climate change

Impact of glacial retreat

- Rise in sea level – challenge for poor and low-lying countries.
- Will affect water supplies
- Variation in temperature and snowfall because water cycle balance changed
- Loss of glaciers would impact to those countries' human beings, animals and vegetation which are dependent on it.

Chain of events

- Computation of fossile fuels due to human activities
- Increase of GHG
- Global warming
- climatic changes
- Meeting of glaciers
- flooding/rise in sea level
- submergence of low-lying coastal lands
- large scale destruction of ecosystems and extinction of species



CONTEMPORAY UPDATES

Environment Ministry Launches a Regional Project to Tackle Stubble Burning

In another significant step to combat climate change, the Ministry of Environment, Forest and Climate Change has approved a regional project ***on 'Climate Resilience Building among Farmers through Crop Residue Management'*** under the **National Adaptation Fund for Climate Change** (NAFCC).

The project not only aims to mitigate climate change impacts and enhance adaptive capacity, but will also counter the adverse environmental impacts that arise from burning.

The problem of crop residue burning has been intensifying over the years, with Punjab, Haryana and Uttar Pradesh being the major burning hotspots. Increased mechanization, declining number of livestock, long period required for composting and no economically viable alternate use of residues are some of the reasons for residues being burnt in field. This not only has implications for global warming, but also has an adverse impact on air quality, soil health and human health.

National Adaptation Fund for Climate Change (NAFCC)

- 100% central grant is provided to the State Governments for implementing climate change adaptation projects.
- (NABARD) is the National Implementing Entity (NIE) responsible for implementation of adaptation projects under the NAFCC.

Blue Flag Project

With the prime objective of enhancing standards of cleanliness, upkeep and basic amenities at beaches, the environment ministry has launched a pilot project for beach clean-up and development, also striving for the 'Blue Flag' certification for such identified beaches.

The **'Blue Flag'** is a certification by the Foundation for Environmental Education (FEE) that a beach, marina or sustainable boating tourism operator, meets its stringent standards.

Do you know?

- The Foundation for Environmental Education (FEE) is a non-governmental, non-profit organisation promoting sustainable development through environmental education. FEE is active through five programmes; Blue Flag, Eco-Schools, Young Reporters for the Environment (YRE), Learning about Forests (LEAF) and Green Key.

Petcoke

In news: On November 17, the Centre informed the Supreme Court that it had banned the use of petcoke in Uttar Pradesh, Haryana and Rajasthan as a part of the efforts to curb the suffocating level of air pollution in the NCR region.

Petroleum coke, abbreviated coke or petcoke, is a final carbon-rich solid material that derives from oil refining, and is one type of the group of fuels referred to as cokes. Petcoke is the coke that, in particular, derives from a final cracking process–a thermo-based chemical engineering process that splits long chain hydrocarbons of petroleum into shorter chains—that takes place in units termed coker units.

Sulphur content, petcoke with 75,000 ppm (parts per million) is clearly one of the dirtiest fuels on earth. Even coal, the biggest contributor to greenhouse gas emissions, has just 4,000 ppm of sulphur.

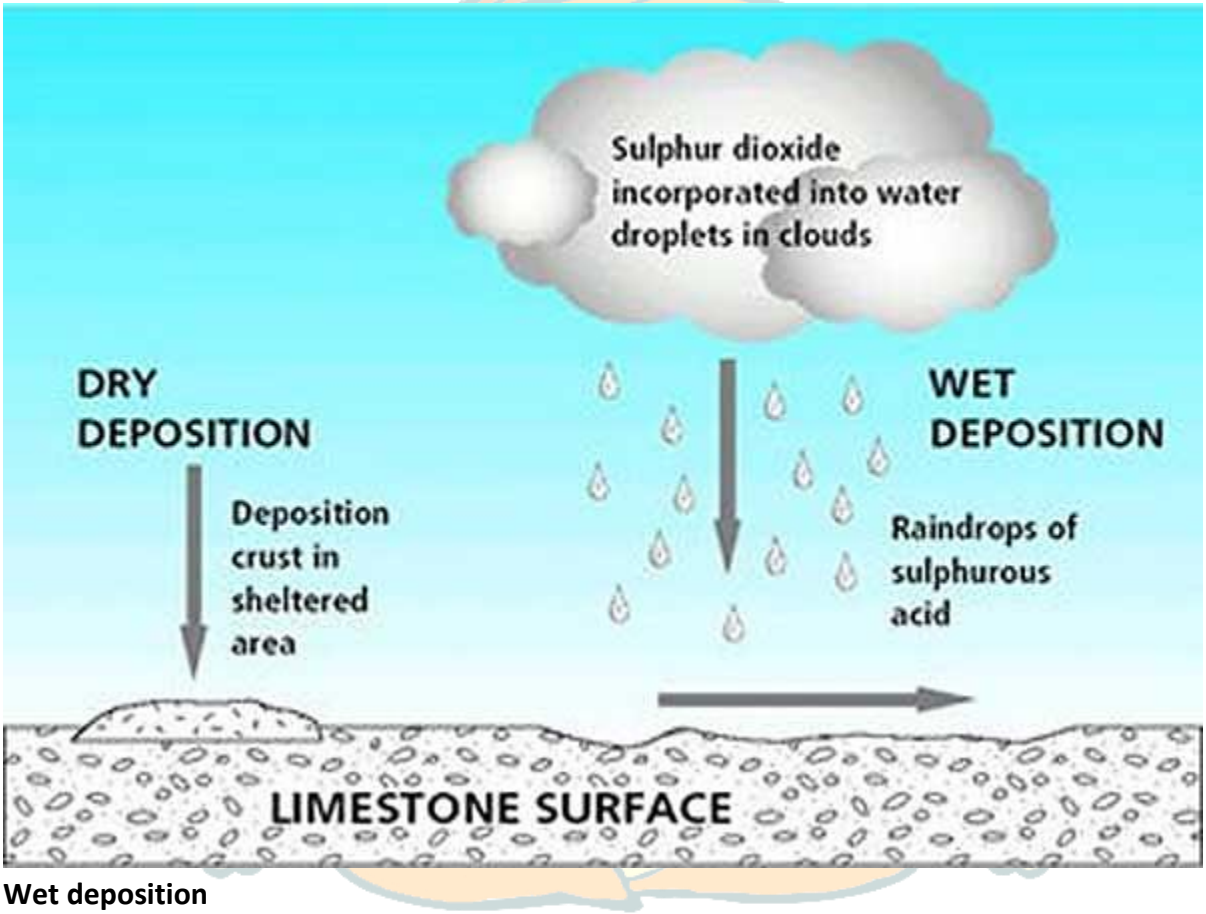
Do you know?

- According to new study published in medical journal The Lancet, India has topped list of countries with pollution-related deaths in 2015
- **Parali I island**, one of biodiversity-rich uninhabited islands part of **Lakshadweep** has disappeared due to coastal erosion and another four such islands in Lakshadweep sea are shrinking fast.
- **Delicate mosses** found on rocks and trees in cities around the world can be used to measure the impact of atmospheric change and could prove a low-cost way to monitor urban pollution

ACIDIFICATION

- Acid rain is caused by emissions of sulfur dioxide and nitrogen oxide, which react with the water molecules in the atmosphere to produce acids.
- Rain with a pH of < 5.6.
- Acid rain is damaging to lakes, streams, and forests and the plants and animals that live in these ecosystems.

Types of acid deposition



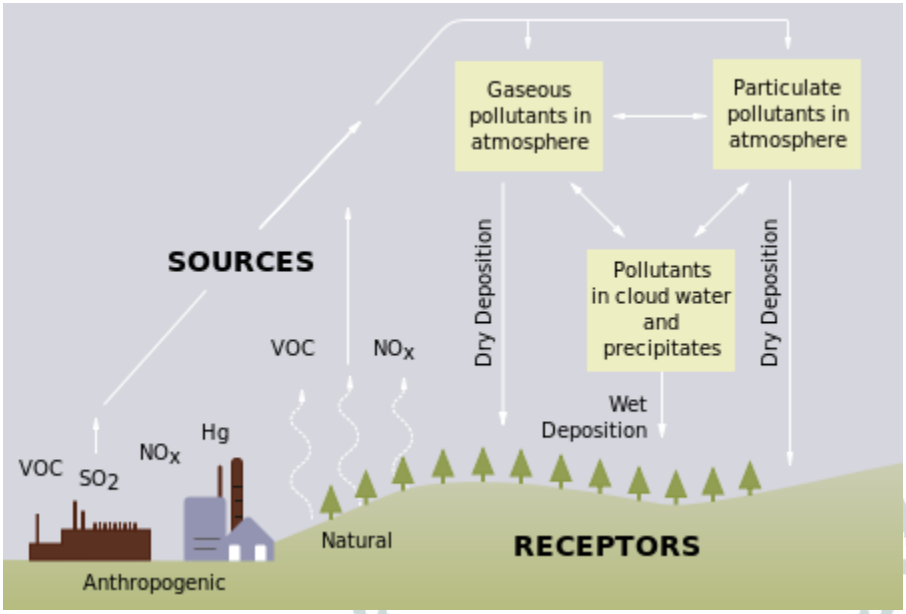
Wet deposition

- Wet deposition of acids occurs when any form of precipitation (rain, snow, and so on.) removes acids from the atmosphere and delivers it to the Earth's surface.
- As it flows it affects a variety of plants and animals.
- Strength of the effects depends on –
    - How acidic water is
    - types of fish, trees, and other living things that rely on the water.

Dry deposition

- If weather is dry, the acid chemicals may become incorporated into dust or smoke and fall to the ground through dry deposition, sticking to the ground, buildings and vegetation, cars, etc.
- Dry deposits can be washed by rainstorms.

Sources of Compounds causing Acid Rain



Sulphur

Natural resources –

- Seas and oceans
- Volcanic eruptions
- Biological processes in the soil. E.g. Decomposition of organic matter.

Manmade sources –

- Burning of coal and petroleum products
- Smelting of metal sulfide ores to obtain the pure metals.
- Industrial production of Sulfuric acid in metallurgical, chemical and fertilizer industries.

Nitrogen

Natural sources:

- Lightening,
- Volcanic eruption
- Biological activity.

Anthropogenic sources:

- Forest fires
- Combustion of oil, coal, and gas

Formic acid

- Biomass burning due to forest fires causes emission of formic acid (HCOOH) and formaldehyde (HCHO) into the atmosphere.
- Large fraction formaldehyde gets photo - oxidation and forms formic acid in the atmosphere.

