



TARGET PRELIMS 2024

BOOKLET-16; EB&CC-6

CLIMATE CHANGE, OZONE LAYER, DESERTIFICATION

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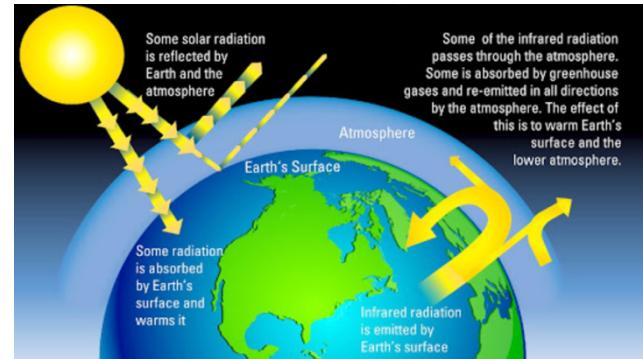
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2. CLIMATE CHANGE AND GREEN HOUSE GASES

- **Climate:** Long term pattern of weather in a particular area.

- **Climate Change:**

- The increasing temperature of earth due to greenhouse effect is known as climate change. It is leading to extreme weather events, melting of Polar ice, rising of sea levels etc.



- **Green House Effect:** Class discussion

- **Greenhouse Gases:** Gases in the earth's atmosphere that trap heat are known as Greenhouse gases. They let sunlight pass through the atmosphere, but they prevent the heat that the sunlight brings from leaving the atmosphere. Greenhouse gases are crucial for survival of life on earth. In the absence of Greenhouse gases, the average temperature on earth would have been -18 degree Celsius instead of the present 15 degree Celsius.

1) WATER VAPOR:

It is the most important Greenhouse gas and plays an important role in controlling earth's temperature.

- Water Vapors account for about 60% of the warming effect. The amount water in atmosphere rises with rising temperature and decreases with the fall in temperature. So, in a way it can be said that water vapors in atmosphere is controlled by the temperature.
- But it is the non-condensable gases (mainly CO₂ which is bringing the increase in the temperature after the first industrial revolution) which are really responsible for recent rise in global warming.

2) CARBON DIOXIDE (CO₂)

- It is produced by **burning of carbon containing substances**, mostly fuels (Coal, natural gas, oil), Solid waste, trees, other biological materials etc.

- CO₂ is removed from atmosphere when it is absorbed (sequestered) by plants during photosynthesis.

- **Concentration of CO₂ in atmosphere:**

- For the first time in history, the atmospheric CO₂ level reached 419 parts per million (PPM), as measured by the United States' National Oceanic and Atmospheric Administration's Mauna Loa Atmospheric Baseline Observatory in Hawaii.
 - » This is nearly 45% above the pre-industrial baseline of 278 PPM in 1750 accepted by IPCC.
- Our annual CO₂ emission have grown about 70 times since the pre-industrial era reaching nearly **36.4 Gt** in 2019.



3) METHANE

- As per UNEP, **Methane** is a GHG which is responsible for 30% of the warming since pre-industrial times. Its contribution is 2nd only to carbondioxide.
 - » Although the warming effect of methane is 30 times greater than CO₂, it is a shorter lived and lasts in the atmosphere for about 12 years. (CO₂ lingers for centuries)
- **Why special focus on methane is needed in our fight against climate change?**
 - » IPCC had said that the methane mitigation has the greatest potential to slow warming over the next 20 years.
 - A 0.3% reduction per year in methane is equivalent to net-zero for CO₂ - there would be no additional warming if this level of reduction is achieved.
- **Methane Emission: Biggest Source:**
 - **Natural Sources:** Wetlands, termites etc.
 - **Wetlands** are the largest source of methane.
 - **Agriculture** - Rice cultivation, animal husbandry etc. generate substantial amount of methane.
 - **Energy Production** (fossil fuel) - Among anthropogenic factors, after Agriculture, it is this sector which contributes to the highest methane production. It is released during the extraction, processing, and transport of fossil fuels, including coal, oil, and natural gas.
 - **Leakage:** For e.g. the ruptures in the underwater Nord stream in Sep 2022 caused the single largest such release of the greenhouse gas.
 - **Landfills** in recent times are also becoming a big source of methane emissions.
 - **Thawing of permafrost** in polar region is also releasing methane. In future, it may become a big source of methane emissions.
- **Current Emission levels:**
 - As per US NOAA, the atmospheric level of methane has jumped to 17 parts per billion in 2021, beating the previous record set in 2020.

A) INTERNATIONAL EFFORTS TO FIGHT METHANE POLLUTION

IMPROVING DETECTION:

- UNEP has launched International Methane Emissions observatory - the Methane Alert and Response System (MARS) at COP27. It is focused on scaling up global efforts to detect and act on major emissions sources in a transparent manner and accelerate implementation of the global methane pledge.

GLOBAL METHANE PLEDGE ANNOUNCED AT COP26

- By COP27, 150 countries have joined the initiative lead by USA and EU. They have promised to cut their methane emission by at least 30% from 2020 levels by 2030.
- **Significance:**
 - » Global warming would be reduced by at least 0.2 degree Celsius by 2050, if countries deliver according to the pledge.

- » **Health benefits:** Oxidation of methane is responsible for formation of ground-level ozone (smog), which is a harmful air pollutant.
- **Why has India not joined the pledge?**
 - » India's methane emissions are 'survival emissions' and not 'luxury' emissions.
 - The two prominent source of methane in India are enteric fermentation and 'paddy cultivation' and any restriction on them would harm small and marginal farmers.
 - » Other than harming farmers, it may also reduce agri production. Currently, India is one of the largest producers and exporters of rice.
 - » India also argues that 6th IPCC report has highlighted that CO2 is the major global warming gas and this pledge is shifting focus to methane which has a lifetime of only 12 years, whereas CO2 can survive for more than 100 years.
- **India has not joined the global methane pledge**, but it doesn't mean the India is not worried about methane emissions. There are several fronts on which India is working.
 - » **National Innovation in Climate Resilient Agriculture (NICRA)** project of ICAR has developed several technologies with the potential to mitigate methane emissions.
 - For instance, the 'System of Rice Intensification' has the potential to enhance rice yield from 36-49% with 22-35% less water than conventional transplanted rice. It also uses less seed, fertilizers, and pesticides.
 - » Key steps involve:
 1. Planting young seedlings (less than 15 days old) with only one or two leaves
 2. Planting them singly, spaced widely apart
 3. Maintaining soil moisture at a level that promotes aerobic soil conditions
 4. Controlling weeds by mechanical means, such as hand weeding or using a rotary hoe
 5. Using organic matter to improve soil fertility.
 6. Applying small amounts of fertilizer at specific stages of plant growth
 - Another technology, 'Direct Seeded Rice' reduces methane emissions as it does not involve raising nurseries, puddling, and transplanting. Unlike transplanted paddy cultivation, standing water is not maintained in this system.
 - **Harit Dhara:** It is an anti-methanogenic feed supplement developed by ICAR. It can cut down cattle methane emissions by 17-20% and can also result in higher milk production.
 - Under Crop Diversification Program, methane emission is being avoided due to diversion of paddy to alternate crops like pulses, oilseeds, maize, cotton, and agro-forestry.

B) REPORT: METHANE GLOBAL TRACKER REPORT BY IEA (FEB 2023)

- **Summary:**
 - » **Emissions from Energy Sector:** The energy sector accounts for around 40% of the total average methane emissions from human activity, as oil and natural gas companies are known to release methane into the atmosphere when natural gas is flared or vented. The greenhouse gas is also released through leaks from valves and other equipment during drilling, extraction and transportation process.
- **How can methane emission be reduced:** Although, it's impossible to completely eliminate all the emissions, **75% of the methane emissions from the energy sector** can be reduced with the help of cheap and readily available technology. However, **fossil fuel companies have failed to take any substantial action regarding the issue.**
- The effort will cost less than 3% of the net income received by the oil and gas industry in 2022.
- **Details:**
 - » Fossil fuel companies emitted 120 million metric tonnes of methane into the atmosphere in 2022, only slightly below the record high seen in 2019.
 - » The cheap and readily available technology can reduce 75% of the methane emissions from the energy sector.

C) BURP CONTROL: HOW CAN METHANE RELEASED IN LIVESTOCK BELCHED BE REDUCED? (DEC 2022: SOURCE - DTE)

- **Feed Supplements** - which can reduce a potent greenhouse gas belched out by stock animals like cattle, goat and sheep. A food supplement is considered ideal if it can **lower methane emissions by at least 20%**.
- In 2021, **EU approved a food supplement, Bovaer**, developed by Dutch bioscience company Royal DSM, saying it consistently reduces methane emissions from dairy cows by 30-80%.
 - **Bovaer**, is a fine granular powder containing **3-nitrooxypropanol**, which inhibits an essential enzyme responsible for the methane production.

D) TERMITES EMIT METHANE: BUT THE EXTENT OF THEIR RISK TO GLOBAL WARMING IS UNCERTAIN (SOURCE: DTE)

- As per the Global Carbon Project, in 2008-17, the world emitted 576 Tg of methane per year, of which termites contributed 9 Tg.
- **However**, scientists say that the real emissions may be greater or lesser than this. To establish certainty, there is a need to understand the relationship between termite colonies and methane.
- **How is methane produced by Termites?**
 - In natural ecosystems, they feed on and recycle the nutrients present in dead and decaying plant and animal matter.
 - It is this cellulose-rich diet that causes their emissions.
 - **Methanogenic microorganisms** that live in the gut of termites break down the cellulose entering the body and release methane.

4) NITROUS OXIDE (N₂O)

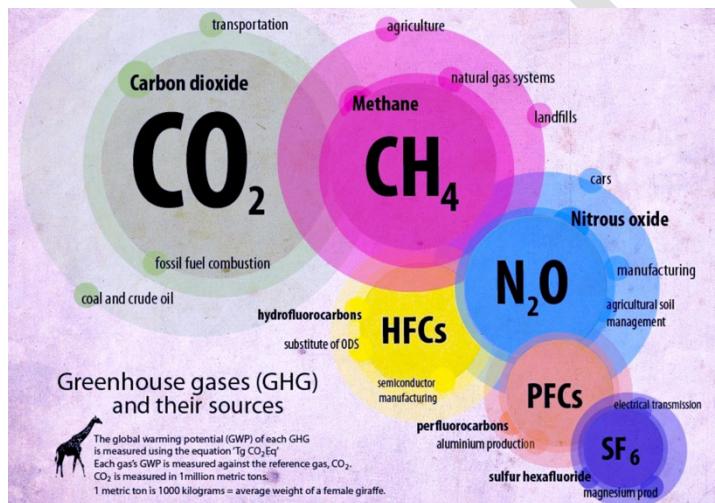
- It is the third most important GHG. It is long lived (average > 100 years), and also has ozone depleting properties.

- It is a natural part of the nitrogen cycle. Bacteria in soil and the ocean make it. It is also produced during agricultural and industrial activities, combustion of fossil fuels and solid waste, as well as during treatment of wastewater.
- **Reports: Global Nitrous Oxide Budget**
 - N₂O is accumulating in the atmosphere at an increasing rate, with **global emissions of 17 Tg N in 2016, 10% greater than in the 1980s**. **Net emission** (thus net addition) is **4.3 Tg**.
 - **Main Anthropogenic factors** is the agriculture.
 - Other factors include - fossil fuels, industry, waste and wastewater, and biomass burning.

5) OZONE (O₃) -> ALREADY COVERED WITH AIR POLLUTION

6) FLUORINATED GASES (HFCS, PFCS, SF₆, NITROGEN TRIFLUORIDE (NF3) ETC.)

- Not naturally found in atmosphere and are manmade.
- Fluorinated gases are used as substitute for ozone depleting substances like CFCs, HCFCs, and Halons.
- Though they are released in small quantities, but their global warming potential is very high.



7) BLACK CARBON

- **What is black carbon?**
 - » It is the sooty black material emitted from gas and diesel engines, coal-fired power plants, and other sources that burn fossil fuel. It comprises a significant portion of particulate matter or PM, which is an air pollutant. It consists of pure carbon in several linked forms.

- **Environment Pollutant** - It is a short-lived pollutant which is the key component of PM_{2.5}. It has negative implications for our health and may cause respiratory and cardio-vascular diseases, cancer, birth defects and premature mortality.
- **Climate Change:** It is also responsible for **climate change**.
 - » BC deposits can **accelerate the pace of glacier and snow melt** in the Himalayan region.
 - How?
 - » It is also responsible for affecting the cloud formation and thus affects rainfall.
 - » A recent study has shown that it may also be depleting ozone layer.
- **Main Sources: Incomplete burning of fuel** (i.e., inefficient burning environment) produces black carbon.
 - » **Solid Fuel burning** [coal, biomass etc.]
 - Industry (primary brick kilns) and residential burning of solid fuel together account for about 45-66% of anthropogenic BC deposition in Himalayan region.
 - » **Diesel exhausts** etc. contributes to 7-18% of BC deposits in the Himalayan region.
 - » Since, India has a large population depending on **bio-mass and solid fuel**, it contributes to around 25% of the world's Black Carbon emission.
 - According to a study published in the journal *Atmospheric Research* in April 2019, India is the 2nd largest contributor to Black carbon in the world.
- **Steps taken by Government to reduce black carbon:**
 - Enhancing **fuel efficiency standard of Vehicles**, phasing out diesel vehicles and promoting electric vehicles
 - Promotion of the use of **LPG** for cooking (**PM Ujjawala Yojana**)
 - Clean Cookstoves program
 - Upgrading brick kiln technologies
 - **Real time monitoring of black carbon aerosols in the Glaciated valley of northwestern Indian Himalayas.**
- However, with all existing measures, water from glacier melt is still projected to increase in absolute volume by 2040, with impact on downstream activities and communities.

8) BROWN CARBON

- **Brown carbon** is emitted mainly by **biomass combustion**. It is a **light absorbing** part of the **organic aerosol** (note: soot is also light absorbing in nature). In recent years it has come under a lot of research.
 - It absorbs strongly in the ultraviolet wavelength (high frequency) and less significantly into the visible (low frequency).
- **Sources of Brown Carbon**
 - » **Tar Material** from smoldering fires or coal combustion.
 - » **Breakdown products** from biomass burning, stubble burning.
 - » **A mixture of organic compounds** emitted from soil, and volatile organic compounds given off by vegetation.

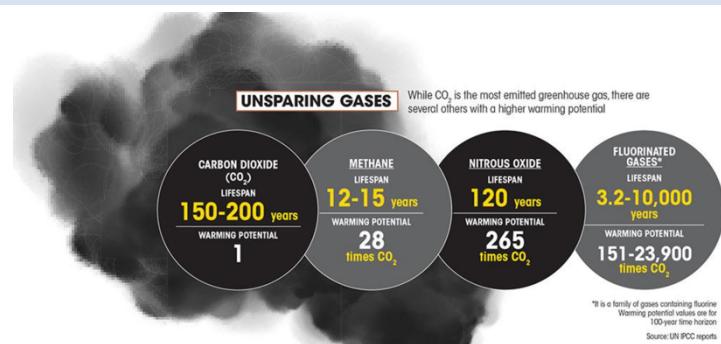
- **TAJ: The Pollutants causing discoloration identified**
 - » **Particulate carbon and fine dust particles** that are deposited on the marble are responsible for its browning.
 - » **Brown Carbon:** The group of carbon which absorbs light in the blue region of spectrum, and this is called brown carbon. Discoloration is because of what is happening to reflectance, reflectance in turn is influenced by these particles.
 - » **Presence of hematite in the dust** that is responsible for the **brown hue**. If hematite is not present in the dust then the dust would be only scattering in nature. Hematite is the ingredient that absorbs the blue wavelength of the spectrum.
- **Note: Brown Carbon vs Black Carbon**
 - » Black carbon is primarily produced by high temperature combustion and brown carbon is emitted mainly by biomass combustion.
 - » Of the total atmospheric absorption by aerosol, brown carbon contributes about 19%, while 72% is contributed by Black carbon. The remaining 9% is due to the coating effect of sulfate and organic aerosols on black carbon.
 - » Both of these are two most important light absorbing substances in the atmosphere.
- **Tarballs and its implications**
 - » Tarballs are formed from brown carbon. They are small light absorbing, carbonaceous particles formed due to burning of fossil fuels that deposit on snow and ice.
 - » Recent research has shown that tarballs from long-range transport can be an important factor in the climatic effect of glacier melting in Himalayas.
 - Nearly, 28% of particles collected from the air samples from a research station in Himalayan-Tibetan Plateau were tarballs.

Extra for Pre

Blue Carbon: It is the carbon that is stored and sequestered in the coastal ecosystem such as Mangroves, seagrass meadows and intertidal saltmarshes.

9) EFFECT OF A GAS ON CLIMATE CHANGE DEPENDS ON THREE MAIN FACTORS:

1. **Quantity** i.e., how much of the gas is present in the atmosphere.
 2. **Life** i.e., for what duration can the gas survive in atmosphere
 3. **Strength** i.e., how strongly they trap the heat
- For each gas a **Global Warming Potential (GWP)** is calculated by considering its duration of existence (i.e., life) and strength of its impact.



10) SDG AND CLIMATE CHANGE

- **Goal 13: Climate Action**
- **Targets**
 - Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries
 - Integrate climate change measures into national policies, strategies and planning.
 - Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning
 - Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly \$100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible
 - Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities.

3. IPCC AND ASSESSMENT REPORT 6 (AR-6)

- **Recent News:**
 - Scotsman **James Skea** elected new IPCC chair in Nairobi. He is a professor of sustainable development at Imperial College London and will lead IPCC through its seventh assessment report (July 2023: Source: DTE)
 - » The election was held at 59th session of IPCC which was held at UNEP headquarter in Nairobi, Kenya.
- The Intergovernmental Panel on Climate Change (IPCC) is the UN body for assessing the science related to climate change. Its job is **to assess already published scientific literature** to update our knowledge of climate change science.
 - IPCC's Assessment Reports (ARs), which are produced every few years, are the most comprehensive and widely accepted scientific evaluations of the state of Earth's climate.
 - They form the basis for government policies against climate change and provide scientific foundation for the global Climate Change negotiations.
 - So far, **Six Assessment Reports** have been produced.
- **IPCC was set up in 1988** by World Meteorological organization (WMO) and United Nations Environment Program (UNEP) to provide policy makers with regular assessment of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigations.
- Currently it has 195 members and relies on thousands of scientists who volunteer their time to support its work.
 - **India** is a member of IPCC

A) WHAT HAVE PREVIOUS REPORTS (AR-1 TO AR-5) SAID?

- The first **Assessment Report** (1990) noted that anthropogenic emissions are increasing atmospheric GHGs. In the business-as-usual scenario, temperature was likely to increase by 2 degree C compared to pre-industrial levels by 2025, and 4 degree C by 2100.
 - » The report formed the basis for the negotiation of the UNFCCC in 1992, known as the Rio Earth Summit.
- The **Second Assessment Report** (1995) revised the projected rise in global temperature to 3 degree C above pre-industrial level by 2100. It was the scientific underpinning for the Kyoto Protocol of 1997.
- The **third Assessment Report** (2001) projected the rise in global temperature to 1.4 to 5.8 degree C by 2100 compared to 1990.
- The **fourth Assessment Report** (2007) said that the GHG emissions increased by 40% between 1970 and 2004 and the atmospheric CO2 was the most in 650,000 years. In the worst-case scenario, the global temperature could rise by 4.5 degrees.
 - » The report won the 2007 Nobel Peace Prize for IPCC. It was also the scientific input for the 2009 Copenhagen Climate meeting.
- The **fifth Assessment Report** (2014) said that more than 50% of the temperature rise since 1950 is due to human activities. The rise in global temperature by 2100 could be as high as 4.8 degree C from pre-industrial times, and more frequent longer heatwaves were "virtually certain". It formed the scientific basis of the Paris Agreement in 2015.

1) IPCC SYNTHESIS REPORT

- **Why in news?**
 - » The IPCC has released its Synthesis report for the sixth assessment Cycle on 20th March in Interlaken, Switzerland
 - The report was signed by country representatives - an unusual step taken to ensure governments accept its findings (March 2023)
- **What is the report?**
 - » It is a compilation of the main findings of the IPCC's sixth assessment report, based on the results from three Working Groups (WGs).
 - **WG I evaluated the physical science basis of the climate change.**
 - **WG II evaluated the impacts, adaptation, and vulnerability,**
 - **WG III evaluated the mitigation.**
 - The synthesis report also drew from Special Report based on Global Warming of 1.5 degree C (Oct 2018), Climate Change and Land (August 2019), and the Ocean and Cryosphere in a Changing Climate (Sep 2019)
 - » The report was finally approved by nations after major economies like China, Brazil, Saudi Arabia, the US, and EU raised concerns about the working of the text.
 - » **Key Highlights:**

- The report highlights the urgency of drastically reducing the emission of greenhouse gases and so limit rising global temperature by 1.5 degree C from pre-industrial levels, set by the Paris Agreement.

2) AR-6

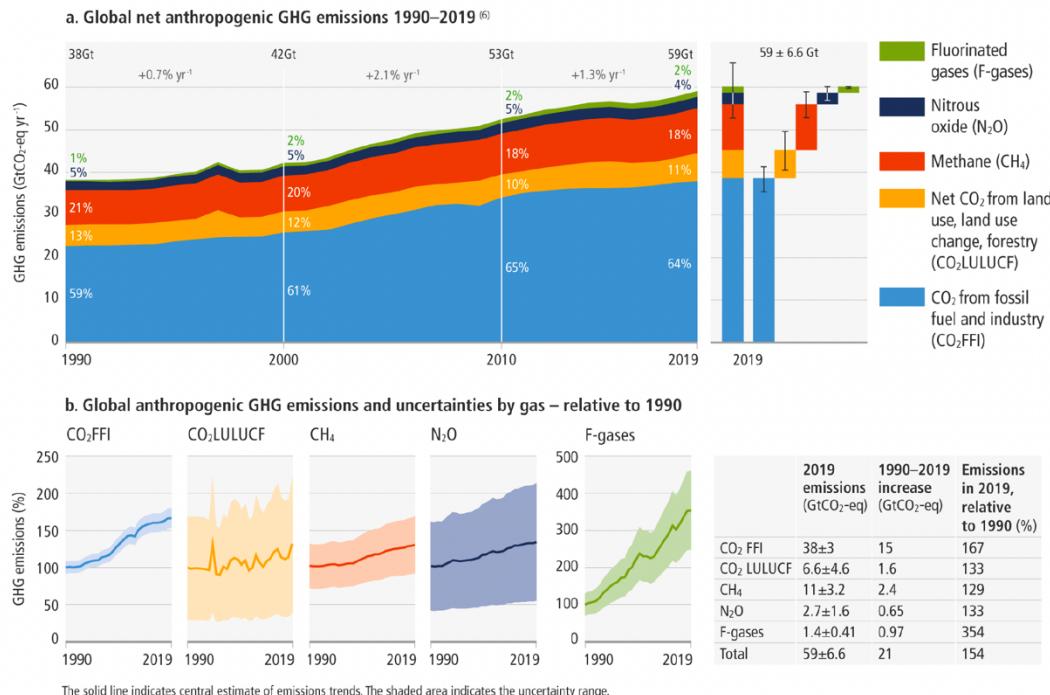
- The sixth report was published in **three parts**: - the first in Aug 2021, the second in Feb 2022, and the third in April 2022. These three parts were by **three working groups of scientists**:
 - **Working Group-1:** Deals with **scientific basis of climate change**
 - **Working Group-2:** Looks at **likely impacts, vulnerabilities, and adaptation issues**.
 - **Working Group-3:** Deals with **action that can be taken to combat climate change**.
- The first report "**Climate Change 2021: The Physical Science Basis**" highlighted the following:
 1. Climate was changing more rapidly than originally anticipated by climate scientists.
 2. Rise in **global temperature was direct result of human activities** and there is 'unequivocal evidence' about it.
 3. Temperature has already rise by 1.1 degrees from the pre-industrial 19th century.
 4. **Greenhouse gas Emissions:**
 - Emissions of Carbon dioxide, methane and nitrous oxide breached records in 2020.
 - CO2 Concentration in the atmosphere - at around 416 parts per million - are the highest they have been in 2 million years.
 5. **Impact:**
 - A more intense and frequent heatwaves; increased incident of extreme rainfall; a dangerous rise in sea-levels; prolonged droughts; Melting of glaciers.
- The second report: **Climate Change 2022: Impacts, Adaptation and Vulnerability**
 - The report recognizes the interdependence of climate, ecosystem, and biodiversity, and human societies and integrates knowledge more strongly across the natural, ecological, social and economic sciences than earlier IPCC reports.

A) THE THIRD REPORT: CLIMATE CHANGE 2022: MITIGATION OF CLIMATE CHANGE

- The report lays out actions that the world can take to stop global temperatures rising beyond certain levels by the end of the century.
- If countries stick to current NDC commitments, it will lead to breach of 1.5 degree C temperature rise.
 - Even the 2-degree Celsius target, in that case, would rely on "rapid acceleration" of climate actions after 2030.
 - **What should be the reduction to prevent temperature rise beyond 1.5 degree C?**
 - Global GHG emissions to peak before 2025 at the latest and be reduced by 43% by 2030; at the same time methane also needs to be reduced by 43% by 2030. Global use of coal, oil and gas in 2050 must decline by about 95%, 60% and 45% respectively, relative to 2019.
 - Even if all this happens, it is almost inevitable that this ceiling would be temporarily breached but, with appropriate action, it could again dip by the end of century.

- Global warming would stabilize if emissions reach net zero.
 - For 1.5 degree C target, this meant achieving net zero emissions globally in the early 2050s; for 2 degree C, it is in early 2070s.
 - Even limiting warming to 2 degree C would require greenhouse gas emissions to peak before 2025 at the latest and be reduced by a quarter by 2030.

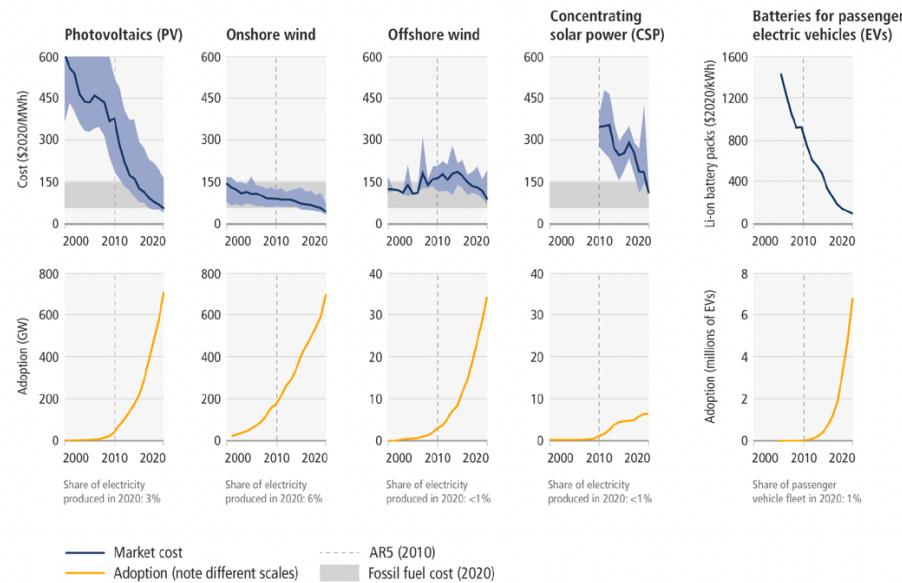
Global net anthropogenic emissions have continued to rise across all major groups of greenhouse gases.



- Carbon Inequality remains pervasive as ever with LDCs emitting only 3.3% of global emissions in 2019.
 - Their average per capita emissions in the period 1990-2019 were only 1.7 tonnes CO2e, compared to global average of 6.9 tCO2e.
- The Least Developed Countries (LDCs) emitted only 3.3% of global emissions in 2019.
- Abundant and Affordable Solutions exist across sectors including energy, buildings, and transport, as well as individual Behavioural changes.
 - The report has detailed 60 different options and pathways that can lead to 40-70% reduction in global emissions.
 - It states with high confidence that "several mitigation options, notably solar energy, wind energy, electrification of urban systems, urban green infrastructure, energy efficiency, **demand side management**, improved forests - and crop/grassland management and reduced food wastage and loss, are technically viable, are becoming increasingly cost effective and are generally supported by the public".

- The per-unit costs of several low emissions technologies have fallen continuously since 2010, however innovation has lagged in developing countries due to weak enabling conditions.
 - On a unit costs basis, solar energy has dropped 85%, wind by 55%, and lithium-ion by 85%.
 - Their deployment and usage has increased multifold since 2010 - 10 times for solar and 100 times for electric vehicles.
 - Factors:** Higher public spending in R&D; Funding for demonstration and pilot projects; and demand pull instruments such as deployment subsidies to attain scale.

The unit costs of some forms of renewable energy and of batteries for passenger EVs have fallen, and their use continues to rise.