Other Acids

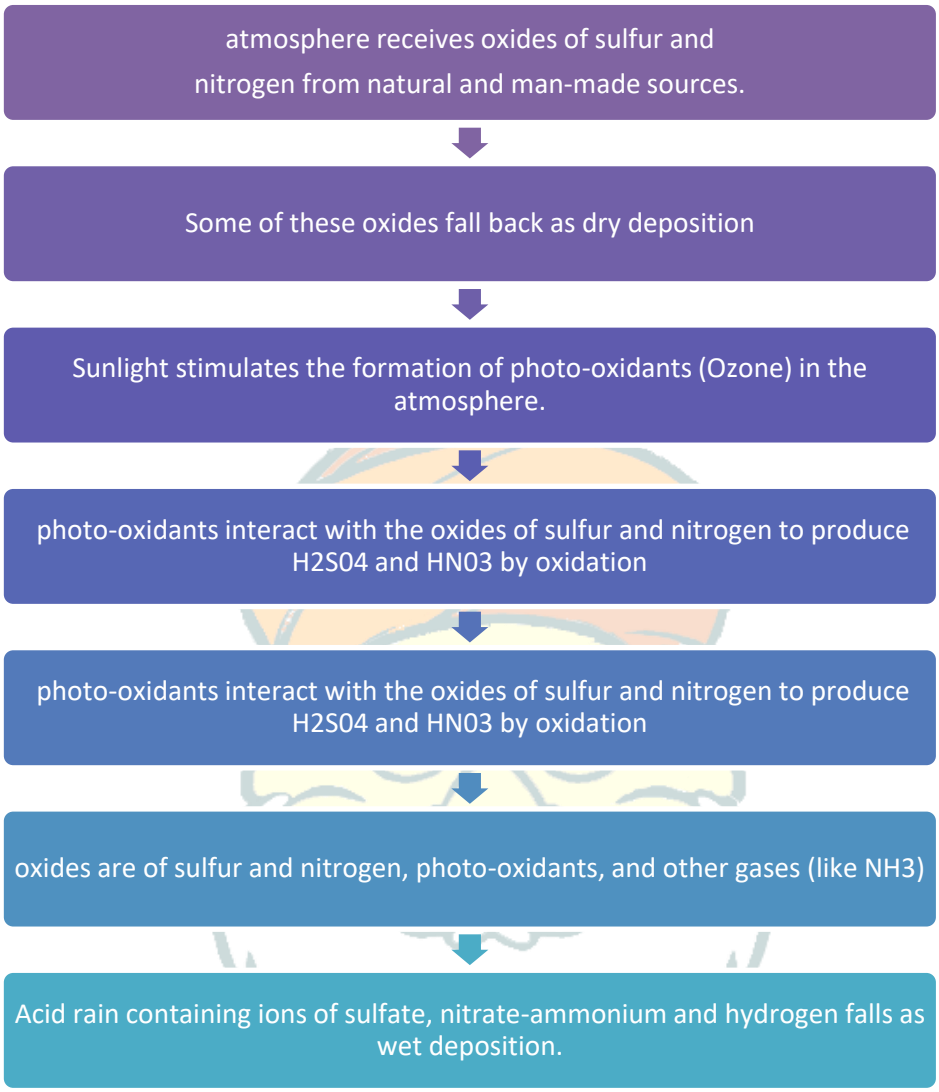
- Chlorine
- Phosphoric acid
- Hydrochloric acid (smokestacks).
- Carbon monoxide and carbon dioxide (automobiles). These become carbonic acid.

Acid rain area common characteristics – (very briefly)

- Concentrated in the industrialized belt
- Often upland and / or mountainous areas, which are well-watered by rain and snow.
- Possess numerous lakes and streams and also have more land covered with vegetation.
- Thin soils and glaciated bedrock.

Formation of Acid rain

6 Steps –



Impact of acid rain

Soil

- Leaching of Acid nutrients → make soil infertile.
- Decrease in the respiration of soil organism.
- Decrease in other nutrients → increase in ammonia → decreases the rate of decomposition
- Decrease in nitrate level
- Acid rain impacts less in case of India because Indian soils are alkaline.

Vegetation

- Causing reduced growth or abnormal growth
- Growth decreasing symptoms are -
- Discoloration and loss of foliar biomass

- Loss of feeder-root biomass, especially in conifers
- Premature senescence (aging) of older needles in conifers
- Increase in susceptibility of damage to secondary root and foliar pathogens
- Death of herbaceous vegetation beneath affected trees
- Prodigious production of lichens affected trees.
- Death of affected trees.

Microorganism

- pH determines the proliferation of any microbial species and the rate at which it can produce.
- Optimum pH of most bacteria and protozoa – near neutrality
- Most fungi prefer an acidic environment.
- Most blue-green bacteria prefer an alkaline environment.
- Microbial species shift from bacteria-bound to fungi-bound and cause an imbalance in the microflora.
- Causes a delay in the decomposition of soil organic material.
- Increase in fungal disease in aquatic life and forests.

Wildlife

- Effects – not very obvious
- can directly affect the eggs and tadpoles of frogs and salamanders
- indirectly affect wildlife (toxic substances may be ingested by animals, like birds, that feed in such an environment)
- Other indirect effects - loss or alteration of food and habitat resources.

Human

- Bad smells, reduced visibility, irritation of the skin, eyes and the respiratory tract.
- Chronic bronchitis, pulmonary emphysema and cancer.
- Indirect effect – food poisoning vis a vis drinking water and food.

Acid rain damage on materials

Material	Type of Impact	Principal Air Pollutants
Metals	Corrosion, tarnishing	Sulphur Oxides and other acid gases
Building stone	Surface erosion soiling, black crust formation	Sulphur Oxides and other acid gases
Ceramics and glass	Surface erosion, surface crust formation	Acid gases, especially fluoride-containing
Paints and organic coatings	Surface erosion, discolouration, soiling	Sulphur dioxides, hydrogen sulphide
Paper	Embrittlement, discolouration	Sulphur Oxides
Photographic Materials	Micro-blemishes	Sulphur Oxides
Textiles	Fading, colour change	Nitrogen oxides, ozone
Leather	Weakening, powdered surface	Sulphur oxides
Rubber	Cracking	Ozone

Trigger effect of Acid rain on pollutants

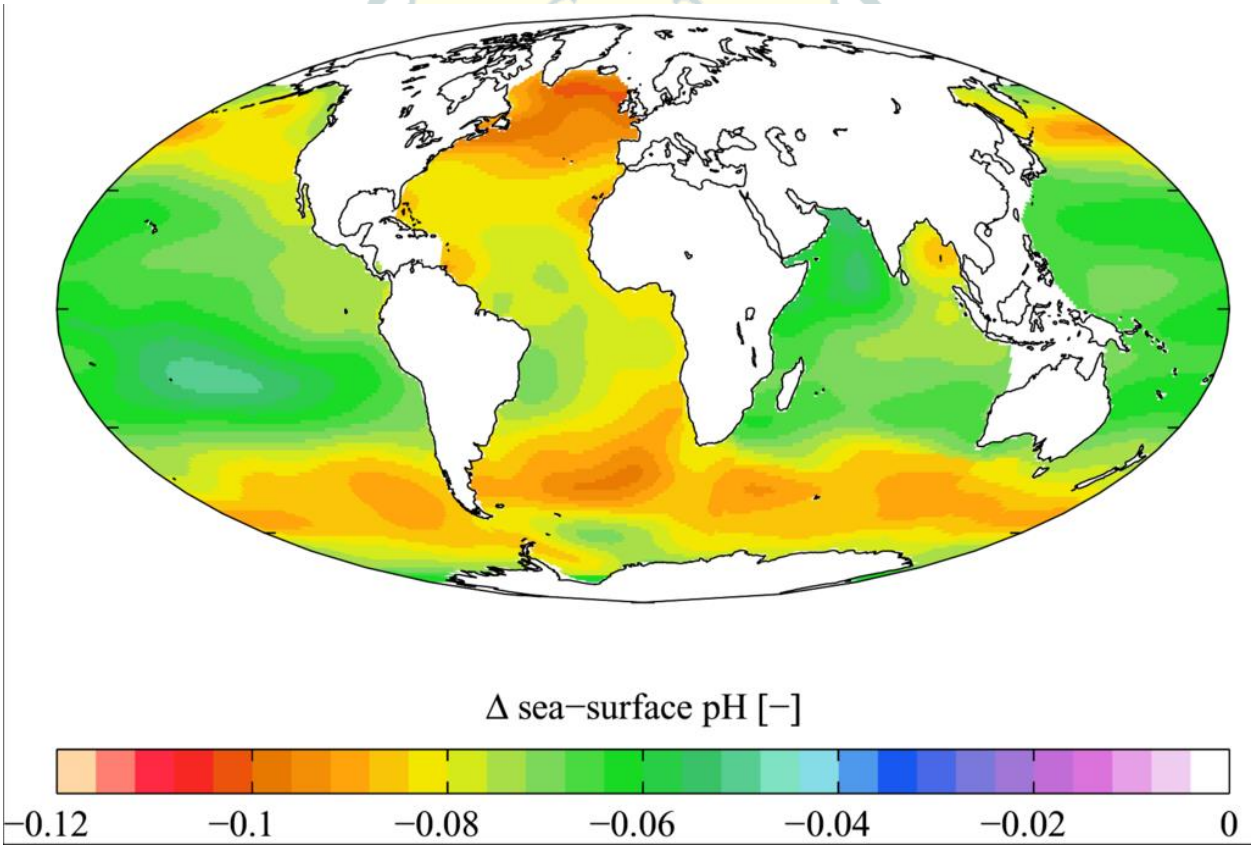
- Methyl mercury and alkyl mercury accumulate in edible fish tissue (dangerous to humans)
- Increase the partitioning of **methyl mercury** into the water column.
- Use of lime has helped in reducing the **mercury** levels in fish.
- Leach substantial amounts of **aluminum** from watersheds
- Cadmium can enter the drinking water supply through corrosion of galvanized pipe or from the copper-zinc through corrosion of galvanized piper or from the copper-zinc solder used in the distribution systems.
- Lower than normal blood levels of lead can cause mental deficiencies and behavioral problems.
- Fetuses and infants are highly susceptible to drinking water lead contamination.
- Asbestos in natural rock can be released by acidic waters.