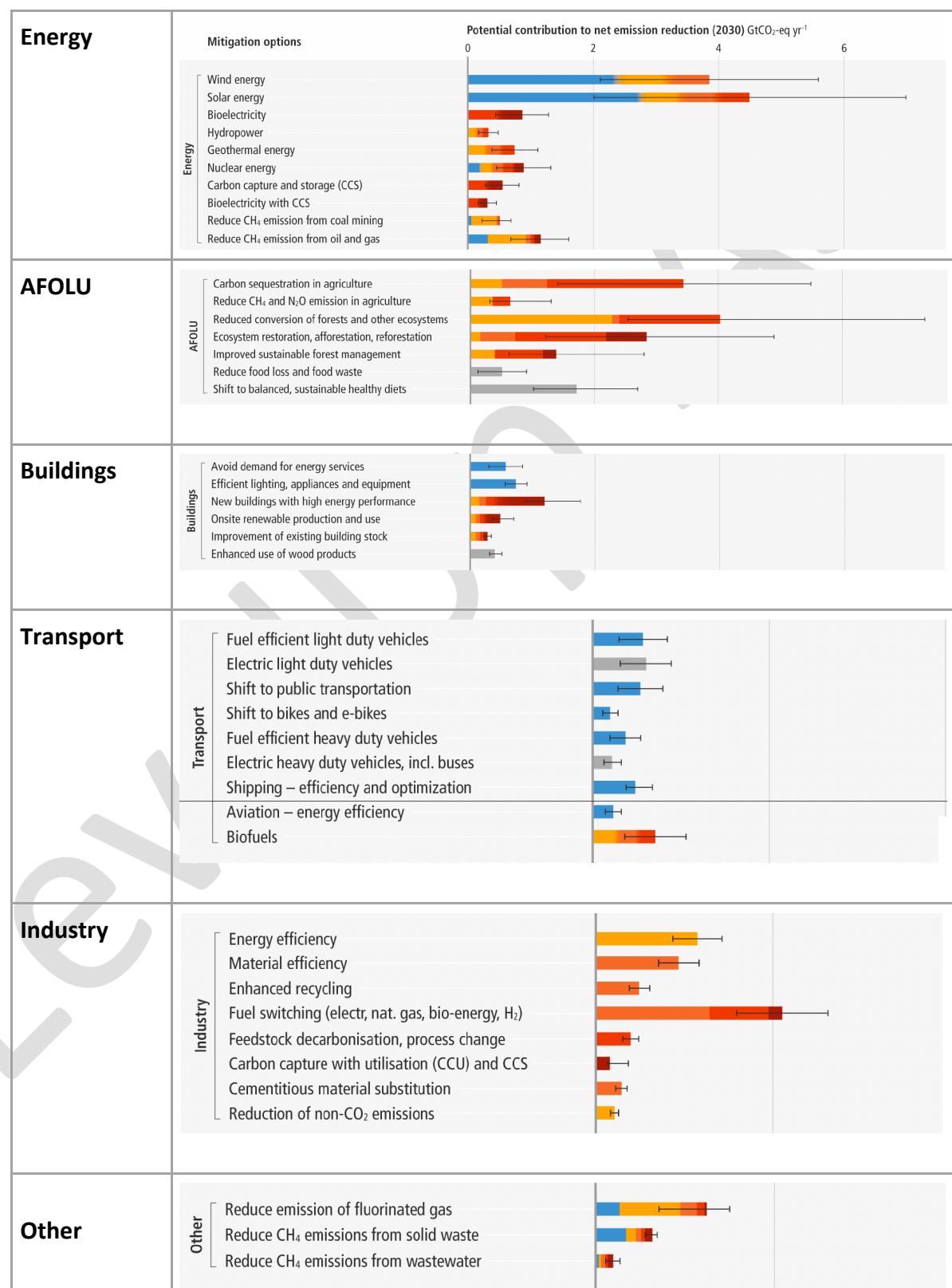
- The report covers **demand side mitigation** and states that it can help reduce emissions by 40-70% by 2050.
 - Demand Side Mitigation can be achieved through changes in socio-cultural factors, infrastructure design and use, and end-use technology adoption by 2050.

Food	Industry	Land transport
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<p>■ Socio-cultural factors</p> <p>Dietary shift (shifting to balanced, sustainable healthy diets), avoidance of food waste and over-consumption</p> <p>■ Infrastructure use</p> <p>Choice architecture¹ and information to guide dietary choices; financial incentives; waste management; recycling infrastructure</p> <p>■ End-use technology adoption</p> <p>Currently estimates are not available (for lab-based meat and similar options – no quantitative literature available, overall potential considered in socio-cultural factors)</p>	<p>Manufactured products</p> <p>■ Socio-cultural factors</p> <p>Shift in demand towards sustainable consumption, such as intensive use of longer-lived repairable products</p> <p>■ Infrastructure use</p> <p>Networks established for recycling, repurposing, remanufacturing and reuse of metals, plastics and glass; labelling low emissions materials and products</p> <p>■ End-use technology adoption</p> <p>Green procurement to access material-efficient products and services; access to energy-efficient and CO₂ neutral materials</p>	<p>Mobility</p> <p>Teleworking or telecommuting; active mobility through walking and cycling</p> <p>Public transport; shared mobility; compact cities; spatial planning</p> <p>Electric vehicles; shift to more efficient vehicles</p>
<p>Building</p> <p>Shelter</p> <p>Social practices resulting in energy saving; lifestyle and behavioural changes</p> <p>Compact cities; rationalisation of living floor space; architectural design; urban planning (e.g., green roof, cool roof, urban green spaces etc.)</p> <p>Energy efficient building envelopes and appliances; shift to renewables</p>	<p>Electricity</p> <p>■ Additional electrification (+60%)</p> <p>Additional emissions from increased electricity generation to enable the end-use sectors' substitution of electricity for fossil fuels, e.g. via heat pumps and electric cars {Table SM5.3; 6.6}</p> <p>■ Industry</p> <p>■ Land transport</p> <p>■ Buildings</p> <p>■ Load management²</p> <p>Demand-side measures -73%</p> <p>Reduced emissions through demand-side mitigation options (in end-use sectors: buildings, industry and land transport) which has potential to reduce electricity demand³</p>	

- **Individuals can also contribute in other ways:**
 - Putting political pressure on leaders.

- Many options available now in all sectors are estimated to offer substantial potential to reduce net emissions by 2030. Relative potential and cost will vary across countries in the longer term compared to 2030.



- **Implementing these mitigation strategies** would come at a substantial cost. The report estimates that taking the actions to keep temperature below 2 degree C could **reduce global GDP by 1.3% to 2.7% by 2050**, but not doing so has its own costs.
- **Climate Finance:**
 - Tracked financial flows were still **falling short** of the levels needed to achieve mitigation goals across all sectors and regions.
 - The **gaps are the widest** for the agriculture, forestry, and other land use (**AFOLU**) sector and for **developing countries**.
 - But the **global financial system is large enough** and "sufficient global capital and liquidity" exist to close these gaps.
- **Implications of the report for India**
 - The report warns against opening new coal plants.
 - The report says that Coal-fired power plants, without the technology to capture and store carbon (CCS), would need to be shuttered by 2050 if the world aspired to limit global temperature rise to 1.5-degree C.

B) OTHER IPCC REPORT

IPCC Report, 2018: The Special Report on Global Warming (1.5C Report)

IPCC Report: Special Report on Climate Change and Land

IPCC Special Report on the Ocean and Cryosphere (SROCC)

4. REPORTS ABOUT CLIMATE CHANGE

A) REPORT BY WORLD METEOROLOGICAL ORGANIZATION (WMO)

- **About WMO**
 - **WMO** is a specialized body of UN which is an authoritative voice on behaviour of earth's atmosphere, its interaction with the oceans, the climate it produces and the resulting distribution of water resources.
 - **Headquarter:** Geneva
 - It originated from the International Meteorological Organization, which was founded in 1873. It was established in 1950, and became the specialized agency of UN in 1951 for Meteorology (weather and climate), operational hydrology and related geophysical sciences.

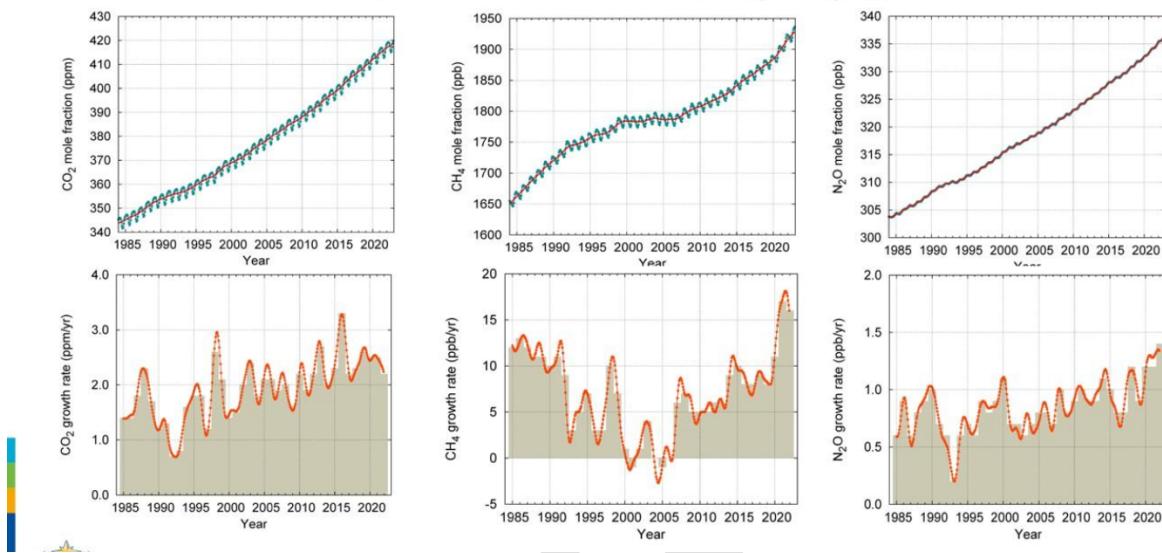
B) STATE OF GLOBAL CLIMATE REPORT, 2023

- Provisional data shows that 2023 is set to be the warmest year on record. Data until the end of Oct 2023 shows that the year was about 1.4 degree C (with a margin of uncertainty of +-0.12 degree C) above the pre-industrial levels.

C) GREENHOUSE GAS BULLETIN, 2023 BY WMO

The abundance of heat-trapping greenhouse gases in the atmosphere once again reached a new record last year (i.e. in 2022) and there is no end in sight to the rising trend, according to a new report from the World Meteorological Organization (WMO).

Main greenhouse gases (CO_2 , CH_4 , N_2O)



D) GLOBAL OCEAN OBSERVING SYSTEM (GOOS) REPORT CARD, 2022

It was prepared in collaboration with WMO, the Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO) and other GOOS partners and experts, and produced by its operational centre OceanOP.

E) OTHER REPORTS BY WMO

- State of Climate in Asia, 2021
- State of Climate Service Report

3) REPORTS BY UNEP

F) THE EMISSION GAP REPORT, 2023

- About the Report

- The report provides the latest assessment of scientific studies on current and estimated future Green House Gases (GHG) emissions and compares these with the emission levels permissible for the world to progress on a least-cost pathway to achieve the goals of Paris agreement. The

difference between "where we are likely to be and where we need to be" has become known as the "**emission gap**".

- **Key Highlights of the 2023 Report:**

- There has been progress since the Paris Agreement was signed in 2015.
- GHG emissions in 2030, based on policies in place, were projected to increase by 16 per cent at the time of the agreement's adoption.
- Today, the projected increase is 3 per cent.
- However, predicted 2030 greenhouse gas emissions still must fall by 28 per cent for the Paris Agreement 2°C pathway and 42 per cent for the 1.5°C pathway.

G) THE ADAPTATION GAP REPORT

- **Introduction:**

- The report by UNEP looks at the progress in planning for, financing and implementing adaptation - with a focus on nature-based adaptation.
- Adaptation action is critical to enable both public and private sectors to prepare for and respond to the impacts of climate change.
- **Adaptation Gap Report 2023: Underfinanced. Underprepared – Inadequate investment and planning on climate adaptation leaves world exposed**
 - The report finds that progress on climate adaptation is slowing when it should be accelerating to catch up with these rising climate change impacts.

H) OTHER REPORTS BY UNEP

- Global Environment outlook report

4) REPORTS BY GLOBAL CARBON PROJECT

- Global Carbon Budget 2022 Report
- Global Methane Budget (GMB)
- Global Nitrous (N₂O) Budget

I) ABOUT GLOBAL CARBON PROJECT (GCP)

- » GCP is a global research project of Future Earth and a research partner of the World Climate Research Program.
- » It was formed to work with international science community to establish a common and mutually agreed knowledge base to help fight climate change.
- » It was established in 2001 by a shared partnership between the International Geo-Sphere-Biosphere Program (IGBP), the International Human Dimension Program on Global Environmental Change (IHDP), the World Climate Research Program (WCRP) and Diversitas. This partnership constituted the **Earth Systems Science Partnership** which subsequently evolved into future Earth.
- Goals

- » Develop complete picture of the global carbon cycle, including both in biophysical and human dimensions together with the interactions and feedbacks between them.

5) OTHER REPORTS

J) CLIMATE CHANGE PERFORMANCE INDEX (CCPI)

- Published since 2005, CCPI is an independent monitoring tool of countries' climate protection performance. It aims to enhance transparency in international climate politics and enables the comparability of climate protection efforts and progress made by individual countries.
- The CCPI assesses each country's performance in **four categories**:
 - **GHG emissions** (40% of the overall ranking)
 - **Renewable Energy** (20%)
 - **Energy Use** (20%)
 - **Climate Policy** (20%)
- **59 countries** (which together are responsible for 92% of the global emissions) are assessed under the ranking.
- The report is **jointly presented** by: **GermanWatch**, NewClimate Institute and Climate Action Network (CAN).

K) GLOBAL CLIMATE RISK INDEX – BY GERMANWATCH

L) OTHER REPORTS

- Climate and Development: An Agenda for Action: By the World Bank
- NDC Synthesis Report, 2022: UNFCCC
 - It is the annual summary of climate commitments made by countries and their impact on GHG emissions.
- Investing in Carbon Neutrality: Utopia or the new green wave
- State of Climate Action Report 2022 – By Climate action tracker (an independent analytic group comprising Climate Analytics and New Climate Institute), the United Nations High Level Climate Change Champions, World Resource Institute and Others
- The World Heritage Glaciers Report – Jointly released by UNESCO and IUCN
 - 1/3rd of the World Heritage Glaciers will disappear by 2050.
 - Note: So far, around 50 UNESCO Heritage sites have glaciers in them.

5. OTHER MISCELLANEOUS TOPICS

A) WET BULB TEMPERATURE

- **What is wet bulb temperature?**
 - Wet bulb temperature is the lowest temperature to which air can be cooled by the evaporation of water into the air at a constant pressure.

- It is therefore measured by wrapping a wet wick around the bulb of a thermometer and the measured temperature corresponds to the wet bulb temperature.
- In simpler terms, wet bulb temperature is the lowest temperatures that our bodies can reach when we are in hotter environments, by sweating. It tells us at what level our bodies will not be able to cool themselves down by sweating. In this case the threat of heat stroke rises dramatically.
- The **dry bulb temperature** is the ambient temperature.
- **The difference between** the two temperatures (dry bulb and wet bulb) is a measure of humidity of the air. The higher the difference in these temperatures, lower the humidity of the air.
- **Why is wet bulb temperature important?**
 - Dry temperature, or the temperature that we see in daily weather forecast - doesn't tell us the full story. Wet bulb temperature, especially in times of heat waves, tells us how habitable a place is for human body.
 - **A wet bulb temperature of 32 degree C** is the maximum that a human can endure and carryout normal outdoor activities. This is equivalent to dry temperature of 55-degree C. The theoretical maximum wet bulb temperature is 35 degree C - most humans, even with unlimited water supply, are likely to suffer heat strokes at this level, likely leading to death.
- **Climate Change and Wet Bulb temperature:**
 - IPCC study shows that with climate change, the wet bulb temperature in India is going up.
 - If emissions continue to increase Lucknow and Patna would be the cities which would reach wet bulb temperature of 35 degree C. Parts of Central India, including Vidarbha are at risk of exceeding wet bulb temperature of 32-34 degree C

6. IMPACT OF GLOBAL WARMING

GWG emissions is breaching all the records: As per the AR6, **Emissions of Carbon dioxide, methane and nitrous oxide breached records in 2020**. CO₂ Concentration in the atmosphere - at around 419 parts per million - are the highest they have been in 2 million years.

- **Three factors** make carbon budgeting complex:
 1. **The pollutants** - primarily GHGs like CO₂ and methane - have an extraordinary long life. Thus, historic emissions continue to warm up the planet just like current emissions.
 2. GHG emissions are linked to economic growth.
 3. **Sharing of burden** becomes difficult as the emissions are associated with economic growth.

1. Rising Temperatures

- » As per the AR6 of IPCC, the global temperature has already risen by 1.1 degree C since preindustrial 19th century. This could increase upto 1.5 degree Celsius in less than 20 years (before 2040).
 - **Further, the 2 degree C warming** is likely to get exceeded by the end of this century unless immediate and deep reductions in greenhouse gas emissions are initiated immediately.
 - **In business-as-usual approach**, or in **worst case scenario**, the temperature rise by the end of this century would exceed even 4 degree Celsius'

- The report is also 'unequivocal' (i.e. there is almost no doubt) that most of the observed warming of the planet since the late 1800s is caused by human activities.
 - » As per the WMO, the decade 2010-20 and the five years (2015-20) were the hottest in the earth's history
- 2. Melting of Glaciers and Sea Level Rise -> Submergence of coastal region**
- » AR6: Sea level rise has tripled compared with 1901-1971. The Antarctic sea ice is the lowest in last 1,00 years.
 - » The temperature of Antarctica rose above 20 degree Celsius for the first time on record.
- 3. Heating up of Oceans -> marine heat waves, intense cyclones etc.**
- 4. Increasing variability in weather patterns**
- » **Heat waves and floods** which used to be once-in-a century event are becoming more regular occurrence.
 - » **Weather Disasters** have displaced millions of people this year and **affected rainfall patterns** from India to northern Russia and the Central United States.
 - » **For instance: India saw 13 Deficit Monsoons in 18 years between 2001-18.**
- 5. Compounding extremes** (several climate change drivers operating together) are maximizing disaster in India and elsewhere.
- » E.g., heavy rainfall, landslides, snow avalanches, and flooding occurring together is an example of compounding event.
- 6. Thawing of Permafrost and Arctic Lakes Bubbling Methane**
- » **Reasons: Permafrost Thawing producing methane gas**
 - Organic matter in Artic generally remain frozen. But, with climate change thawing is taking place. This thawing is leading to organic matter decaying into carbon di oxide and methane which is leading to methane getting emitted in atmosphere.
 - » **Warmer temperature increases the thawing of permafrost and release methane to the atmosphere**
 - But this also means that growing season increases, more plant growth takes place and thus more CO₂ getting absorbed. But overall, the increase in release of GHGs would be much higher.
 - » **Presently Arctic is a net carbon sink**
 - But soon arctic could become a carbon source, if the earth continues to warm, and a lot of permafrost thaws out. This would start a cycle of releasing more carbon from permafrost thawing and less absorption where the extra carbon in the atmosphere results in increasing warming.
- 7. Sea Water is 26% more acidic** than at the start of the industrial era. This is leading to degradation of marine ecosystem.
- 8. Biodiversity Loss**
- » **At least 1 million species were at risk** because of the rising CO₂ concentration in the atmosphere and global warming.

- For instance, a recent study shows that seal pups (IUCN: LC) are finding it tough to survive in the Baltics in the absence of ice. 100s of grey seal pups are dying on the shores of the Baltic Sea in Estonia and Latvia as the Nordic coastline faced winter without ice in decades.

9. Negative Impact on Food Security, Agriculture and Economy

- » Variability in rainfall
- » Increased temperature and evaporation of water sources
- » Increased chances of Locust attacks
- » Extreme weather events triggered by climate change costs India \$87 billion annually : State of Climate in Asia, 2020 (report by WMO)

10. Climate Change has adversely affected both physical and mental health of people.

- » Impacts on health is mediated by both through natural and human systems, including economic and social conditions and disruptions.
- » Extreme heat events -> Mortality and morbidity
- » Climate related food borne and water borne diseases has increased. The incidence of vector borne diseases have also increased due to range expansion and/or increased reproduction of disease vectors.
- » Some mental health challenges are associated with increasing temperatures, trauma from weather and climate extreme events, and loss of livelihood and culture. Exposure to wildfire smoke, atmospheric dust, and aeroallergens have been associated with climate sensitive cardiovascular and respiratory distress.

11. Achievements of SDG targets have been negatively hindered.

12. Shrinking of Stratosphere:

According to a study published by NASA, the earth's energy imbalance doubled over the 14 year period between 2005 - 2019, doubling the pace at which the Earth retains heat from 2005. As a result of this we are already on the brink of losing stratosphere

7. UNFCCC – PARIS AGREEMENT TO COP27

1) UNFCCC

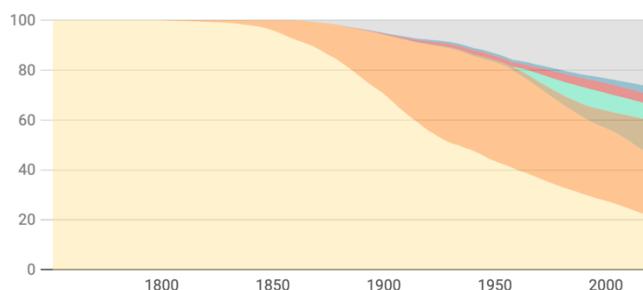
- It is one of the three conventions adopted at the Rio Earth Summit (UN summit Conference on Environment and Development (UNCED)) in 1992. Its sister Rio Conventions are the UN Convention on Biological Diversity and the Convention to Combat Desertification.
- This was the first multilateral legal instrument on climate change and came into force in 1994 after a sufficient number of countries had ratified it.
- **Ultimate Aim** of UNFCCC
 - Prevent dangerous human interference with the climate system by stabilizing greenhouse gas concentration in atmosphere.

- It sets on **non-binding limits** on greenhouse gas emission for individual countries and contain **no enforcement mechanism**.
- **Parties to Convention**
 - **197 parties**
 - All UN member states, Palestine (observer state), Niue and Cook Island (non-member states) and the European Union.
 - **Annex 1 Parties** -> Industrialized OECD countries, Economies in Transition (EIT), EU
 - **Annex 2 Parties** -> OECD members of Annex-1, NO EIT.
 - Provide financial and technical support to EITs and developing countries for mitigating Climate change.
 - **Non-Annex 1 Parties** -> Mostly developing
 - **Least Developed Countries (LDCs)**

Over the last 250 years, Europe and the US have contributed to most of the world's CO2 emissions

% share in cumulative global CO2 emissions

EU-28* United States China Russia Japan India ROW



*28 nations in the European Union

Source: Global Carbon Project; Our World in Data • [Get the data](#) • [Created with Datawrapper](#)

Key Significance of UNFCCC - 1) Recognition of the problem 2) Setting target of stabilizing GHGs 3) Onus on Developed countries 4) Funds and technology transfer to developing countries 5) Regular Reporting -> Keep a tap on the problem.

A) KYOTO PROTOCOL

- It was an international agreement to reduce greenhouse gas emissions. It was negotiated under the UNFCCC during a meeting held in Kyoto, Japan, in 1997 and came into force in 2005 (due to complex ratification process)
 - **The first commitment period** was 2008-2012
 - **The second commitment period** beginning 1 Jan 2013 to 2020.
 - Launched by Doha Amendment (2012)
- The objectives of KP included reducing greenhouse gas emissions through enforcement of compliance; promote sustainable development through tech-transfer and investment; and encourage developing countries and private sector to contribute to emission reduction.
- **Parties to Kyoto Protocol**
 - **Annex B:** Nearly identical to Annex - I of the UNFCCC; Agreed for emission reduction.
 - **Non-Annex B Parties:** Countries which are not listed in Annex B of KP.
- **Key Features**
 - The protocol 'operationalized' the UNFCCC. It commits industrialized countries to stabilize greenhouse gas emissions based on the principles of the Convention.
 - **Binding Emission targets for 38 industrialized countries and the European Community (Annex 1 Parties)** in its first commitment period.

▪ Only bound developed countries - Common but Differentiated Responsibility

- Flexible Architecture of KP Regime to meet target
 - National Measures and Market Based Mechanisms
 - This market based mechanism allows GHG abatement to start where it is most cost-effective - for e.g. in the developing world.
 - 3 Components - Carbon Trading, Clean Development Mechanisms and Joint Implementation
- Penalties for not meeting the targets
- What is the status of the Kyoto Protocol?
 - The Protocol was ratified by 191 countries and EU. Canada withdrew from the Protocol in 2012.
 - The US was the only country that signed the protocol and never ratified it.
 - Internal country politics.
 - Were targets met?
 - Most countries didn't meet the targets for emission reduction assigned for the first period of commitment (2008-2012).
 - So protocols impact was very small.
- Kyoto Beyond 2012
 - At Doha in 2012, the amendments to Kyoto Protocol for the 2nd commitment period (the Doha Amendment) were successfully adopted for the period 2012-2020.
 - It entered into force on **31st Dec**, following an acceptance by the mandated minimum of at least 144 states, although the second commitment period ended on the same day.
 - **It entered into force in 2020** as the required number of countries didn't deposit their instrument of accession earlier.
 - But some developed countries started implementing their commitments under the '**opt-in**' provisions of the Doha Round.
 - Note: India ratified the second commitment period of Kyoto Protocol in Jan 2017

B) PARIS AGREEMENT

- The Paris Agreement and the accompanying COP decisions are focused on enhancing **efforts to mitigate and adapt to climate change beyond 2020.**
 - a. Long Term Goal:
 - » Reaffirm the goal of limiting global temperature increase well below 2 degree Celsius, while urging efforts to limit the increase to 1.5 degrees.
 - » **Two long term emission goals**
 - Peaking of emissions as soon as possible (with a recognition that it will take longer for developing countries)
 - A goal of Net Green House Gas Neutrality (expressed as "a balance between anthropogenic emissions by sources and removals by sinks") in the second half of this century.
 - b. **Ends the Strict Differentiation between developed and developing countries:** Provides for a framework that commits all countries to put forward their best efforts against climate change and keep strengthening these efforts.

- c. **Mitigation - Binding Procedural Commitments** -> Preparing, communicating and maintaining NDC; Communicate new progressive NDC every five years;
 - » The agreement commits parties to "pursue domestic measures with the aim of achieving the objectives" of its NDC.
 - » Doesn't make implementation or achievement of NDCs a binding obligation.
- d. **Carbon Markets** – the agreement recognized that the parties may use internationally transferred mitigation outcomes to implement its NDCs.
- e. **STOCKTAKE/SUCCESSIVE NDCs**
 - » To ensure successive improvement in efforts, the agreement provides for **two linked processes**, each on a five-year cycle.
 - **Global Stocktake** to assess collective progress towards the agreement's goals. The first global stocktake took place in 2023.
 - **New NDCs** every five years informed by the outcomes of the global stocktake. Signatories should ensure that the new NDCs are more ambitious than the previous ones.
- g. **Finance**
 - **Provisions for Support to poor developing countries by Developed countries.**
 - **Finance Mobilization goal.**
 - The COP decided to extend the \$100 billion-a-year goal through 2025, and beyond that, by 2025 COP will set a "new collective quantified goal from a floor of "\$100 billion a year".
- h. **Adaptation**

A major priority for many developing countries was strengthening adaptation efforts under the UNFCCC. The agreement does that by:

 - Establishing a global goal of "enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change"
 - Committing enhanced adaptation support for developing countries
 - Including a review of adaptation progress, and of the adequacy and effectiveness of adaptation support, in the global stocktake to be undertaken every five years.
- i. **Loss and Damage**
 - In a victory to small island countries and other countries highly vulnerable to climate impacts, the agreement includes a **free-standing provisions** extending the Warsaw International Mechanism for Loss and Damage
 - The mechanism, established at COP-19 is charged with developing approaches to help vulnerable countries cope with unavoidable impacts, including extreme weather events such as sea-level rise.
 - Potential approaches include early warning systems and Risk insurance.
 - Loss and Damage provision "did not involve or provide a basis for any liability or compensation.

C) WHEN DID PARIS AGREEMENT ENTER INTO FORCE?