Control measures

Controlling or eliminating sources of pollution by –

- Adding a neutralizing agent to the acidified water to increase the pH. E.g. lime in the form of calcium oxide and calcium carbonate is used.
- Reducing the emission of S02 from power stations by burning less fossil fuel, using alternate energy sources like tidal, wind, hydropower etc.
- Using low sulphur fuel
- desulphurization
- decreasing emission of NOx from power stations
- Modification of engines.
- Stricter enforcement of bharat stage emission standards.
- Emissions of SOx can be controlled by
    - Converting to sulphuric acid
    - Converting it to elemental Sulphur
    - Neutralizing it and using it in the manufacture of other products.

Ocean Acidification



- Ocean acidification is the ongoing decrease in the pH of the Earth's oceans, caused by the uptake of carbon dioxide (CO2) from the atmosphere.
- It increases **the concentration of hydrogen ions** and decreases the concentration of carbonate ions.
- Seawater is slightly basic (meaning pH > 7), and the process in question is a shift towards pH-neutral conditions rather than a transition to acidic conditions (pH < 7).

Other factors which increases ocean acidification

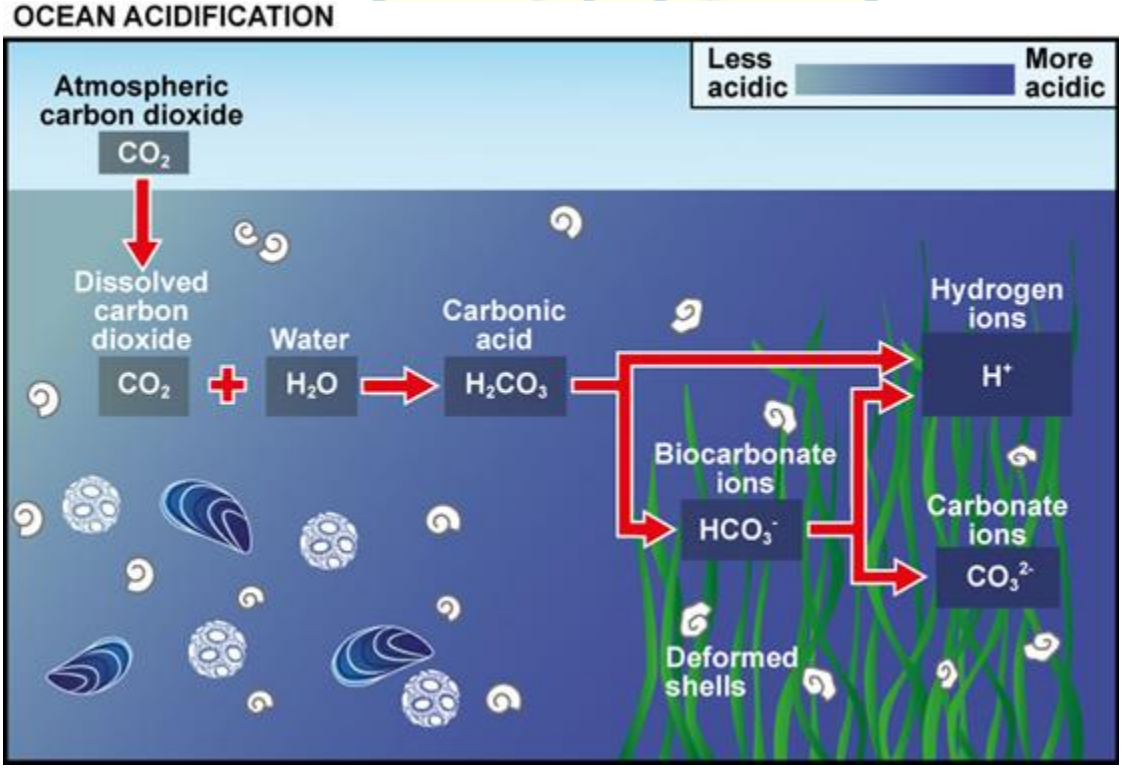
Acid rain

- It increases the acidity but impact is limited to locally and regionally (very small globally)

Eutrophication

- Excessive nutrients result in algal bloom which collapse and sink to the sea bed. Subsequent respiration of bacteria decomposing the algae leads to a decrease in sea water oxygen and an increase in C02 (a decline in pH).

CO2 reactions with water



Two reactions –

- 1st reaction - Formation of carbonic acid with subsequent release of hydrogen ions.
- 2nd reaction – between carbonate ions, C02 and water produces bicarbonate ions.

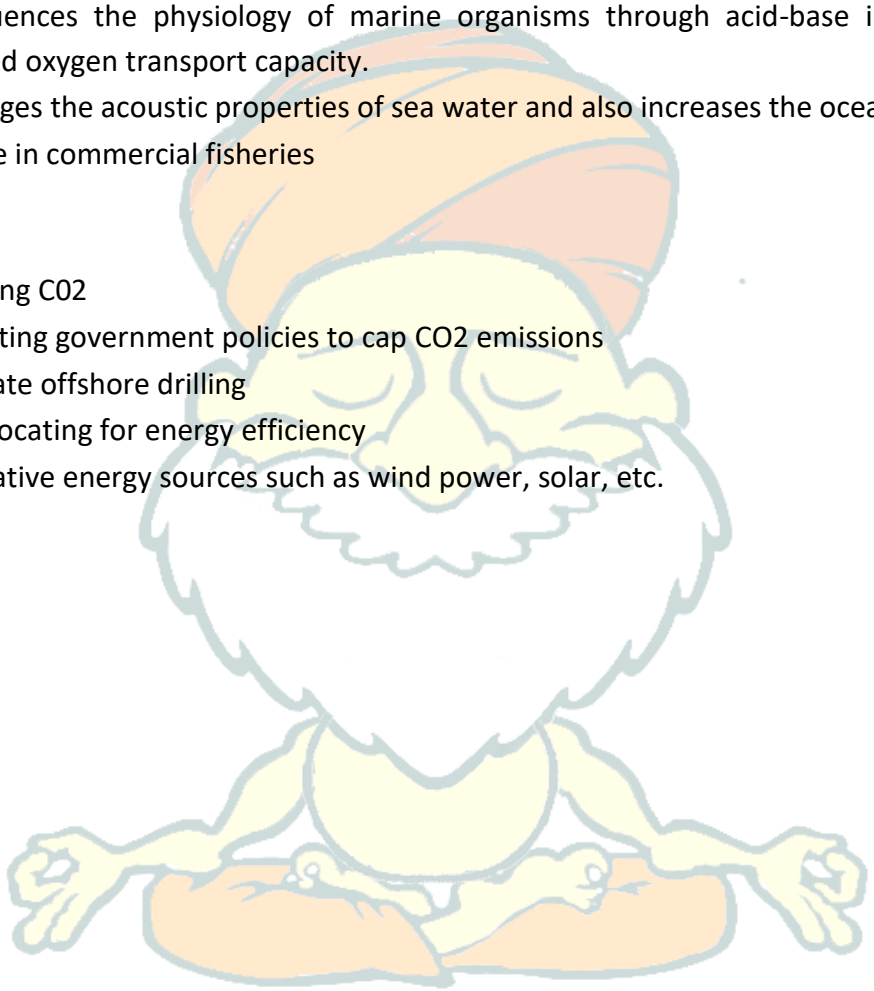
- Combined effect of both these reactions not only increases acidity but also lowers the availability of carbonate ions.

Effect of ocean acidification

- Altering the seawater chemistry of the world's oceans
- The ability of marine animals, most importantly pteropod molluscs, foraminifera, and some benthic invertebrates, to produce calcareous skeletal structures is directly affected. It's like trying to build a house while someone keeps stealing your bricks.
- It influences the physiology of marine organisms through acid-base imbalance and reduced oxygen transport capacity.
- It changes the acoustic properties of sea water and also increases the ocean noise.
- Decline in commercial fisheries

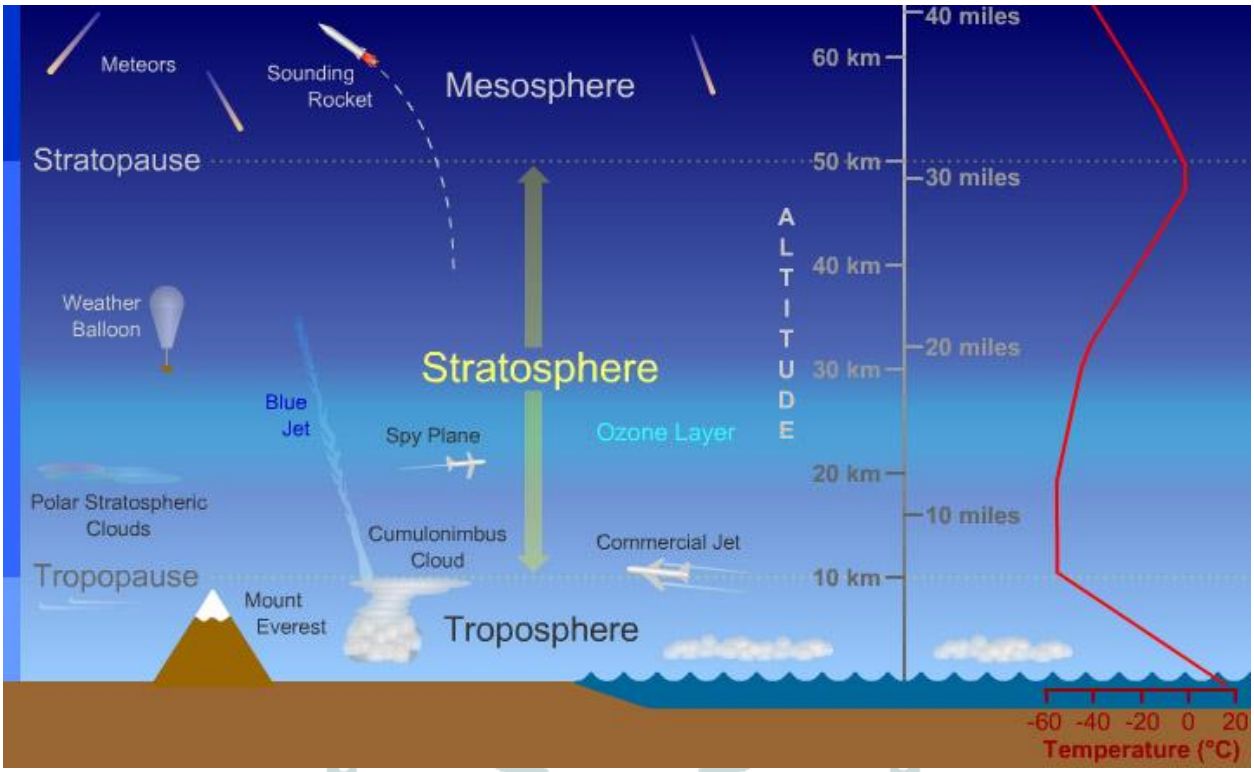
Mitigation

- Reducing C02
- Promoting government policies to cap CO2 emissions
- Eliminate offshore drilling
- By advocating for energy efficiency
- Alternative energy sources such as wind power, solar, etc.