- It required approval of atleast **55 countries accounting for atleast 55 percent of greenhouse gas emission.**
- It came into force on **Nov 4, 2016** (a month after required number of ratification)

D) INDIA'S UPDATED FIRST NDC UNDER PARIS AGREEMENT (AUG 2022)

- India submitted its INDC on 2nd Oct 2015.
- The NDC submitted in Aug 2022 is India's first NDC under the Paris Agreement. The Article 4, paragraph 9 of the Paris Agreement provides that each Party shall communicate a nationally determined contribution every five years in accordance with the decision of COP21.
- So, in Aug 2022, India communicated an update to its first NDC submitted earlier on Oct 2, 2015 for the period upto 2030, as under:
 - To put forward and further propagate a healthy and sustainable way of living based on traditions and values of conservation and moderation, including through a mass movement for 'LIFE'–'Lifestyle for Environment' as a key to combating climate change [UPDATED].
 - To adopt a climate friendly and a cleaner path than the one followed hitherto by others at corresponding level of economic development.
 - To reduce Emissions Intensity of its GDP by 45 percent by 2030, from 2005 level [UPDATED].
 - To achieve about **50 percent cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030**, with the help of transfer of technology and low-cost international finance including from Green Climate Fund (GCF) [UPDATED].
 - To create an **additional carbon sink of 2.5 to 3 billion tonnes of CO2 equivalent** through additional forest and tree cover by 2030.
 - To better **adapt to climate change by enhancing investments in development programmes** in sectors vulnerable to climate change, particularly agriculture, water resources, Himalayan region, coastal regions, health and disaster management.
 - To mobilize domestic and new & additional funds from developed countries to implement the above mitigation and adaptation actions in view of the resource required and the resource gap.
 - To **build capacities, create domestic framework and international architecture for quick diffusion of cutting edge climate technology** in India and for joint collaborative R&D for such future technologies.

This update to India's existing NDC is a step towards our long term goal of reaching net-zero by 2070.

E) INDIA'S LONG TERM LOW EMISSION DEVELOPMENT STRATEGY (LT-LED STRATEGY) (NOV 2022)

- **Details**
 - LT-LED is a requirement emanating from the 2015 Paris Agreement whereby countries must explain how they will transition their economies beyond achieving near-term NDC targets, and work towards the larger climate objective of cutting emissions by 45% by 2030 and achieve net zero around 2050. This is what scientists say, offers the best chance of keeping temperature rise below 1.5 degree C. So far, no country is on track towards such a pathway.

- Very few countries (including India) have submitted their Long-Term Strategy. So far.
- **Highlight of India's Long-Term Strategy:**
 - i. **Nuclear Power Capacity** - It will be increased at least 3-fold in the next decade.
 - ii. India will focus on increasing the proportion of ethanol in petrol - with ethanol blending to reach 20% by 2025 and a strong shift to public transport for passenger and freight traffic.
 - iii. India would also become an international hub of producing green hydrogen.
 - iv. India will also focus on **energy efficiency** by the Perform, Achieve and Trade (PAT) scheme; increasing electrification; enhancing material efficiency; and recycling and ways to reduce emissions.
 - v. The country is also on track to achieve the NDC commitment of 2.5 to 3 billion tonnes of additional carbon sequestration in forest and tree cover by 2030.
 - vi. The emphasis is on ensuring energy security, energy access and employment, while keeping focus on our vision of Atmanirbhar Bharat.

2) THE CONTINUING UNFCCC NEGOTIATION

- **The Continuing UNFCC Negotiations:**
 - After the COP-21 - Paris Agreement, the negotiations have continued. COP-22 (Marrakech Summit, 2016), COP-23 (Bonn Summit, 2017), COP-24 (Katowice Summit, 2018), COP-25 (Madrid Summit, 2019), COP-26 (Glasgow, 2021);

B) COP 26 (GLASGOW PACT) - KEY OUTCOMES: 2021

- **Mitigation:**
 - » It asked countries to strengthen their 2030 climate action plan or NDCs by 2022.
 - » First clear recognition of the need to move away from fossil fuels -> it called for "phase down of coal" and "phase out of inefficient fossil fuel subsidies".
- **Adaptation:**
 - » Asked developed countries to atleast double the money being provided for adaption by 2025 from the 2019 levels.
 - » It created a two year work program to define a goal on adaptation.
- **Paris Rule Book has been finalized.**
 - » 'Transparency Framework' was completed - it included reporting rules and formats for emissions, progress on pledges and financial contributions.
 - » Carbon Market provisions have been finalized [a major achievement of COP26].
 - **Credit generated from earlier periods**, including through Clean Development Mechanism were transferred to the Paris Agreement but only since 2013. This will allow developing countries to meet its first NDC targets.
 - On the issue of double counting, it has been decided that a country that generates a credit will decide whether to authorize it for sale to other nations or

to count towards their climate targets. The emission cuts will be counted only once.

- **Various Positive "Parallel Outcomes"** (not part of the official COP26 negotiations)
 - » India's announcement of a Panchamitra
 - » Plurilateral Agreement on Methane Reduction among 100 countries is crucial. (Note: India is not a member)
 - » Plurilateral Agreement to reverse deforestation among another group of 100 countries. (Note: India didn't join the group due to concerns over a clause on possible trade measures related to forest products).
 - » COP26 Transport Declaration -> 100% transition to emission less (electric vehicles) cars by 2040.
 - This has also been signed by over 30 countries.
 - » Glasgow Financial Alliance for Net Zero (Gfanz): 450 of the world's banks and other financial institutions have pledged to report annually on the carbon emissions linked to the projects they lend to.
 - They also plan to lend trillions of dollars in green finance - while committing to net zero emission across the board by 2050.
- **Problems that remained:**
 - » Funding
 - » L&D
 - » Didn't specifically raise emission reduction targets.

C) COP-27 (SHARM EL SHEIKH, EGYPT)

- **Quotes:**
 - » The UN Secretary General had declared at the start of the conference, "We are on a highway to climate hell with foot still on the accelerator".
- **Key Highlights:**
 - » Nod for establishment of Loss and Damage Fund.
 - » Estimates of Financial Requirements -> COP27 agreement for the first time, quantified the financial needs for climate action. It said about US\$ 4 trillion had to be invested in the renewable energy sector every year till 2030 if the 2050 target of net zero was to be achieved.

D) COP28: DUBAI, UAE (30TH NOV 2023 – 12TH DEC 2023)

- The meeting reviewed the Progress of commitment made by 197 countries under the Paris Agreement to mitigate the razing global warming.
- **Outcome: Dubai Consensus:**
 - Negotiators adopt resolution titled "Dubai Consensus"; the text reflects a compromise between developed and developing countries on emissions.
- **Highlights of Global Stocktake (GST):**

- The GST text echoed the GST input findings that 1.5 degree target would require "deep, rapid and sustained" reduction in global emissions of 43% by 2030 and 60% by 2035 from the 2019 levels and eventually reaching net zero by 2050.
- **Fossil Fuel Phase-out:**
 - » Fossil fuels was the most hotly contested issue of the COP28; It was first time that fossil fuel was at the centre of discussion at UNFCCC COP.
 - » **Outcome:**
 - COP28 agreement has called upon countries to contribute towards "transitioning away" from fossil fuels and phase down of unabated coal power so as to achieve net zero by 2050.
 - » **Criticisms:**
 - No timelines
 - Not using the phrase "fossil fuel phase-out" and instead the use of "transitioning away".
 - While calling for phase down of "unabated coal power", the door was left open for "low-carbon fuels", "low emission" technologies, "low-carbon hydrogen" - all terms with very loose definitions.
- **Tripling global renewable energy capacity by 2030** (from 3400 GW today to 11000 GW) and **doubling of global average rate of energy efficiency improvements by 2030**.
 - COP28 calls the member countries to achieve these two targets which have the potential to avoid emissions of about 7 billion tonnes of carbondioxide equivalent between now and 2030.
 - **Tripling is a global target for renewables is not incumbent on every country** individually. It is not thus clear how this tripling will be achieved.
 - This is the only outcome that contribute to additional emission reduction between now and 2030.
- **Accelerating and substantially reducing non-carbon-dioxide emissions globally**, including in particular methane emissions by 2030.
 - **Criticisms:** No target mentioned
 - **Note:** A group of about 100 countries at Glasgow (in 2021) had made a voluntary commitment to reduce methane emissions by 30% by 2030.
- **Reduction of emission from road transport** on a range of pathways, including through development of infrastructure and rapid deployment of zero-and low-emission vehicles;
- **Phase down of inefficient fuel subsidies** that don't address energy poverty or just transition, as soon as possible.
- **Operationalization of L&D Fund:**
 - **Background:** A decision to set up a Loss and Damage Fund had been taken last year in Sharm el-Shaikh (COP27) but it had not been created, and no money had been promised.

- COP28 operationalized the fund and several countries have already made commitments worth around \$800 million by the end of the conference.
 - COP28 decided that the fund will be serviced by new, dedicated and independent secretariat. It will be supervised and governed by the Board.
 - The fund is accountable to and functions under the guidance of the CoP serving as the meeting of the Parties to Paris Agreement (CMA).
- This is the most significant outcome for vulnerable countries as L&D fund is meant to provide financial help to countries trying to recover from climate-induced disasters.
- Santiago network has also decided to avert, minimize, and address loss and damage to catalyze the technical assistance of relevant organizations, bodies, networks and experts for the implementation of relevant approaches associated with climate change impacts.

Santiago Network: At COP25, the parties to UNFCCC decided to set up a Santiago network as part of Warsaw International Mechanism (WIM) for loss and damages. It is aimed to organize the technical assistance of relevant organizations for the implementation of relevant approaches in developing countries that are particularly vulnerable to adverse impacts of climate change.
- Global Goal on Adaptation (GGA):
 - » Background: COP26 at Glasgow had decided to set up a two-year work program to define the contours of adaptation framework.
 - Adaptation hasn't received enough attention and the entire focus of various agreements have been on mitigation. But, developing countries have been arguing for a global framework for adaptation.
 - The two year work program resulted in identification of some common adaptation goals like reduction in climate-induced water scarcity, attaining climate-resilience in food and agricultural production, supplies and distribution and resilience against climate induced health impacts.
 - » The COP28 retains calls for a doubling in adaptation finance and plans for assessment and monitoring of adaptation needs in the coming year.
 - An explicit 2030 date has been integrated into the text for targets on water security, ecosystem restoration, health.
- Issue of Climate Finance Targets will be reviewed in next COP:
 - » Currently, the \$100 billion goal hasn't yet been met (although it appears on track this year) and is far short of what is needed.
 - » COP28 saw an agreement to draft a post 2025 finance target ahead of COP29. This is a step forward, but details will only be hammered next year.
- COP28 Declaration on Climate Change and Health
 - » This is the first ever move to commit action and finance to combat the health impact of climate change.
 - » The COP28 Presidency and the WHO together issued the 'COP28 UAE Declaration on Climate and Health'.

- It's signatories aim to accelerate action to protect public health and communities from negative and growing climate impacts and strengthen healthcare systems to cope with the effects of extreme heat, air pollution, infectious and zoonotic diseases and environmental risk factors.

- **Other Related Outcomes:**
 - » A group of **22 countries** signed a **declaration to triple nuclear energy capacity** between 2020 and 2050, in order to reduce dependence on oil, gas, and coal.
 - » **G7 countries** have announced to phase out coal by 2030 and have urged G20 countries to also agree on it.
 - » India and Sweden co-launched Phase II of the Leadership Group for Industry Transition (LeadIT 2.0) for the period 2024-26 at COP-28. They also launched the Industry Transition Platform, which will connect the governments, industries, technology providers, researchers, and think tanks of the two countries.
 - » **Green Industrialization Initiative**: African leaders came together on the third day of COP28 to launch the initiative. The GII is set to accelerate green growth of industries in Africa and attract finances and investment opportunities.

- **Limitations/Criticisms:**
 - » **Countries failed to adopt rules to set up global carbon market**: Civil society has hailed the move as parties didn't agree to adopt weak rules for carbon markets.
 - » **Climate Finance issue** is still pending and would be taken up in COP25.
 - » **No timelines for fossil fuel transitioning**: The text related to fossil fuel transitioning is weak, in-adequate and with loopholes.
 - » **NDCs** remain far away from achieving Net Zero by 2050.
 - » **Net Zero by 2050** target is expected to bring pressure on China and India whose net zero targets are for 2060 and 2070 respectively.
 - » **Major Decisions** have not been integrated with agendas like 'Common but differentiated responsibilities'.

3) NET ZERO

- **Details**
 - » Achieving a global balance between emissions and removal of greenhouse gases to and from the atmosphere is called **net zero** (or no net emissions). The Paris agreement targets this to be achieved somewhere in the second half of this century, but the earlier this happens, the greater the chances of keeping global warming below 2-degree C.
 - » Electricity and heat are responsible for 25% of global GHGs. The **International Energy Agency** envisages that in a net-zero world, almost 90% of electricity could come from renewable sources, mostly solar and wind, with nuclear power making up most of the rest.

- **Achieving Net Zero:**
 - » **Focus on 2030 goal first:**

- IPCC's AR6 emphasized that to keep temperature rise within 1.5 degree C, global emissions should be reduced by 45% from 2010 levels by 2030, on the way to net zero by 2050.
 - But the UN NDC report says that as per the current NDCs, the global emission is expected to increase by 16.3% in 2030 (compared to 2010 levels).
- » **Energy Conservation and Efficiency:** Global emissions show that energy is the biggest emitter (73.2%) including its use in transport, industry, and building. Therefore, energy efficiency can play a crucial role in achieving net zero.
 - Targeted consumer education and behavioral change would also be important here.
- » **Renewable Energy:** Gradually phasing out thermal energy (coal, petrol, gas etc.) and increase the capacity of renewables with improved grid infrastructure, smart grids, etc.
 - Insure against Renewable Droughts through other sources like **Nuclear Energy**.
- » **Transport Sector:** Accelerated transition to e-mobility and non-motorized transport is required.
- » **Create Offset:** Inspite of all the efforts, humans would still produce some billions of tonnes of emissions by mid-century. This will have to be balanced by removals to achieve net zero. Offset can be in the form of afforestation, increasing soil organic carbon, and advanced carbon sequestration techniques.
- » **Enhancement in Funding:** The Promised funding from developed to developing countries need to be delivered.
- » **More R&D in advanced technology** like low and zero emission technologies across all sectors. There is also a need of innovation for renewable integration, power to x-storage, and conversion and reconversion pathways. Moreover, carbon-removal technologies need to be focused upon.
- » **CBDR should not be ignored:** Developed countries should achieve net zero earlier and few extra decades should be available to developing countries.

4) INDIA'S DECISION TO ACHIEVE NET ZERO BY 2070: CRITICAL ANALYSIS

- At COP26, PM Modi has proposed a **fivefold strategy** for India to play its part in helping the world get closer to 1.5 degrees Celsius. India's 'Panchamrita' promises include:
 - » India will get its non-fossil energy capacity to **500 GW** by 2030.
 - This is a 50 GW increase from its existing target.
 - » India will meet 50% of its energy requirements till 2030 with renewable energy.
 - » India will reduce its projected carbon emission by one billion tonnes by 2030.
 - » India will reduce the carbon intensity of its economy by 45% by 2030.
 - » India will achieve net zero by **2070**.
- **India's demand from developed countries:**
 - » In the spirit of climate justice, the developed countries should be providing at least \$1 trillion in climate finance to assist the developing countries and those most vulnerable.
- **Analysis:**
 - This is a very positive move as India had resisted any net zero target in the run up to the COP26. This announcement is expected to put India on a firm path towards decarbonization.
 - This announcement also keeps in mind the Common but Differentiated Responsibilities and Respective Capabilities (CBDR-RC).

- India's net zero comes in 2070 and NDC is subject to funding from developed countries
- **India is contributing more than its share:** Despite a 2070 net zero year for India, India's cumulative emissions between 1900-2100 would be lower than the US, China or EU.
- **India continues to show international leadership** - It has launched the Infrastructure for Resilient Island States - an initiative under the coalition for Disaster Resilient Infrastructure to support vulnerable island countries. India has also launched Green Grids Initiative in partnership with UK to tap into renewable energy resources everywhere.

- **Critics of shifting to a Net Zero target**

- **Over-appropriation of global carbon budget** by a few.
 - Countries which have higher emissions presently are taking more advantages of the environment.
 - The campaign to achieve net zero by 2050 is designed to achieve Paris goals by the "lowest cost" methods, foregoing equity and climate justice.
- **Wasn't mandated by Paris Agreement.**
- **India is anyways a small contributor** - Our emissions are 4.37% of the world's share (with 18% population).

Critics of Sustainability of India's Net Zero Strategy

- India's plan to increase dependence on hydro projects and nuclear energy will create displacement, deforestation, hazardous radiation etc.
- Solar and Wind Energy is also focused on Mega energy parks which may cause displacements.

5) MECHANISMS AND ISSUES WITH CLIMATE FUNDING

- **Introduction**

- » Money has been central to many a fight at the Climate Change negotiations. UNFCCC as part of its CBDR principle requires developed countries to provide financial assistance to developing nations in their fight against the climate change.
- » **Globally**, there are two funding mechanisms - **The Green Climate Fund** and the **Global Environment Facility**.

- **Green Climate Fund (GCF)**

- » Established at COP-16 in 2010, it is the financial mechanism for UNFCCC under article 10. It is regarded as the chief instrument for the fulfillment of developed world's annual support of \$100 billion annually till 2025.
- » **COP-21 held at Paris** also decided that **GCF shall serve the Paris Agreement**.

- **Global Environment Facility (GEF)**

- » Created at Rio Earth Summit in 1992 to help tackle planet's most important environmental problems.

- **What has it done so far? / What does GEF do?**

- » GEF also serves as financial mechanism for the following conventions:
 - CBD
 - UNFCCC
 - UNCCD

- Stockholm Convention on Persistent Organic Pollutants (POPs)
- Minamata Convention on Mercury
- It also supports implementation of Montreal Protocol on substances that deplete the ozone layer in countries with economies in transition.

- **Current Funding Situation:**

- **Requirement:** As per COP27 (Sharm el-Sheikh agreement), the global transition to a low-carbon economy would likely require about US\$ 4-6 trillion every year till 2050. This is 5% of the global GDP.
 - The cumulative requirement of developing countries, just for implementing their climate action plans, was about US\$ 6 trillion between now and 2030.
- **Availability:**
 - The \$100 billion amount, that the developed countries have promised is the only money in play right now. And of this only around US\$50-80 billion per year is being mobilized. This indicates that the fund available in less than 10% of what is required.

- **Key Problems of current climate funding are:**

- **Requisite finance** hasn't been mobilized.
- **Funding bias in favour of climate change mitigation activities**. This bias is there because mitigation efforts are easily visible in short run and returns from adaptation efforts will be visible after long time.
 - For e.g., if we adapt by moving away from coasts, the benefit of this adaptation efforts would be visible much later.
- **Developing world** in itself cannot fight the climate crisis as they are still struggling for finance for their development needs.
- **A number of countries** are unable to access global finance. Present rules and regulations of global financial systems, make it difficult for many countries to access international finance, particularly those with political instabilities
- **Lack of transparency** is leading to problems of double counting and green washing.

- **Way Forward:**

- **Availability and Access** are two main dimensions to the problem of climate finance.
- **Increasing Availability:**
 - **Developed countries** need to increase their contribution.
 - But, even if this happens, this won't be able to fulfill the requirement of around \$6 trillion needed annually.
 - **Mobilize resources from private sector**: Businesses and Corporations need to invest money into green projects.
 - In climate finance thus far, private investment have lagged behind public money. Barely 30% of current financial flows are coming from private sources.
 - **Creation of right environment for investments in green project** -> Private sector will not invest unless they are reasonably sure of healthy returns.
 - Here, international financial institutions should engage with governments, central banks, commercial banks etc. to incentivize climate friendly investments and discouraging, or even penalizing, dirty investments.

- **Carbon Tax** - Common citizens will have to contribute to the bulk of the additional financial resources.
- **Increasing Access:** There is a need to simply lending mechanisms and overhaul credit rating systems.
- **Increased Transparency:**
 - Climate finance flows through a maze of channel - bilateral, regional, multilateral. It is in the form of grants, concessionary loans, debt, equity, carbon credit, and more. As a result, there are widely different opinion on the quantum of climate finance currently being mobilized. This needs to be addressed.

8. OTHER EFFORTS TO FIGHT CLIMATE CHANGE

1) REDD+

- **Need of REDD+**
 - Deforestation and forest degradation account for 17% of carbon emissions, more than the entire global transportation sector and second only to energy sector. Therefore, **conservation of forests can play a very crucial role in controlling climate change.**
- **Introduction to REDD+**
 - **REDD+** is a climate change mitigation solution developed by parties to UNFCCC. It **incentivizes developing countries to keep their forest standing** by offering results-based payments for actions to reduce or remove forest carbon emissions.
 - » The idea is that developing nations should be able to financially benefit from the ecosystem services that their forests provide, such as carbon storage and as reservoirs of biodiversity.
 - The payment is targeted at five activities:
 - » **Reducing Emissions** from Deforestation
 - » **Reducing Emissions** from forest degradation.
 - » Conservation of carbon stocks
 - » Sustainable management of forests
 - » Enhancement of Carbon stocks.
 - **REDD+ goes beyond simply deforestation and forest degradation and includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks.**
 - **In 2019, Brazil** became one of the first countries to receive results-based aid.
 - **In 2020, Uganda** has become the first African country to submit the results for Reducing Emissions from Deforestation and forest degradation (REDD+) to the UNFCCC.
 - Uganda has now become eligible for results based payments.
 - In 2020, **Uganda became eligible** for REDD+ payments, the first African country to do so.

A) REDD+ IN UNFCCC

- First negotiated in UNFCCC 2005 (COP-11).
- Adopted at COP-13 in 2007 in Bali.
- In 2013, **COP-19** produced at least seven decisions on REDD+, which are jointly known as the "**Warsaw Framework on REDD-Plus**".
- And finally, the remaining decisions on REDD+ was **completed at COP21** in 2015 and the UNFCCC rulebook on REDD+ was completed. **All countries were also encouraged to implement and support REDD+ in Article 5 of the Paris Agreement**. This was part of the broader article that specified that all countries should take action to protect and enhance their greenhouse gas sinks and reservoirs (stores of sequestered carbon).
- UNFCCC requests All developing countries aiming to undertake REDD+ to develop the following elements:
 1. A **national strategy or action plan**;
 2. A **national forest reference emission level** and/or forest reference level.
 3. A **national forest monitoring system** for monitoring and reporting on REDD+ with if possible subnational monitoring

Elements of UNFCCC Warsaw Framework for REDD+



B) REDD AND REDD+

- REDD originally referred to "reducing emissions from deforestation in developing countries" the title of the original document on REDD. It was superseded in the negotiation by REDD+.
- REDD+ refers to "reducing emissions from deforestation, and forest degradation in developing countries, and the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks in developing countries". This is the most recent elaborated terminology used by COP.

C) INDIA'S REDD+ STRATEGY (RELEASED IN AUG 2018)

- The strategy has been **prepared by Indian Council for Forestry Research & Education (ICFRE)**, Dehradun.
- The strategy builds upon existing national circumstances which have been updated in line with India's National Action Plan on Climate Change, Green India Mission, and India's NDC to UNFCCC.
- **Key focus**
 - Cooperation and involvement of the tribals, other forest dwelling communities and the society as a whole
- **Significance**
 - Reiterates India's commitment to Paris Agreement on CC
 - It will help in conservation of forests and enhance productivity of forest ecosystem.
 - REDD+ strategy will help India fulfill its NDC commitment and contribute to the livelihood of the forest dependent population.

2) THE UN REDD PROGRAM (THE UN COLLABORATIVE PROGRAM ON REDUCING EMISSIONS FROM DEFORESTATION AND DEGRADATION IN A DEVELOPING COUNTRIES)

- It is a multilateral body which partners with developing countries by assisting them to develop the capacities needed to meet the UNFCCC REDD+ requirements.
 - It does so through a country based approach that provides advisory and technical support services tailored to national circumstances and needs.
- It is a collaborative initiative of FAO, UNDP, and UNEP. It also harnesses technical expertise of other UN agencies.

3) CENTRAL AFRICAN FOREST INITIATIVE (CAFI)

- CAFI was founded in 2015 as a collaborative agreement between six Central African Countries - the Central African Republic, the Democratic Republic of Congo, the Republic of Congo, Gabon, Equatorial Guinea and Cameroon - and six financial partners: the European Union, France, Norway, Germany, South Korea and the Netherlands.
 - It is **based around the REDD+ mechanism** developed by the parties to the UNFCCC.

9. MITIGATION STRATEGIES

Key issues covered – Carbon Sequestration, Carbon Sink, Carbon Credit, Carbon Offset, Carbon Tax, and Geo-Engineering

1) CARBON SEQUESTRATION

- It is the process of capturing and storing atmospheric carbon dioxide. It is one of the methods of reducing the amount of carbon dioxide in the atmosphere with the aim of fighting climate change.
- **There can be two major types of carbon sequestration:**
 - » **Biological:**
 - Biological Carbon Sequestration is the storage of carbon dioxide in **vegetation** such as grasslands, or forests, as well as in **soils and oceans**.
 - **Plant rich landscapes** like forests, grasslands etc. capture 25% of the global carbon emissions.



- **Soil** can store carbon in the form of Soil Organic Carbon.
 - Soil can also store carbon as carbonates.
- **Colder and nutrient rich part of ocean** can absorb more carbon dioxide than warmer parts. Therefore, polar regions generally serve as carbon sink.

» **Geological Carbon Sequestration**

- It is the process of storing carbon dioxide in underground geologic formations, or rocks.
- **Naturally, Carbonates** are created over thousands of years when carbon dioxide dissolved in water and percolates in soil, combining with calcium and magnesium minerals, forming '**caliche**' in desert and arid soil.
- **Artificially**, CO₂ captured from industrial, or any other sources may be injected into porous rocks for long-term storage.
 - **Hydrodynamic Trapping**: It refers to a time-dependent hydrogeological process where injected CO₂ is effectively trapped by the existence of very long travel times to the surface.
 - **Solubility Trap**: CO₂ dissolved in liquid like water or oil.
 - **Mineral Carbonation**: CO₂ can be made to react to naturally occurring minerals to form stable compound which can stay like that for years (e.g. Calcium carbonate)

» **Technological Carbon Sequestration**

- These are the new ways being explored by scientists to capture and store carbon using innovative technologies and to make useful products out of it.
- **Graphene Production**
- **Direct Air Capture** - Capturing carbon directly from air using advanced technology plants.
 - For now the technology is highly expensive and energy intensive. But with more advancement in technologies, this may become a viable option.
- **Engineered Molecules** - These molecules can change shape by creating new kinds of compounds capable of singling out and capturing carbon dioxide from the air.

2) CARBON SINK (GREEN AND BLUE CARBON)

- **Green Carbon**: It is the carbon which is stored by vegetation (forests, grasslands, etc.). It is basically **biological carbon sequestration**. Reforestation and Afforestation are mechanisms to enhance Green Carbon
- **Blue Carbon**: Carbon stored by coastal, aquatic or marine ecosystems. These include mangroves, seagrasses etc.
 - Coastal ecosystems are more efficient carbon sinks when compared to tropical rain forests.

1) CARBON CREDIT AND CARBON OFFSETTING (ALREADY DISCUSSED WITH MARKET BASED MECHANISM)

2) CARBON PRICING INCLUDING CARBON TAX

- **Carbon Pricing** is a method which captures the external cost of green house emissions - i.e. the losses to different sectors like agriculture, health, property etc. due to addition of Greenhouse gas in atmosphere. There are **two major types** of Carbon Pricing - **Emission Trading System** (or Cap and Trade System) and **Carbon Tax**.
- **Advantages of Carbon Pricing:**
 - » Shifts the cost on polluters -> internalize the external cost of pollution
- **Carbon tax** is a potential alternative to the 'cap and trade' method currently used by the Kyoto protocol to reduce the carbon emission.
 - » A carbon tax aims to internalize the externality of climate change by setting a price on the carbon content of energy consumed or greenhouse gas emitted in the production of consumption of goods.
- **Advantages of carbon taxes over 'Quantitative limits' or 'Cap and trade' system**
 1. **Avoids the problem of choosing a baseline** : In a price approach, the natural baseline is a zero carbon tax.
 2. **Better adaptation to element of uncertainty** which pervades the science of climate change.
 - Quantitative limits are related to the stocks of greenhouse gas emissions, while the price limits are related to the flow of emissions.
 3. **Less volatility and more predictability** : From uncertainty (point 2) arises volatility. Carbon tax regime is likely to cause less volatility in the prices of carbon emission
 4. **Less administrative arbitrariness - easier implementation - lack of manipulation**
 - Quantity limiting policies are often accompanied by administrative arbitrariness and corruption through rent seeking. This sends of wrong signals to investors.
 - In a price based system, the investors has an assured long-term regulation to adapt to and can weigh in the costs involved.
 5. **Addresses the problem of equity**
 - Equity is the most contentious issue in any international negotiation on climate change mitigation either at the level of WTO or UNFCCC.
 - The price based approach in the form of carbon tax makes it easier to implement the equity based international adjustments than the quantity based approach.
 6. **Carbon tax will essentially be a Pigovian tax** which balances the marginal costs and benefits of additional emissions, thereby internalizing the cost of environmental damage.
 7. **Better understandability**: the carbon tax is simpler to understand and therefore may be braced by more people
- **Limitations of Global Carbon Tax**
 - **No CBDR**: It penalizes incremental carbon emissions rather than those who have **already spewed into the atmosphere** since the Industrial revolution.
 - **Taxes are part of national social contracts** that emerge out of very specific conditions that can't necessarily be replicated on a global scale.
- **Has India imposed any carbon tax yet?**
 - A carbon tax increases the price that consumers pay for energy. Increase in **fuel taxes** as well as **quadrupling of the coal cess** is sometimes interpreted as a variant of a carbon tax.