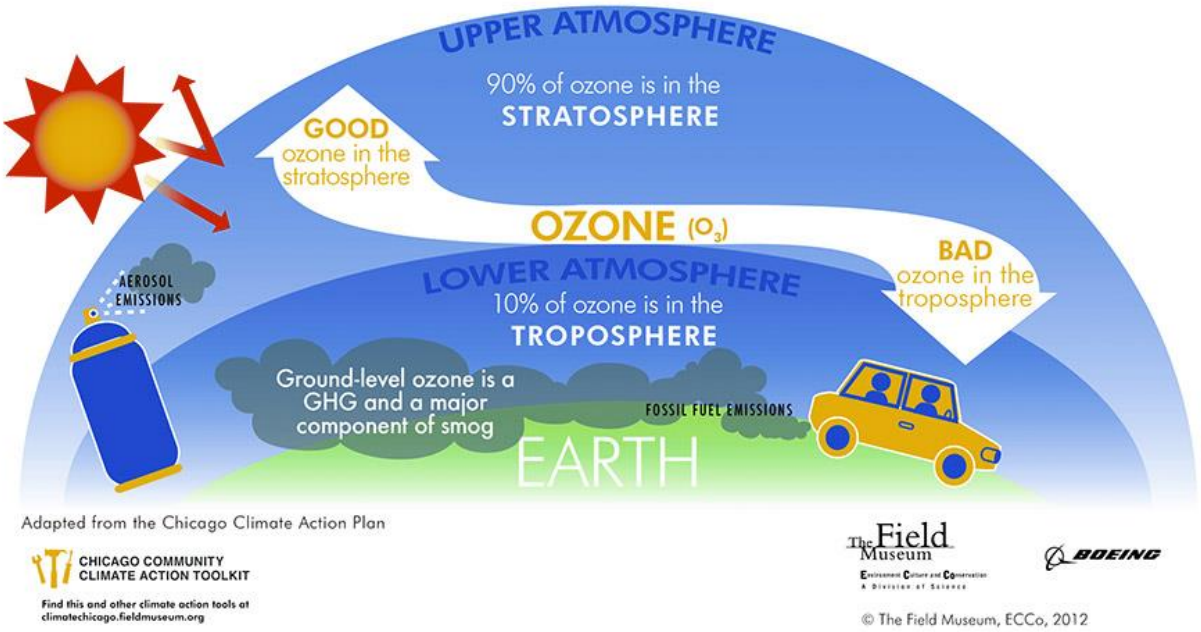


Ozone Depletion

Ozone



- Natural gas
- An **allotrope of oxygen** consisting of three atoms of oxygen
- Chemical symbol - 0_3.
- It is found in two different layers of the atmosphere.



Q.) Why ozone is 'bad in troposphere' and 'good in stratosphere'?

- Ozone in the troposphere – because it dirties the air and **helps to form smog**, which is not good to breathe.
- Ozone in the stratosphere – because it **protects life on Earth by absorbing** some of the sun's harmful **Ultra Violet (UV) rays**.
- Ozone protects oxygen at lower altitudes from being broken up by the action of ultraviolet light and also keeps most of the ultraviolet radiation from reaching the earth's surface.
- Reduces the risks of mutation and harm to plant and animal life.

Q.) How UV rays are harmful for us?

- They cause direct damage to the genetic material or DNA of animal and plant cells.
- Exposure of mammals to UV light act on the immune system, thereby making the body more susceptible to diseases.
- Too much UV rays can cause skin cancer and will also harm all plants and animals.

Ozone depletion

Significant decrease in the concentration of ozone in a particular region of the atmosphere, is called as 'ozone depletion'.

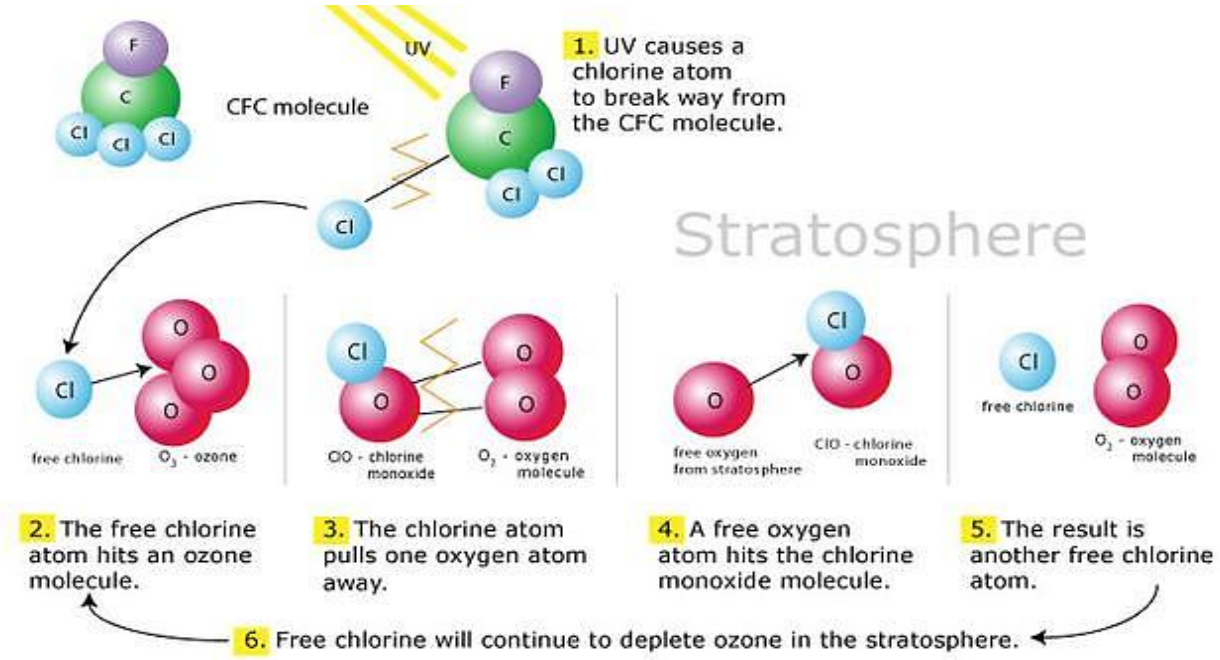
Change in equilibrium

- Equilibrium between the formation and destruction of ozone, has been upset by influx of several substances into the atmosphere which react with ozone and destroy it.
- **Rate of destruction of ozone > Rate of formation of ozone**
- **Best example of ozone depletion** - ozone hole in the, atmosphere over the Antarctic which has only about 50 percent of the ozone that originally occurred there.

Sources

Chlorofluorocarbons (CFCs)

- **Made of** - chlorine, fluorine and carbon.
- **Use** - used as refrigerants, propellants in aerosol sprays, foaming agents in plastic manufacturing, fire extinguishing agents, solvents for cleaning electronic and metallic components, for freezing foods etc.
- **Why they are used** – because of their properties like non-corrosiveness, non-inflammability, low toxicity and chemical stability, etc.
- **Lifetime or residence time –** 40-150 years
- **Removal –** cannot be eliminated by usual scavenging processes like photodissociation, rain-out and oxidation.
- **Escape of CFCs -** CFCs enter into the atmosphere by gradual evaporation from their source. E.g. CFCs can escape into the atmosphere from a discarded refrigerator. Because CFCs are thermally stable they can survive in the troposphere. But in the stratosphere, they are exposed to UV radiation.
- **Chemical reaction –** UV rays breakup CFCs and frees the chlorine atoms which react with ozone molecule and form chlorine monoxide (ClO). ClO further reacts with oxygen atom resulting in free chlorine atom which again react with ozone and divides them and cycle goes on. (see image)



- A single chlorine atom destroys thousands of ozone molecules before encountering reactive nitrogen or hydrogen compound that eventually return chlorine to its reservoirs.
- **CFC substitutes' characteristic's –** they must be safe, low cost, increased energy efficiency, effective refrigerants with low ozone layer depletion potential and low GWP.
    - CFC-12 (R-12) - widely used refrigerant. HFC 134a (R-134a) is the most promising alternative (R-143a) and (R-152a) can also be used.

Nitrogen oxides

- **Sources -** explosions of thermonuclear weapons, industrial emissions and agricultural fertilizers
- **Escape of N_2O** - Nitrous oxide (N_20) is released from solid through denitrification of nitrates under anaerobic conditions gradually reach the middle of the stratosphere, where it is photolytically destroyed to yield nitric oxide which in turn destroys ozone.

Other substances

Bromine

- Bromine containing compounds called halons and HBFCs, i.e. hydrobromo fluorocarbons [both used in fire extinguishers and methyl bromide (a widely used pesticide)].
- 100x of Chlorine i.e. Each bromine atom destroys 100x of more ozone molecules than what a chlorine atom does.

Sulphuric acid particles

- They free chlorine from molecular reservoirs, and convert reactive nitrogen into inert forms thus preventing the formation of chlorine reservoirs.

Monitoring the ozone layer

- Some organizations monitor the atmosphere and form a network of information communication –
    - World Meteorological Organization (WMO)
    - World Weather Watch (WWW)
    - Integrated Global Ocean Services Systems (IGOSS)
    - Global Climate Observing System (GCOS)

Q.) Why has an "ozone hole" appeared over Antarctica when ozone-depleting substances are present throughout the stratosphere?

- Because atmospheric and chemical conditions unique to this region increase the effectiveness of ozone destruction by reactive halogen gases.
- Formation of the Antarctic ozone hole requires temperatures low enough to form polar stratospheric clouds (PSCs), isolation from air in other stratospheric regions, and sunlight.

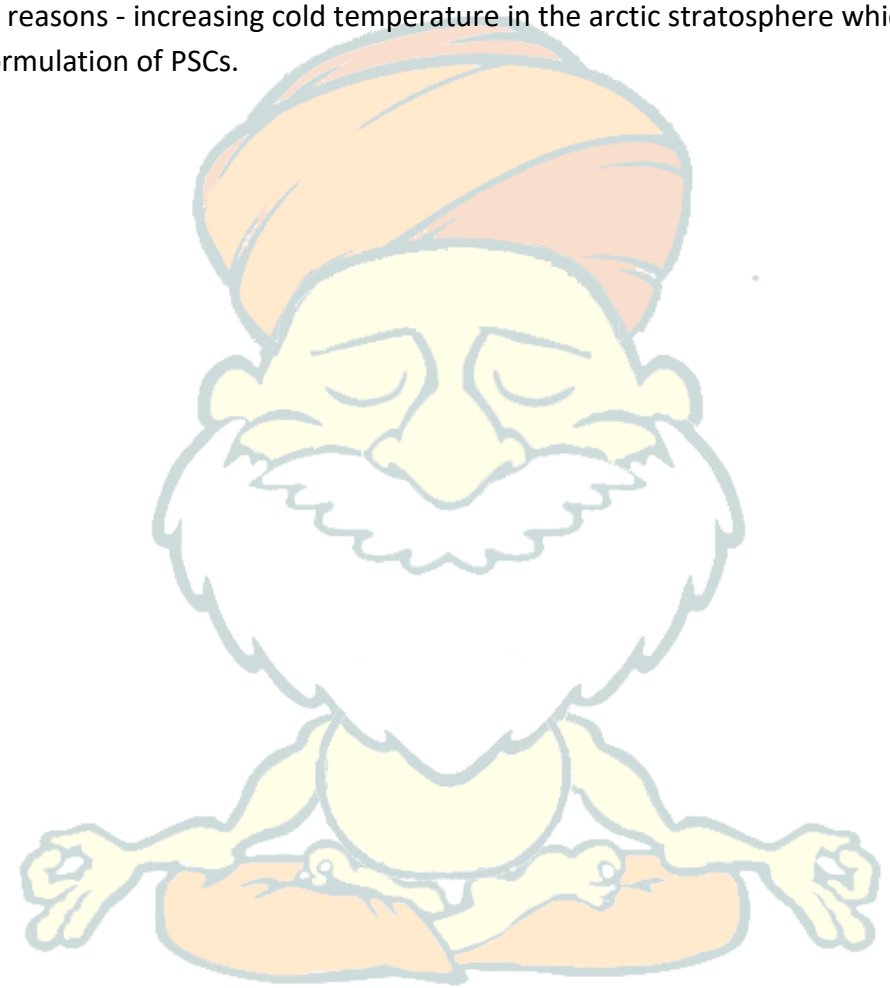
Role of polar stratospheric clouds in ozone depletion

- Correlation between the cycle of ozone depletion and the presence of polar stratospheric clouds (PSCs) i.e. the ice particles of the cloud provided substrates for chemical reactions which freed chlorine from its reservoirs. Usually the reaction between HCL and ClON02 is very slow, but this reaction occurs at a faster rate in the presence of a suitable substrate which is provided by the stratospheric clouds at the poles.

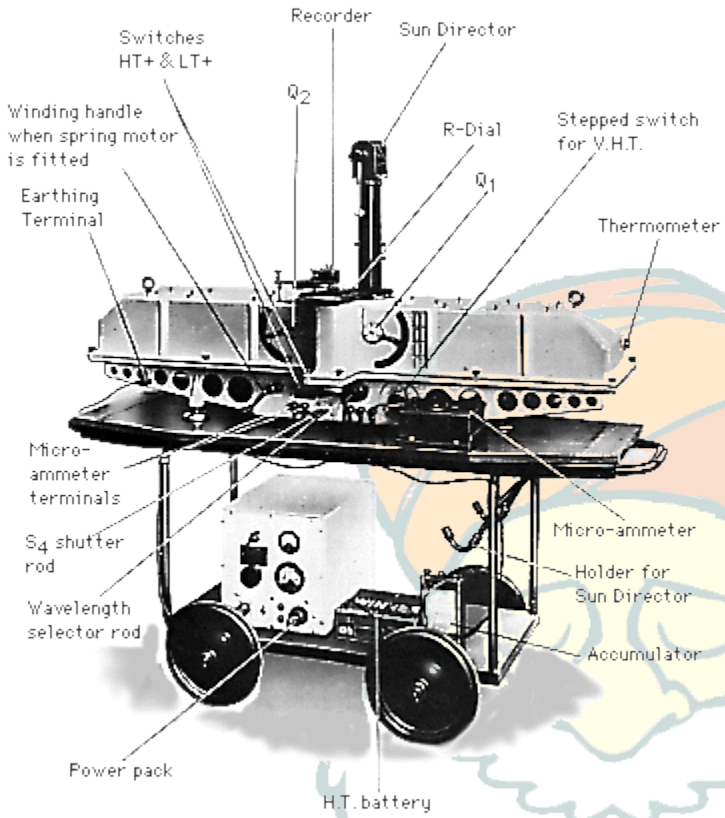
- It will result in formation of molecular chlorine and nitric acid.
- Molecular chlorine → broken down to atomic chlorine and ozone depletion continue
- PSCs activate chlorine + absorb reactive nitrogen.

Arctic Ozone Depletion

- In 1996 it was the greatest depletion of ozone ever seen, in the northern hemisphere.
- It had been caused because of cooling of the upper atmosphere in the northern latitudes.
- Other reasons - increasing cold temperature in the arctic stratosphere which encourages the formulation of PSCs.



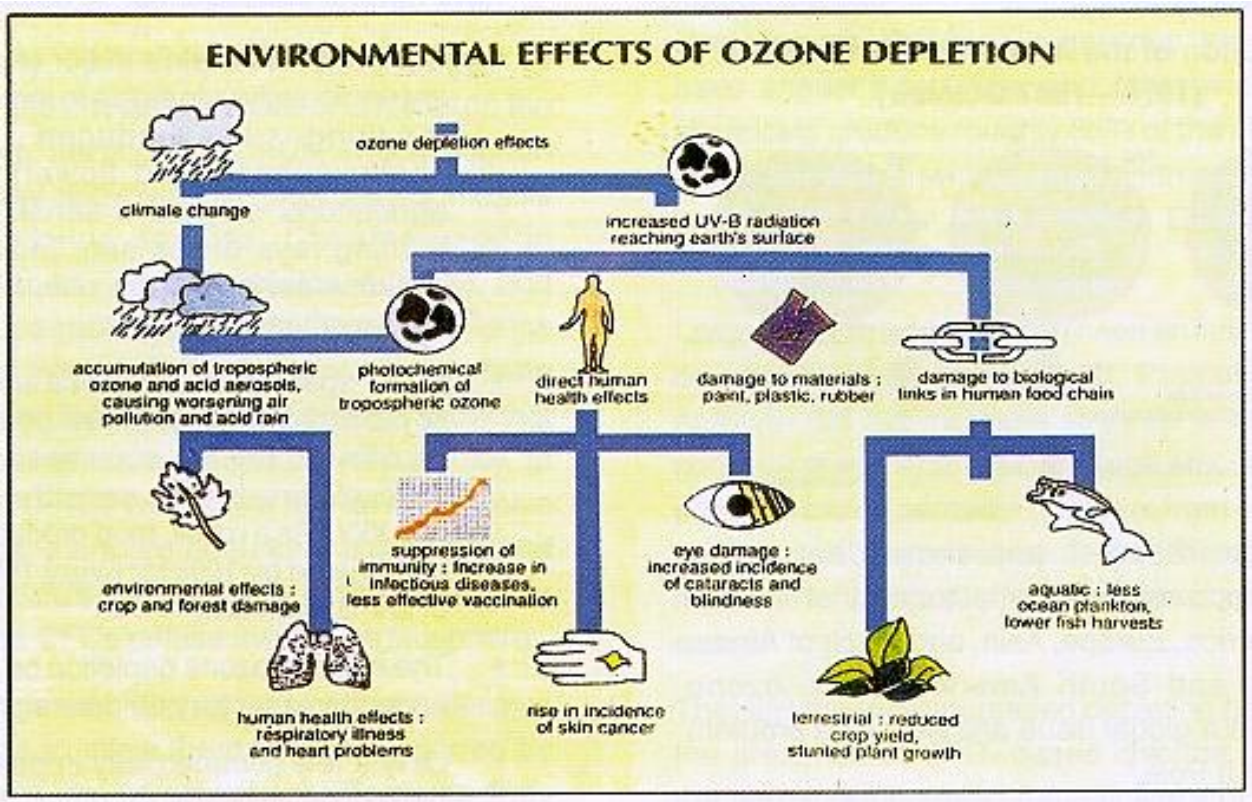
Measurement of ozone



THE DOBSON OZONE SPECTROPHOTOMETER

- Dobson spectrophotometer and the filter ozonometer called M83, and total ozone mapping spectrometer (TOMS) in the Nimbus-7 satellite – tools to measure ozone.