- Similarly, not decreasing the petrol/diesel prices according to the decrease in crude oil prices can also be seen as a method of imposition of carbon tax.

3) GEO-ENGINEERING

- Introduction:**
 - Definition:** Geo-engineering is a theoretical concept which aims to modify and cool environment to defeat the global warming. It may involve reduction of Sunlight reaching earth or absorption of CO₂ to reduce global warming (Carbon Capture Technologies).
 - Since the global community is looking for a Net Zero target by 2050, the Geo-engineering technologies are expected to play a key role in this.
- Reduction of sunlight reaching Earth:**
 - Stratospheric Aerosol Injection:** Injecting the atmosphere with Sulphur/ Hydrogen Sulphide (copies volcanic effect and scatters sunlight).
 - Putting Large Mirrors in Space** - reduce the amount of sunlight reaching earth.
 - Using Wind-Powered Motors to **whiten the cloud** -> by spraying water into the sky -> reflect solar radiation.
- Carbon Capture and Storage (CCS)** (Or Carbon Capture Utilization and Storage (CCUS)) refers to technologies that can capture CO₂, at a source of emissions before it is released into atmosphere.
 - The process starts with capture of CO₂ which undergoes a compression process to from a dense fluid. This eases the transport and storage of the captured CO₂.
 - This dense fluid is transported via pipelines and then injected into the underground storage facilities. It can also be used as a raw material in other industrial processes such as bicarbonates.
- CDR** takes the form of both natural means like afforestation or reforestation, and technologies like direct air capture where machines mimic trees by absorbing CO₂ from their surrounding and storing it underground.
 - E.g. Fake Trees containing compounds which can react with CO₂ to absorb it and store it in solid from.
- Other Carbon Capture Technologies**
 - Ocean Iron Fertilization:** Seeding the Sea with Iron
 - Phytoplankton prefer iron and flourish in its presence, thus absorbing a lot of CO₂.
- How significant is the role of CCS and CDR in achieving net-zero by 2050?**
 - In IPCC AR6, there is no pathway to 1.5 degrees C that doesn't use CDR.
- Limitations/Problems with these CCS and Geoengineering method:**
 - CCS and CDR** are still technologies under development without demonstrated feasibility at large scale despite decades of development.
 - It also suffers from other challenges like high energy requirements; high cost; challenges in the transport and long-term storage of carbon.
 - CDR** methods like afforestation, reforestation, Bioenergy with Carbon Capture and Storage (BECCS) are constrained by their need of land. It may also hamper food and water security.

- » **Ocean Iron Fertilization:** The Convention of Biological Diversity has already imposed a de facto moratorium based on precautionary principle. It could result in eutrophication, which may adversely affect the ocean ecosystem.
- » **Stratospheric Aerosol Injection** is also highly controversial as this could have unintended effects on global and regional climates.
- » Further, there are concerns related to **fairness, equity, and justice** in the adoption of geo-engineering technologies as most of the R&D is dominated by North American and Western Euro.

- So far, there has been very little progress on these technologies and most of the R&D is dominated by North American and Western European Nations. Emerging economies like China and India have also begun to look into these options more seriously.
 - CCS is **absent from INDCs of most of the countries**, indicating that most of the countries have not yet accepted it as promising technology.
 -
- **Why very little progress?** - Lack of policy support and spending on R&D.

4) OCEAN CARBON DIOXIDE REMOVAL

- **Introduction:**
 - » Ocean stores about 50 times more carbon than the atmosphere. So, for taking carbon out of atmosphere and storing it someplace where it won't continue to warm the planet, the ocean is the single biggest place it can go.
 - » **Ocean Carbon dioxide Removal (Ocean CDR)** uses the ocean's natural ability to take up carbon on a large scale and amplifies it.
 - **Carbon gets into ocean from atmosphere in two ways:**
 1. Air dissolves in the ocean surface. Because sea water is slightly alkaline, the CO₂ is absorbed into the ocean.
 2. The second involves **biologic pump**.
 - Ocean is a living medium and has algae, crustaceans, fish, whales etc. When organic material is eaten or dies, it gets recycled. It rains down through the ocean and makes its way to the ocean twilight zone, a level around 200 to 1,000 meters deep.
 - This twilight zone sustains the biological activities of the ocean. It is the soil of the ocean where organic carbon and nutrients accumulate and are recycled by microbes.
 - It is also home to the largest animal migration on the planet. Each day, trillions of fish and other organisms migrate from the depths to the surface to feed on the phytoplankton and one another and go back down, acting like a large carbon pump that captures carbon from the surface and shunts it down into the ocean where it is stored away from the atmosphere.
- **Why is OCEAN CDR drawing so much attention right now?**
 - » Some experts feel that because of its volume and carbon storage potential, the ocean is really the only arrow in our quiver that has the ability to take up and store at the scale and urgency required.

- » A 2022 report by the national academies outlined a research strategy for ocean carbon dioxide removal. The **three most promising methods** highlighted are:
 - **Ocean Alkalinity enhancement:** Oceans are naturally alkaline, with a pH of about **8.1**. Increasing alkalinity by dissolving certain powder rocks and minerals makes the ocean a chemical sponge for atmospheric CO₂.
 - **Add micro-nutrients to ocean surface**, particularly soluble iron.
 - Very small amount of soluble iron can stimulate great productivity (algal growth), which drives a more vigorous biological pump.
 - Over a dozen of these experiments have been done, so the scientists know that it works.
 - **Grow Kelp in the Ocean:** It captures carbon at the surface through photosynthesis, then bale it and sink it to the deep ocean.
- » But, **all these methods** have drawbacks for large scale use, including cost and unanticipated consequences

10. EFFORTS BY AVIATION AND SHIPPING SECTOR

1) ICAO – CORSIA

- **Introduction**
 - » The International Civil Aviation Organization (ICAO) is a specialized agency of UN which deals with administration and governance of the Convention on International Civil Aviation (Chicago Convention).
 - » It was established in **1944** and is headquartered at **Montreal Canada**.
 - » It works with 192 Member states of convention and other industry groups to come to a consensus on **International Civil Aviation Standards and Recommendation Practices (SARPs)** and **Policies** to ensure safe, efficient, secure, economically sustainable and environmentally responsible civil aviation.
 - » It also assists member states in capacity building towards various aviation development objectives.
- **Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)**
 - » In **2016**, ICAO finally (after years of negotiations) sealed the first deal for limiting green-house gases from international aviation. The decision was taken during 39th ICAO general assembly meeting attended by 191 countries.
 - » **Details of the Offsetting Scheme:** From **2021**, any increase in airline CO₂ emission will be offset by activities like tree planting, which soak up CO₂.
 - CO₂ will be allowed to grow to 2020 but after that, emissions will need to be offset.
 - Three Phases:
 - **Pilot Phase:** 2021-2023 (Voluntary)
 - **First Phase:** 2024-2026 (Voluntary)
 - **Second Phase:** 2027-2035 (Mandatory for all member states)
 - The deal will be voluntary till 2026 but most major nations are expected to take part.
 - Review period every three years and it rules out "double counting" of offsets to ensure that forest protection efforts elsewhere aren't used to negate aircraft emissions.

- » Applicable to Civilian passenger and cargo flights.
- » **Exceptions:** Humanitarian, Medical, Firefighting flights etc.
- **Developing countries** like India, China, Brazil etc had opposed the provisions. Why? ?
- **CORSIA** is part of the effort from ICAO to halve the carbon emissions by 2050 compared to 2005 levels.
 - » **Other efforts** include adoption of new technology - including deployment of sustainable alternative fuels, more efficient aircraft operations, infrastructure improvements including modernized air-traffic management systems.
- **DGCA Guidelines to airlines operators** (Oct 2018)
 - » Under these guidelines, all operators engaged in international operations have to capture their fuel consumptions and carbon emissions data annually, starting from Jan 1, 2019.
 - » Further, beginning 2021, the operators will have to meet offsetting requirements by purchasing and cancelling "emission units".

2) INTERNATIONAL MARITIME ORGANIZATION (IMO) REACHES A DEAL TO CUT EMISSIONS

- **Key Highlights of the deal:**
 - » More than 170 countries under the aegis of IMO have agreed to a target to reduce greenhouse gas emissions from shipping by at least 50% of 2008 levels by 2050. This is being called as "initial strategy".
 - » The strategy also proposes to reduce carbon intensity from shipping - the amount of CO₂ emitted from each unit of transport - by at least 40% by 2030, and 70% by 2050.
 - » The final IMO Plan is not expected by 2023.
 - » **Some possible medium term measures** discussed include:
 1. Low carbon and zero carbon fuels
 2. Improved energy efficiency of new and existing ships
 3. Possible market based mechanism to encourage shift to lower carbon fuels.
- **Analysis**
 - » Experts feel that IMO should and could have gone much further in their contribution. Opposition from some countries especially USA, Saudi Arabia and Panama had limited what could be achieved at the IMO session.
 1. To align with Paris goals, the reduction target should be 70-100%.
 - » **Developing countries** like India are worried that a target to reduce emission from shipping sector will negatively hamper their yet to fully develop sector.
- **Note:** Shipping and Aviation sector avoided specific emission-cutting targets in a global climate pact agreed in Paris in 2015.

11. EFFORTS BY INDIA TO FIGHT CLIMATE CHANGE

1) NATIONAL ACTION PLAN ON CLIMATE CHANGE (NAPCC)

- **Introduction**
 - » Challenges emerging from climate change are complex and multi-sectoral, and therefore these have to be dealt with a multi-dimensional approach.

- » Keeping this in mind, **GoI in 2008, adopted NAPCC** which is aimed at promoting development objectives and at the same time tackling climate change effectively.
 - » There are 8 missions which form the core of NAPCC. These missions represent the multipronged and integrated approach required to deal with climate change.
- **How NAPCC was supposed to deal with Climate Change**
- Development and use of **new technologies**.
 - **Involving multiple ministries** which will focus on different mission objectives
 - **Involving private sector** through PPP projects and civil society actions.
 - **Promoting awareness** about climate change, adaptation, energy efficiency etc.
- **Understanding Achievements and Limitations of Individual Missions**
- i. **National Solar Mission** is aimed at increasing the solar energy capacity in the country and thus reducing the emission of GHGs.
 - Governed by Ministry of New and Renewable energy.
 - The target of JNNSM was enhanced to 100 GW by 2022 which includes 60 GW through large and medium scale grid connected solar power projects and 40 GW through rooftop solar.
 - ii. **National Mission for Enhanced Energy Efficiency (NMEEE)** is aimed at improving energy efficiency and thus meeting energy demands of the country.
 - **Ministry:** Ministry of Power
 - The mission commenced in 2010 with a target to achieve the following:
 - GHG reduction of 98.55 million tonnes/ year at full implementation stage.
 - Annual fuel savings of 23 million tons.
 - iii. **National Mission for Sustainable Habitat**
 - **Ministry of Housing and Urban Affairs**
 - The mission commenced in 2010 with an aim to reduce emission in cities.
 - It focuses on GHG reduction opportunities by increasing energy efficiency of the building, improving municipal solid waste management, and encouraging people to use public transport.
 - Some specific initiatives to achieve these objectives are Adaptation of the existing Energy Conservation Building Code and promoting investments in development of high capacity public transport system.
 - iv. **National Water Mission**
 - Ministry of Jal Shakti.
 - The mission commenced in 2011 with an aim to ensure water security and improve access to water resources. It aims to achieve this by promoting water conservation and water use efficiency.
 - It covers the entire sweep of water management to fight climate change impacts: from water conservation to water use efficiency.
 - v. **National Mission for Sustaining Himalayan Ecosystem**

- Governed by **Department of Science and Technology**
 - Commencement in 2011
 - Aimed at developing capacity to assess the health status of Himalayan Ecosystem and helping Himalayan states in policy formulation and implementation.
- vi. **The National Mission on Strategic Knowledge for Climate Change**
- Governed by **Department of Science and Technology**
 - Commencement in 2014
 - Aimed at establishment of knowledge network among the existing knowledge institutions engaged in R&D related to climate change.
 - The two missions (NMSHE and NMSKCC) operated under **DST** and aims to generate new information, building scientific and technical capacity, and produce new channel of collaboration between scientists, policy makers and law makers to ensure that climate action is based on sound knowledge and science.
- vii. **National Mission for Green India**
- **MoEF&CC**
 - Commencement: 2014
 - Aims: To increase forest and tree cover.
 - Under this the focus is on reviving degraded forests with a focus on increasing forest cover & density and conserving biodiversity.
- viii. **National Mission for Sustainable Agriculture**
- Commenced in 2012 with aim to climate-proof agriculture and reduce emission from the sector.
 - There are **four components** under NMSA
 1. **Soil Health Management** aims at nutrient management through judicious use of chemical fertilizers for improving soil health and productivity.
 2. **Rainfed Area Development** to develop or bring agri-land under integrated farming system.
 3. **Sub-Mission on agro-forestry** to promote plantation along with crops.
 4. **Climate Change and Sustainable Agriculture: Monitoring Modeling and Networking** (CCSAMMN) for creating models on adaptation and dissemination of information about climate change.

3) MISSION LIFE

- **Why in news?**
 - » PM Modi launched Mission LiFE (Lifestyle for Environment), in the presence of UN Secretary General Antonio Guterres (Oct 2022)
- **Details about Mission LiFE**
 - » It was first proposed by PM Modi at COP 26 of UNFCCC in Nov 2021. It is envisioned as an India led global mass movement that will nudge individual and collective action to protect and preserve the environment.
 - PM Modi has underlined that Mission LiFE makes the fight against climate change democratic, in which everyone can contribute with their respective capacities.