Effect of ozone depletion



- **Skin Cancer** - exposure to UV rays from sun can lead to increased risk for developing of several types of skin cancers. Malignant melanoma, basal and squamous cell carcinoma are the most common cancers caused by exposure to UV rays.
- **Eye Damage** - UV rays are harmful for our eyes too. Direct exposure to UV rays can lead to Cataract problems, and also Photokeratitis or snow blindness.
- **Damage to Immune system** - our immune system is also highly vulnerable to UV rays. Increased exposure to UV rays can lead to weakening of the response of immune system and even impairment of the immune system in extreme cases.
- **Aging of skin** - exposure to UV rays can lead to acceleration of the aging process of your skin. This will result in you looking older than what you actually are. It can also lead to photo allergy that result in outbreak of rashes in fair skinned people
- In humans, exposure to UV rays can also lead to **difficulty in breathing, chest pain, and throat irritation** and can even lead to **hampering of lung function**.
- UV rays affect other life forms too. It adversely affects the different species of amphibians and is one of the prime reasons for the **declining numbers of the amphibian** species. It affects them in every stage of their life cycle - from hampering the growth

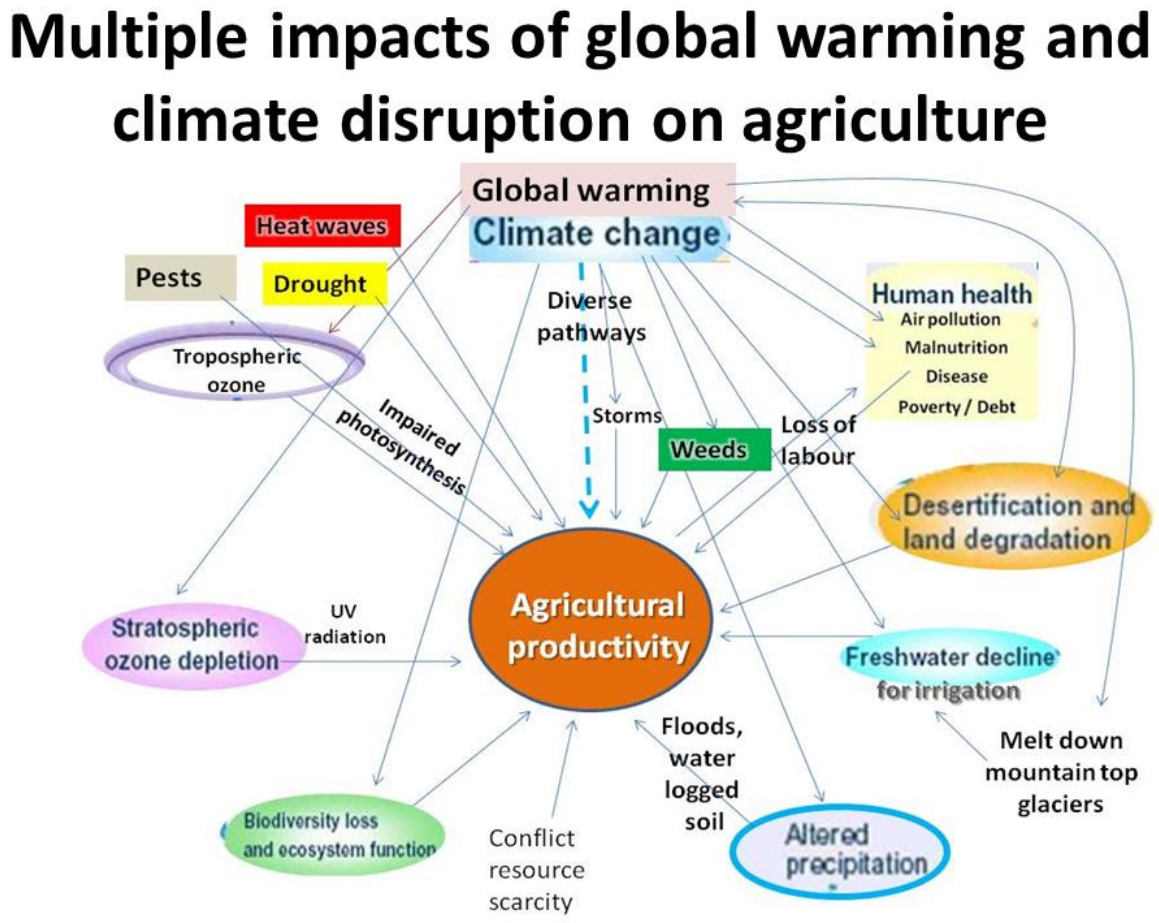
and development in the larvae stage, deformities and decreases immunities in some species and to even retinal damage and blindness in some species.

- UV rays also have adverse **effect on the marine ecosystem**. It adversely affects the planktons which plays a vital role in the food chain and oceanic carbon cycle. Affecting phytoplankton will in turn affect the whole ocean ecosystem.

- UV rays will also affect the plants. UV radiations can **alter the time of flowering** in some plant species. It can also directly **affect the plant growth** by altering the physiological and developmental processes of the plants.

Impact of Climate Change

Agriculture and food security



Impacts on crops

- It can affect crop yield. How?
    - Very simple. Just change or affect the inputs i.e. irrigation, solar radiation and prevalence of pests.
- Rise in temperature (due to Global Warming) affects the crops.
- As it can affect agriculture productions poorest countries will be first to hit by the wrath of CC (climate change) (IPCC report, 2001)
- Report says – crop yield would be reduced in tropical and sub-tropical region because of changed availability of water and pest incidence.
- Though rising CO2 can stimulate plant growth, it also reduces the nutritional value of most food crops. Rising levels of atmospheric CO2 reduce the concentrations of protein and essential minerals in most plant species, including wheat, soybeans, and rice.

Impacts on livestock

- **Heat waves** (projected to increase under climate change) affect animals both directly and indirectly. Over time, heat stress can increase vulnerability to disease, reduce fertility, and reduce milk production.
- **Drought** may threaten pasture and feed supplies. Drought reduces the amount of quality forage available to grazing livestock.
- Climate change may **increase the prevalence of parasites and diseases** that affect livestock.
- **Increases in carbon dioxide (CO2)** may increase the productivity of pastures, but may also decrease their quality. Increases in atmospheric CO2 can increase the productivity of plants on which livestock feed.

Impacts on Fisheries

- Many aquatic species can find colder areas of streams and lakes or **move north along the coast or in the ocean**. Nevertheless, moving into new areas may put these species into competition with other species over food and other resources.
- Some marine disease outbreaks have been linked with changing climate.
- Changes in temperature and seasons can **affect the timing of reproduction and migration**. Many steps within an aquatic animal's lifecycle are controlled by temperature and the changing of the seasons.

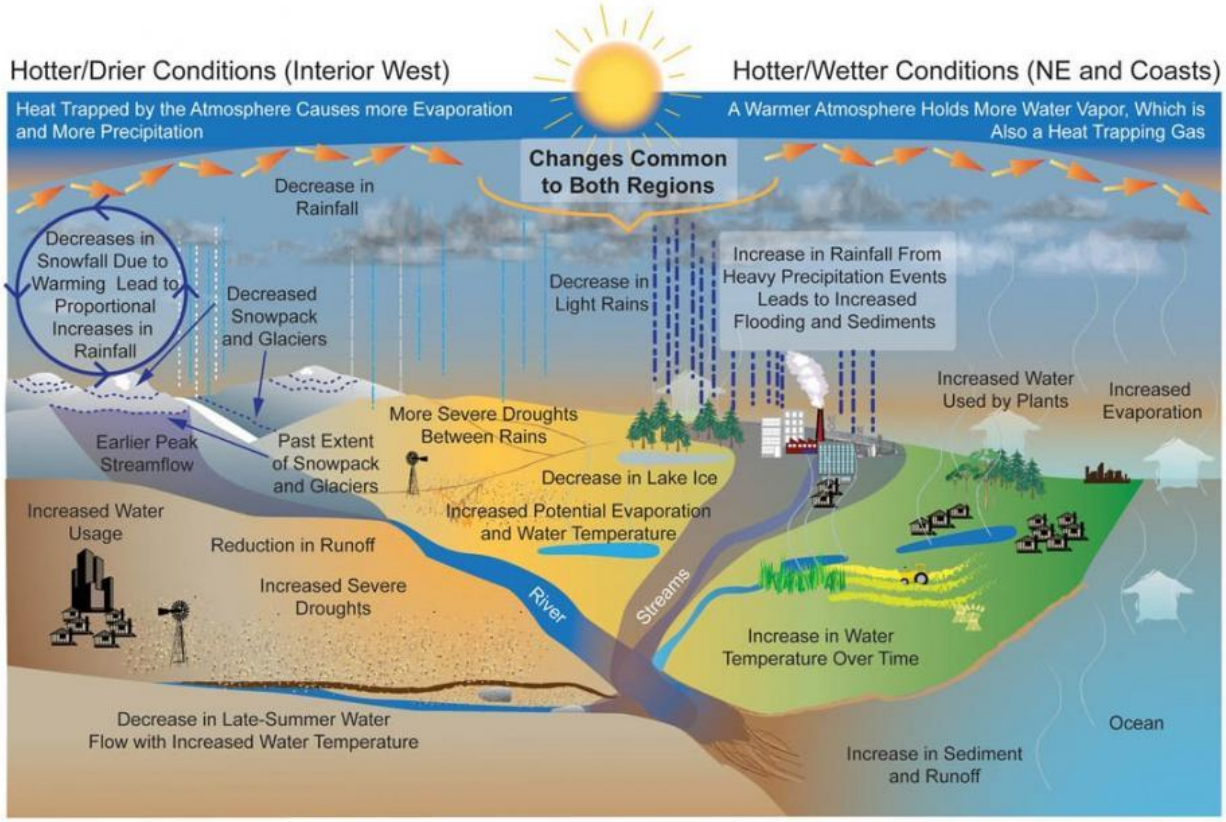
Impacts on Indian agriculture

- Productivity of agriculture depends on the rainfall and its pattern.
- So, phenomenon like El Nino can disturb this pattern → affecting productivity
- Change in rainfall pattern mean threat to agri., economy and food security.
- Summer rainfall – 70% of total annual rainfall – now this shows what would be result if we miss just one monsoon.
- According to studies by 2050s the summer rainfall would see decline.
- By 2050s –
    - Semi desert area of north west India – higher rainfall than normal
    - Central India – 10-20% decrease in rainfall
- Productivity of crops may decrease because of increase in temperature and decrease in water availability.
- Decline in productivity of rabi crops than kharif season crops.
- Rising temperature will increase the use of fertilizers resulting in higher GHG emissions, ammonia and cost of crop production.

Water stresses and insecurity

Water cycle and water demand

- Water cycle's delicate balance of precipitation, evaporation will change.



- Increase in temperature → Increased evaporation → it may dry out some areas and fall as excess precipitation on other areas.
- As temperatures rise, people and animals need more water to maintain their health and thrive. Many important economic activities, like producing energy at power plants, raising livestock, and growing food crops, also require water. The amount of water available for these activities may be reduced as Earth warms and if competition for water resources increases.

Water supply

- Many areas of the world currently face water shortages. The amount of water available is already limited, and demand will continue to rise as population grows.
- In the western part of the India, less total annual rainfall mean that less water will likely be available during the summer months when demand is highest. This will make it more difficult for water managers to satisfy water demands throughout the course of the year.

Water Quality

- Water quality could suffer in areas experiencing increase in rainfall. For example, in the North and North east increase in heavy precipitation events could cause problems for the water infrastructure, as sewer systems and water treatment plants are overwhelmed by the increased volumes of water.
- Heavy downpours can increase the amount of runoff into rivers and lakes, washing sediment, nutrients, pollutants, trash, animal waste, and other materials into water supplies, making them unusable, unsafe, or in need of water treatment.
- Freshwater resources along the coasts face risks from sea level rise. As the sea rises, saltwater moves into freshwater areas.
- As more freshwater is removed from rivers for human use, saltwater will move farther upstream.
- Drought can cause coastal water resources to become more saline as freshwater supplies from rivers are reduced.
- Water infrastructure in coastal cities, including sewer systems and wastewater treatment facilities, faces risks from rising sea levels and the damaging impacts of storm surges.

Impacts on water situation in India

- Increased pressure on water resources.
- Himalayan glaciers' fresh water for perennial rivers, in particular the Indus, Ganga, and Brahmaputra river systems had undergone substantial changes as a result of extensive land use (e.g. deforestation, agricultural practices and urbanization), leading to frequent hydrological disasters, enhanced sedimentation and pollution of lakes.
- Gangotri glacier is retreating about 20-25 m per year and is expected to increase under changed climate conditions, which would lead to increased summer flows in some river systems followed by glaciers disappearance.
- As a result of increase in temperature significant changes in rainfall pattern have been observed during the 20th century in India.
- Different rivers like Kosi, Ganga, Ghaghara, Son, Indus and its tributaries and Yamuna had changed their course a number of times. Recent devastating floods in Nepal and Bihar is result of same (due to change of course of River Kosi)
- Food production has to be increased by 2020 in order to feed India's ever-growing population. It is feared that the fast increasing demand for food in the next 2 or 3 decades could be quite grim because of poor water supply, soil degradation and climate change.

- Rise in population will increase the demand for water leading to faster withdrawal of water and this in turn would reduce the recharging time of the water tables → Result → availability of water bound to reach critical levels sooner or later.
- Growing demand of water in agriculture, industrial and domestic sectors → overexploitation of the groundwater resource.
- The falling ground water levels in various parts of the country have threatened the sustainability of the groundwater resources.
- Agriculture sector - largest consumer of water in India – 83% (If used judiciously, the demand may come down 68% by 2050)
- To meet above demand augmentation of the existing water resources by development of additional sources of water or conservation of the existing resources and their efficient use will be needed.
- The consequences of future climatic change may be felt more severely in developing countries such as India, whose economy is largely dependent on agriculture and is already under stress due to current population increase and associated demands for energy, freshwater and food.

Rise in sea levels

- Sea level rise can be both due to thermal expansion as well as melting of ice sheets.
- Since 1993, sea level has been rising at a rate per year, significantly higher than the average during the previous half-century.
- IPCC predicts that sea levels could rise rapidly with accelerated ice sheet disintegration.
- Global temperature increase of 3-4°C in future means – 330 million people being permanently or temporarily displaced through flooding
- Warming seas will also fuel more intense tropical storms.

Impacts on Coastal States in India

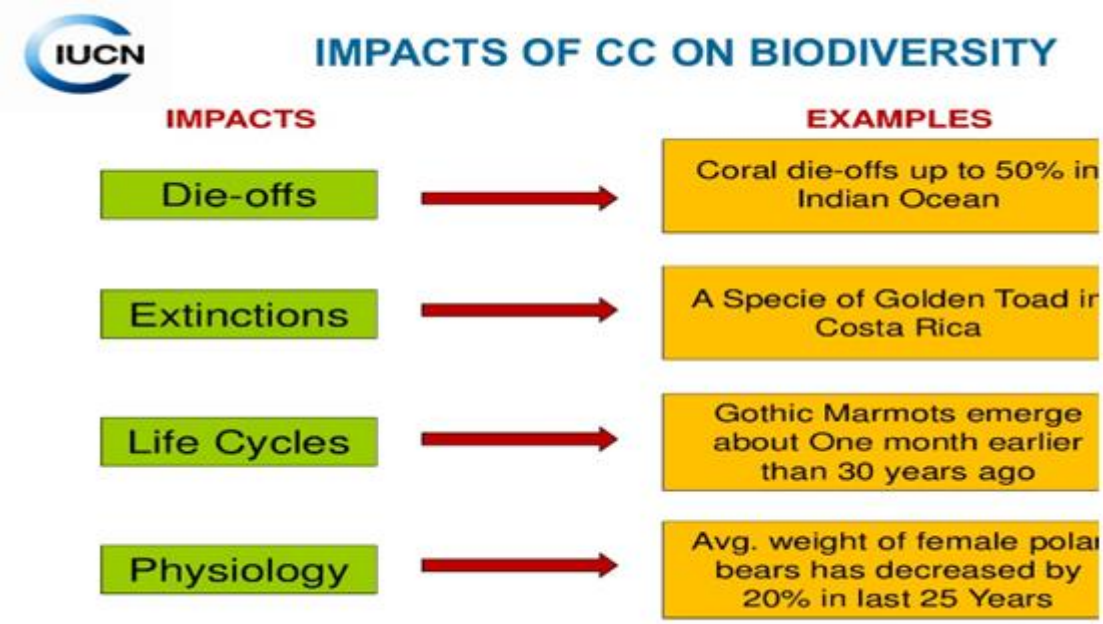
- The short and long term variations in sea level impact the coastal ocean in many different ways.
- Long term sea level rise is expected to have a significant impact on the straight coast as well as islands, barrier reefs, entrance processes of river estuaries, inlets, bays, coastal lagoons, etc., which will subsequently have a cascading effect on environmental processes of these coastal environments.
- Coastal states - Maharashtra, Goa and Gujarat face a grave risk from the sea level rise, which could flood land and cause damage to coastal infrastructure and other property.
- Goa will be the worst hit – will lose large % of land + famous beaches and tourist infrastructure.

- The Global Environmental Outlook (GEO-6) report of UN – "Nearly 40 million Indians will be at risk from rising sea levels by 2050, with people in Mumbai and Kolkata having the maximum exposure to coastal flooding in future due to rapid urbanization and economic growth"
- Mumbai's - northern suburbs like Versova beach, tidal mud flats and creeks – vulnerable to land loss and increased flooding.
- Flooding will displace a large number of people which will put greater pressure on the civic amenities and rapid urbanization.
- Sea water percolation due to inundations can diminish freshwater supplies.
- Threatening to existence of coral reefs, phytoplankton, the fish stocks and the human lives.
- People living in the Ganges Delta share the flood risks associated with rising sea levels.

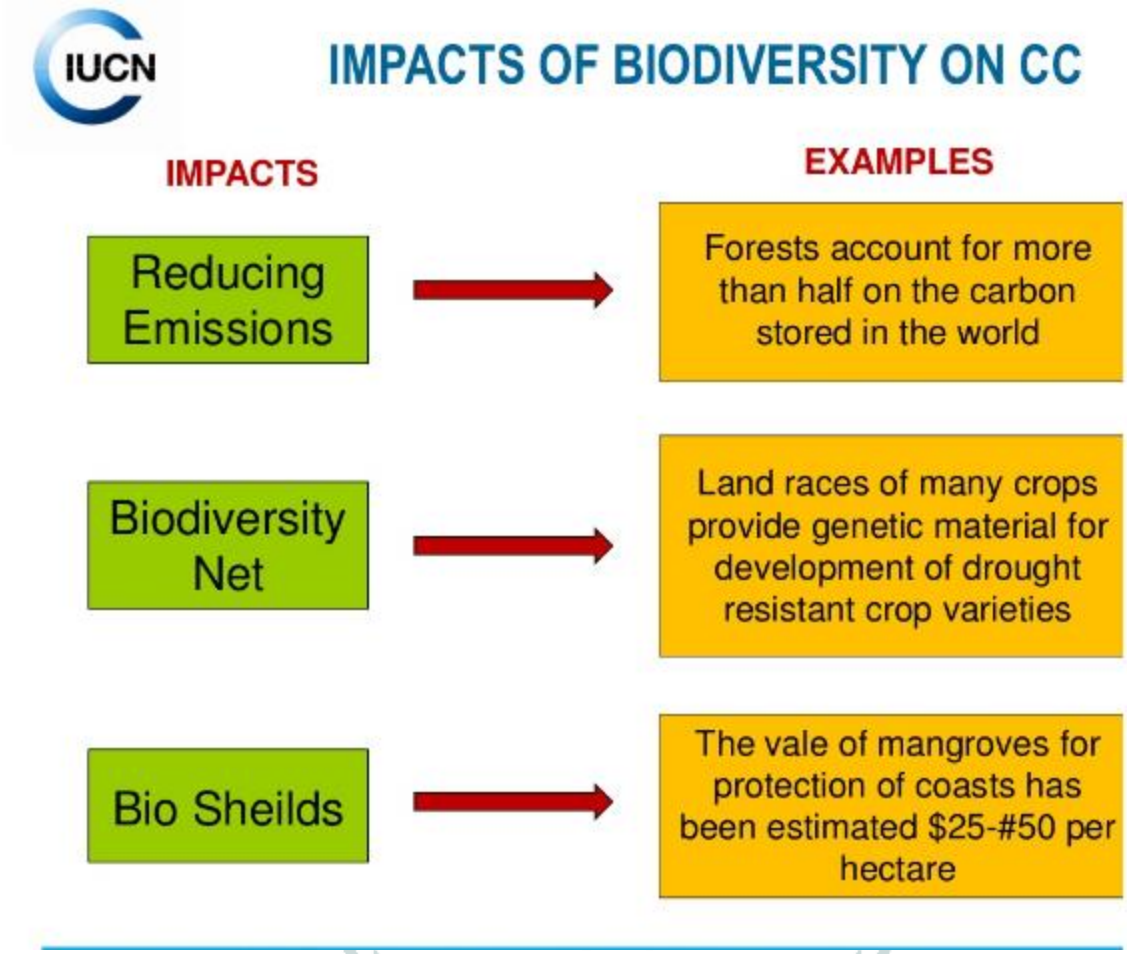
Ecosystems and Biodiversity

- Climate Change has the potential to cause immense biodiversity loss, affecting both individual species and their ecosystems.
- The projected extinctions of flora and fauna in the future will be because of adverse impact of human activities.
- According to International World Wildlife Fund (WWF) species from the tropics to the poles are at risk.
- Many species have started to move but many may be unable to move to new areas quickly enough to survive changes that rising temperatures will bring to their historic habitats.
- WWF asserted that $1/5^{th}$ of the world's most vulnerable natural areas may be facing a "catastrophic" loss of species.
- Climate change will have catastrophic impact on the marine ecosystems. Climate change → ocean acidification → affect marine organism productivity, reproduction, way they live, etc.
- This is expected to negatively affect shell forming organisms, corals and their dependent ecosystems.

Impacts on India's biodiversity



- Mountain ecosystems which are hot spots of biodiversity are fragmented and degraded because of increase in temperature and human activities.
- Himalayan Ecosystems which are lifeline of India, China, Pakistan, Nepal are threatened by climate change.
- Prediction – there will be an increase in the phenomenon of Glacial Lake Outburst Floods (GLOFs) in the Himalayas causing catastrophic flooding downstream with serious damage to life property, forests, farms and infrastructure.
- Indian desert is rich in species diversity of mammals and winter migratory birds.
- There are sign of expansion by deserts i.e. desertification.
- Change in climate pattern – floods in Barmer district of Rajasthan in 2006.



- Mangrove forests acts as carbon sink and habitat for diverse species of plants and animals. Any change in salinity or sea level will affect these unique forests.
- Wetlands – natural barrier to flooding and cyclones.
- Corals – world's most productive ecosystem. Coral bleaching because of climate change.
- Peninsular rivers are heavily dependent on monsoon thus peninsular ecosystem is monsoon dependent.
- India is an agrarian economy heavily dependent on monsoon and so we need to tackle problem of climate change effectively.

Climate change and Health

Temperature-Related Impacts

- Warmer average temperatures will lead to hotter days and more frequent and longer heat waves. It will increase heat related deaths.
- Exposure to extreme heat can lead to heat stroke and dehydration, as well as cardiovascular, respiratory, and cerebrovascular disease.
- Low-income households and older adults may lack access to air conditioning which also increases exposure to extreme heat.
- Urban areas are typically warmer than their rural surroundings.

Air quality impacts

- Changes in the climate affect the air we breathe both indoors and outdoors. Warmer temperatures and shifting weather patterns can worsen air quality, which can lead to asthma attacks and other respiratory and cardiovascular health effects.
- Particulate matter (PM) is the term for a category of extremely small particles and liquid droplets suspended in the atmosphere.
- Some PM such as dust, wildfire smoke, and sea spray occur naturally, while some is created by human activities such as the burning of fossil fuels to produce energy.
- Inhaling fine particles can lead to lung cancer, chronic obstructive pulmonary disease (COPD), and cardiovascular disease.

Impacts from Extreme Weather Events

- Extreme weather events, such as extreme precipitation, flooding, droughts, and storms, threaten the health of people during and after the event.
- Extreme events can affect human health in a number of ways by -
    - Reducing the availability of safe food and drinking water.
    - Damaging roads and bridges, disrupting access to hospitals and pharmacies.
    - Interrupting communication, utility, and health care services.
    - Contributing to carbon monoxide poisoning from improper use of portable electric generators during and after storms.
    - Creating or worsening mental health impacts such as depression and post-traumatic stress disorder (PTSD).

Vectorborne Diseases

- Vectorborne diseases are illnesses that are transmitted by disease vectors, which include mosquitoes, ticks, and fleas.

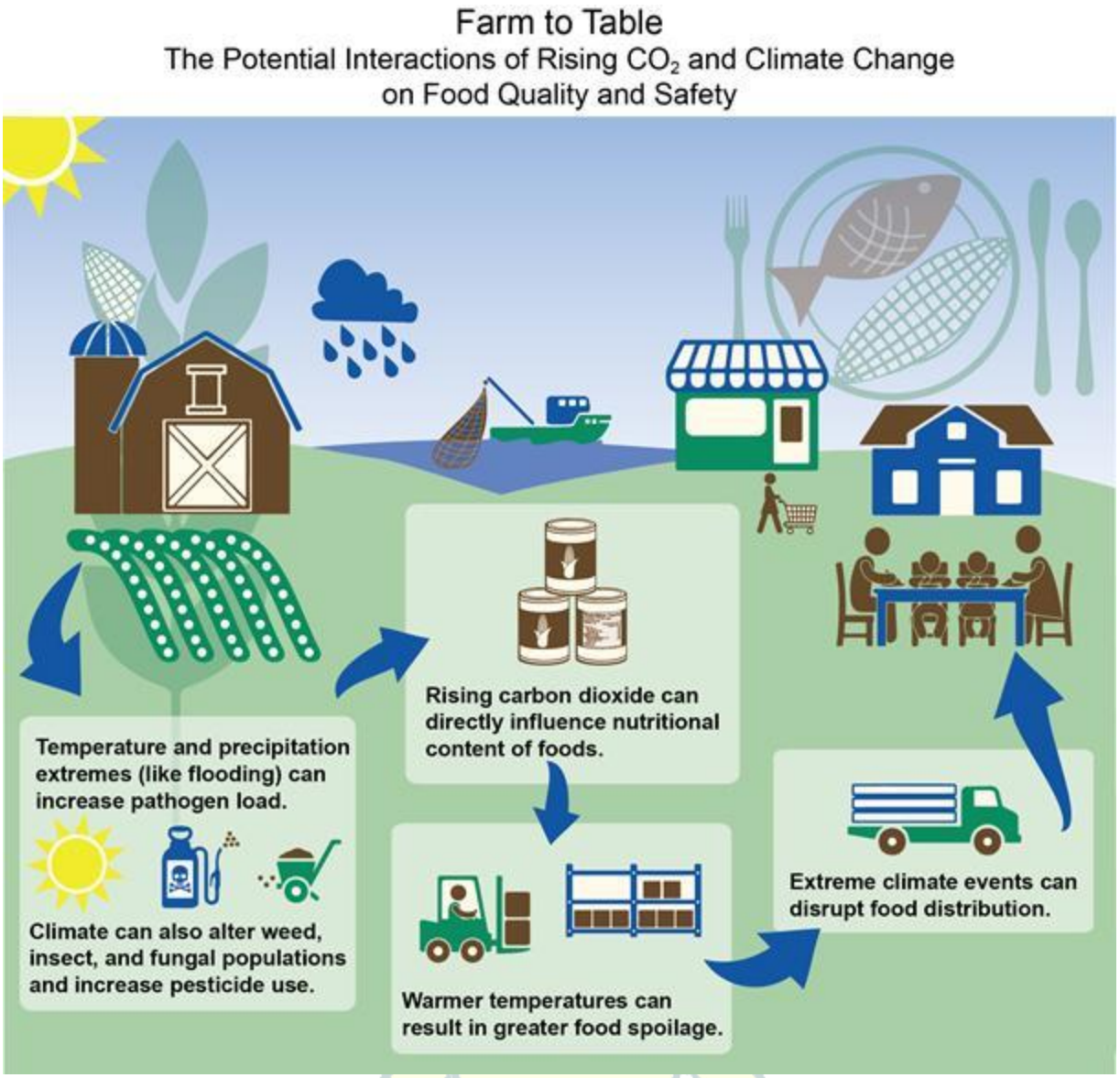
- These vectors can carry infectious pathogens, such as viruses, bacteria, and protozoa, from animals to humans.
- Changes in temperature, precipitation, and extreme events increases the geographic range of diseases spread by vectors and can lead to illnesses occurring earlier in the year.
- The risks for climate-sensitive diseases can be much higher in poorer countries that have less capacity to prevent and treat illness.

Water-Related Illnesses

- People can become ill if exposed to contaminated drinking or recreational water.
- Climate change increases the risk of illness through increasing temperature, more frequent heavy rains and runoff, and the effects of storms.
- Climate impacts can affect exposure to waterborne pathogens (bacteria, viruses, and parasites), toxins produced by harmful algal and cyanobacterial blooms in the water and chemicals that end up in water from human activities.
- Changing water temperatures mean that waterborne Vibrio bacteria and harmful algal toxins will be present in the water or in seafood at different times of the year, or in places where they were not previously threats.
- Runoff and flooding resulting from increases in extreme precipitation, hurricane rainfall, and storm surge will increasingly contaminate water bodies used for recreation (such as lakes and beaches), shellfish harvesting waters, and sources of drinking water.
- Extreme weather events and storm surges can damage or exceed the capacity of water infrastructure (such as drinking water or wastewater treatment plants), increasing the risk that people will be exposed to contaminants

Food Safety and Nutrition

- Climate change and the direct impacts of higher concentrations of CO_2 in the atmosphere are expected to affect food safety and nutrition.
- Extreme weather events can also disrupt or slow the distribution of food.
- Climate change will have a variety of impacts that may increase the risk of exposure to chemical contaminants in food. For example, higher sea surface temperatures will lead to higher mercury concentrations in seafood, and increases in extreme weather events will introduce contaminants into the food chain through storm water runoff.



- Higher concentrations of carbon dioxide in the air can act as a "fertilizer" for some plants, but lowers the levels of protein and essential minerals in crops such as wheat, rice, and potatoes, making these foods less nutritious

Previous Years Questions

The formation of ozone hole in the Antarctic region has been a cause of concern. What could be the reason for the formation of this hole? (Prelims 2011)

a) Presence of prominent tropospheric turbulence; and inflow of chlorofluorocarbons
b) Presence of prominent polar front and stratospheric clouds; and inflow of chlorofluorocarbons.
c) Absence of polar front and stratospheric clouds; and inflow of methane and chlorofluorocarbons.
d) Increased temperature at polar region due to global warming

Which of the following can be threats to the biodiversity of a geographical area? (Prelims 2012)

1. Global warming
2. Fragmentation of habitat
3. Invasion of alien species
4. Promotion of vegetarianism

Select the correct answer using the codes given below:

a) 1, 2 and 3 only
b) 2 and 3 only
c) 1 and 4 only
d) 1, 2, 3 and 4

Acid rain is caused by the pollution of environment by (Prelims 2013)

a) carbon dioxide and nitrogen
b) carbon monoxide and carbon dioxide
c) ozone and carbon dioxide
d) nitrous oxide and Sulphur dioxide

The formation of ozone hole in the Antarctic region has been a cause of concern. What could be the reason for the formation of this hole? (Prelims 2011)

a) Presence of prominent tropospheric turbulence; and inflow of chlorofluorocarbons .
b) Presence of prominent polar front and stratospheric clouds and inflow of chlorofluorocarbons.
c) Absence of polar front and stratospheric clouds: and inflow of methane and chlorofluorocarbons.
d) Increased temperature at polar region due to global warming.