- It emboldens the spirit of the P3 Model: Pro Planet People.
- It functions on the basic principles of 'Lifestyle of the planet, for the planet and by the planet'.
- » At the launch, PM Modi also highlighted that the concept of 'Reduce, Reuse and Recycle' and circular economy; and mentioned that it has been part of the Indian Lifestyle for thousands of years.
- » LIFE also resonates with **climate justice** -> it highlights enhanced obligations for those in developed countries and supports climate adaptation and mitigation for those most affected and yet least responsible.
- **NITI Aayog and MoEF&CC**, in collaboration with Government of Gujarat, organized the global launch of Mission Life.
 - » NITI aayog will curate and incubate Mission Life in the first year, and it will subsequently be implemented by MoEF&CC.
 - » It is a five year program.
- **Significance:**
 - » According to UNEP, more than 2/3rd of the GHG emissions can be attributed to household consumption and lifestyles -> therefore the urgent cuts to global emissions we need can only be achieved through widespread adoption of greener consumption habits.
 - » Life recognizes that small individual actions can tip the balance in the planet's favor.
 - Actions such as saving energy at home; cycling and using public transport instead of driving; eating more plant-based foods and wasting less; and leveraging our position as customers and employees to demand climate-based friendly choices.
 - » Many of the goals of LiFE can be achieved by deploying 'nudges', gentle persuasion technique to encourage positive Behaviour.
 - The UNEP employs proven nudging techniques:
 - Discouraging Food waste by offering smaller plates in cafeterias;
 - encouraging recycling by making bin lids eye-catching;
 - and encouraging cycling by creating cycle paths
- **Note: Other Recent global initiatives launched/initiated by India:**
 - Panchamrita Targets announced by Mr Modi at COP26
 - International Solar Alliance
 - The Coalition for Disaster Resilient Infrastructure

4) GREEN BONDS: MOBILIZING FUNDS

- Though the Paris Agreement provides for mobilization of resources from developed countries, the process has been very slow.
- Thus, India has scaled up its efforts towards greater mobilization of private capital to meet its ambitious climate action goals.
- Green Bonds are financial instruments that generate proceeds for investment in environmentally sustainable and climate suitable projects.
 - Developed countries such as UK, France, Germany etc have been using Green bonds to raise billions of dollars of sovereign green debts.

- In India, as per SEBI's data between 2017 and Sep 2022, 15 Indian corporates have issued green bonds of value of Rs 4,539 crores. Most of this is related to renewable energy generation.
- Union Budget 2022-23 announced the issuance of Sovereign Green Bonds.
 - The final sovereign Green bond framework of India has been issued.
 - The Green Financing working committee has also been set up to oversee and validate key decisions on the issuance of Sovereign green bonds.
 - The committee has the mandate to select the projects for allocation of proceeds, do a time-bound review of the allocation and carry out annual reporting along with an impact assessment of the proceeds from sovereign green bonds issued

A) REGULATORY FRAMEWORK FOR ISSUANCE OF GREEN DEBT SECURITIES

- Reserve Bank of India:
 - In Nov 2021, the RBI published its 'Statement of Commitment to Support Greening India's Financial System' - **NGFS**. Here, the Reserve Bank of India (RBI) laid out, keeping in view its national commitments, priorities, and complexity of our financial system, committed to, among others, exploring how climate scenario exercises can be used to identify vulnerabilities in RBI-supervised entities' balance sheets, business models and gaps in their capabilities for measuring and managing climate-related financial risks.
 - **Also, in 2007, the RB advised banks to put in place an appropriate action plan for making a meaningful contribution** to sustainable development.
 - Over time, RBI has incentivised bank lending towards greener industries and projects.
 - For example, renewable energy projects have been included under Priority Sector Lending (PSL).

B) SECURITIES AND EXCHANGE BOARD OF INDIA (SEBI)

- SEBI introduced the regulatory framework for issuance of green debt securities as a mode of sustainable finance under the erstwhile SEBI (Issue and Listing of Debt Securities) Regulations, 2008, (ILDS Regulations), in 2017.
- At the time of review of the ILDS Regulations, the provisions of the erstwhile circular were subsumed, and the definition of "green debt security" was incorporated as Regulation 2(1)(q) in the SEBI (Issue and Listing of Non-Convertible Securities) Regulations, 2021 ('NCS Regulations'). The disclosure requirements were prescribed vide Operational Circular dated August 10, 2021.
- In Nov 2022, SEBI has allowed an issuer under the SEBI (Issue and Listing of Municipal Debt Securities) Regulations, 2015 ('ILMDS Regulations') to issue a green debt security if it falls within the definition of "green debt security" as per Regulation 2(1)(q) of the NCS Regulations. Such an issuer has to comply with both ILMDS Regulation and NCS Regulation
- In the backdrop of increasing interest in sustainable finance in India as well as around the globe, and with a view to aligning the extant framework for green debt securities with the updated Green Bond Principles recognised by International Organisation of Securities Commission (IOSCO), SEBI undertook a review of the regulatory framework for green debt securities. Based on the review, it has been decided in the SEBI board meeting dated December 20, 2022, to:

- Enhance the scope of the definition of green debt security by including new modes of sustainable finance in relation to pollution prevention and control, eco-efficient products, etc.;
- Introduce the concept of blue bonds (related to water management and marine sector), yellow bonds (related to solar energy) and transition bonds as subcategories of green debt securities.

12. DESERTIFICATION AND LAND DEGRADATION

- **Introduction**
 - Desertification is a type of land degradation in which relatively dry land region becomes increasingly arid, typically losing its bodies of water as well as vegetation and wildlife.
 - Currently, 41% of the landmass worldwide is prone to desertification and more than 2 billion people are affected by desertification and land degradation.
- **Key causes**
 - i. **Deforestation**
 - ii. **Overgrazing and unsustainable agri practices** are other major factors leading to desertification.
 - iii. **Increasing Pollution** also negatively hampers biodiversity (including biodiversity), causes infertility of soil and promotes desertification
 - iv. **Climate Change and higher probability of droughts** have made more areas vulnerable to desertification
 - v. **Salination** caused by overuse of water, degrades soil and promotes desertification.
 - vi. **Unsustainable Mining practices** also degrades the geographic region and promotes desertification.
 - vii. **Invasive species** of plants such as **Proposis Juliflora** have also resulted in the decline of natural vegetation and expansion of deserts.
 - This can be specifically seen in case of **Banni Grassland**, of Kutch Gujarat.
 - viii. **Forest fires** are the other major drivers of desertification.
 - ix. **Lack of Resources** to fight desertification
 - The issue was also raised recently in the 14th COP on UNCCD. Only \$6.4 billion have been spent in last 2 years to combat desertification, the real cost should be as much as \$450 billion annually.
- **Impact**
 - i. **Threatens socio-economic development** by threatening food security, increasing poverty and unemployment due to land degradation.
 - ii. **Increases vulnerability of already vulnerable groups**
 - iii. **Promotes the vicious cycle of degradation**
 - Poverty force people to go for unsustainable agri practices, further promoting desertification.
 - iv. **Desertification adds to and worsens the impact of climate change**
 - It reduces forest cover and thus reduces the sinks for CO₂.

1) UNITED NATION CONVENTION ON COMBATING DESERTIFICATION (UNCCD)

- UNCCD is one of three important conventions finalized in 1992 Earth Summit (the other being CBD and UNFCCC)

- It was **established in 1994** and is the **sole legally binding international agreement linking environment and development to sustainable land management.**
 - The convention addresses specifically the arid, semi-arid and dry sub-humid areas, known as drylands, where some of the most vulnerable ecosystems and peoples can be found.
- The convention has **197 members** who work together to:
 - Improve the living condition of people** in drylands
 - Maintain and restore soil productivity**
 - Mitigate the effect of drought**

2) THE NEW UNCCD 2018-30 STRATEGIC FRAMEWORK

- It is the most comprehensive global commitment to achieve **Land Degradation Neutrality (LDN)** to achieve a land degradation-neutral world consistent with the 2030 Agenda for Sustainable Development.
- **Land Degradation Neutrality**
 - A state whereby the amount and quality of land resources, necessary to support ecosystem functions and services and enhance food security, remains stable or increases within specified temporal and spatial scales and ecosystems.
- **The LDN Target Setting Program**
 - Through this, the Global Mechanism (GM) and Secretariat on UNCCD, in collaboration with multiple international partners, are supporting interested countries in their national LDN target setting process.
- **The LDN Fund**
 - It is an impact investment fund, blending resources from the public, private and philanthropic sectors to support achieving LDN through sustainable land management and land restoration **projects implemented in private sector.**
 - It is the first of its kind investment vehicle leveraging public money to raise private capital for sustainable land projects.
 - It was officially launched at COP 13 in Ordos, China.

3) WORLD DAY TO COMBAT DESERTIFICATION AND DROUGHT: 17TH JUNE

- **Background**

- In 1994, General Assembly established the United Nations Convention to Combat Desertification (UNCCD), the sole legally binding international agreement linking environment and development to sustainable land management, and declared 17th June "World Day to Combat Desertification and Drought".
- Later, in 2007, UNGA declared the decade 2010-2020 as the **UN Decade for Deserts and Fight Against Desertification to mobilize global action to fight land degradation.**
- The 2021 Desertification and Drought day focused on turning degraded land into healthy land.

Desertification & Drought Day

17 JUNE
2021



Restoration. Land. Recovery.

We build back better with healthy land

4) THE BONN CHALLENGE

- It is a global goal to bring 150 million hectares of degraded and deforested landscapes into restoration by 2020 and 350 million hectares by 2030.

5) GREAT GREEN WALL INITIATIVE

- This initiative was launched in 2007 by African Union and is aimed at restoring Africa's degraded landscapes and transform millions of lives in one of the world's poorest regions, the Sahel.
- It will be covering the Sahel region, from Senegal in the west to Djibouti in the East of Africa.
- Once, complete the wall will be the largest living structure on the planet - an 8,000 km natural wonder of the world stretching across the entire width of the continent.
- The initiative has brought together African Countries and International Partners, under the leadership of African Union Commission and Pan-African Agency of the Great Green Wall.
- **Objectives:**
 - By 2030, restore 100 million ha of currently degraded land; sequester 250 million tons of carbon; and create 10 million green jobs.



6) UN HIGH LEVEL DIALOGUE ON DESERTIFICATION, LAND DEGRADATION, AND DROUGHT

- **Why in news?**
 - PM Modi gave a keynote address at the UN 'High-Level Dialogue on Desertification, Land Degradation and Drought' (June 2021)
- **Details**

- The President of General Assembly convened a High-Level Dialogue to assess the progress made in the fight against DLDD during the UN Decade for Deserts and the Fight Against Desertification (2011-2020) and map the way forward. This dialogue took place in May 2021.

- **Key Purpose**

- Bring attention to how COVID-19 recovery process can be aligned to address DLDD through job creation project in land restoration, regenerative agriculture, renewable energy and energy efficiency, and investments in sustainable land management.
- Elevate the discourse on DLDD issues' global significance for the entire SDG agenda and for climate, biodiversity and disaster risk reduction.
- Build upon the commitments made by member states during CBD summit, UNFCCC summit and so on.
- Encourage all UN members to adopt and implement Land degradation Neutrality targets and National Drought Plans as part of their NDCs to Paris Agreement.
- Call member countries to support the Land Degradation Neutrality Fund and other funding mechanisms to scale up land restoration by all sectors of society
- Share experiences, best practices, cutting edge technologies and innovative business models that advance green, resilient and inclusive recovery strategy.

- **Key Highlights of PM Modi's Address**

- In India, we have **always given importance to land and considered the sacred Earth as our mother.**
- **Key steps by India:**
 - » **Afforestation:** Over last 10 years, India has added 3 million hectares of forest cover.
 - » India is on track to achieve our national commitment of Land Degradation Neutrality [SDG target 15.3].
 - » India is also working towards restoring 26 million hectares of degraded land by 2030.
 - This would also contribute to India's NDC commitment of an additional 2.5 to 3 billion tonnes of carbon dioxide equivalent.
 - » In the spirit of south-south cooperation, India is also helping fellow developing countries to develop land restoration strategies.
 - » A centre of excellence is being set up in India to promote scientific approach towards land degradation strategy.
- **Restoration of land** can start the virtuous cycle of good soil health, increased land productivity, food security and improved livelihood.

7) DESERTIFICATION AND LAND DEGRADATION ATLAS OF INDIA

- It has been published by Space Application Centre, ISRO Ahmedabad (June 2021)
- The Atlas provides state wise area of degraded lands for the time frame 2018-19. It also provides change analysis for the duration of 15 years, from 2003-05 to 2018-19.
- **Key Highlights**
 - 29.7% of India's land is degraded.
 - i.e. 97.8 million hectares of India's total geographical area (TGA) of 328.72 mha underwent land degradation

- Area under **desertification** have also increased to 83.69 million hectares in 2018-19 from 82.64 mha in 2011-13.
 - Note: Land degradation within dry land regions (arid, semi-arid, and dry sub-humid regions) is termed as desertification.
- **Statewise breakup**
 - **Increase in level of desertification** have been seen in 28 out of 31 states and UTs between 2011-13 and 2018-19.
 - Even in **Goa and Odisha** where desertification had earlier declined (between 2003-05 and 2011-13), it has increased now.
 - Land degradation and desertification was **declining** in UP, Rajasthan and Telangana in 2018-19.

Around 23.79% of the area undergoing desertification with respect to the TGA of the country was contributed by Rajasthan, Maharashtra, Gujarat, Karnataka, Ladakh, Jharkhand, Odisha, Madhya Pradesh, and Telangana.

13. OZONE LAYER

- Ozone is a natural gas, it is an allotrope of oxygen consisting of three atoms of oxygen bound together in a non-linear fashion. The chemical symbol for ozone is O₃.
- It's a pale blue gas with distinctive pungent smell.
- **Pollutant at ground level** - discussed with air pollution
- **Ozone Layer**
 - » The ozone layer or ozone shield is a region of Earth's stratosphere that absorbs most of the sun's ultraviolet (UV) radiation. It contains high concentration of Ozone (O₃) in relation to other parts of the atmosphere, although still small in relation to other gases in the stratosphere.
 - » Ozone layer is mainly found in lower stratosphere (approx. 20-30 km above earth)
- **Usefulness of ozone layer:** Prevents damaging Ultraviolet from reaching earth thus benefitting both plants and animals; Protects oxygen of lower layer which would break up by the action of ultraviolet rays otherwise.

1) OZONE LAYER DEPLETION

- **What caused Ozone Layer depletion?**
 - » In 1970s scientists discovered that Chlorofluorocarbons (CFCs), broke apart in the atmosphere and released **chlorine atoms**. This caused the ozone depletion. The same effect resulted when bromine atoms were released by halons. Thus, **CFCs and halons** are examples of Ozone depleting substances.
- **What are the uses of Ozone depleting substances/ when and why they are produced?**
 - » **Chlorofluorocarbons (CFCs):** Used as refrigerants and aerosol propellants, for making plastic foam, cleaning of electronic equipment.

- Lifetime and removal of CFCs: Unlike other chemicals, CFCs cannot be eliminated from atmosphere by the usual scavenging processes like photo dissociation, rain-out and oxidation.
 - Escape of CFCs: The CFC enter into atmosphere by gradual evaporation from their source (discarded refrigerators etc.) Since the CFCs are thermally stable, they can survive in the troposphere. But in the stratosphere, they are exposed to UV radiation.
- **Bromine containing compounds:** Bromine containing compounds called halons and HBFCs, i.e., hydro Bromo fluorocarbons [both used in fire extinguishers] and methyl bromide (a widely used pesticide).
- **Carbon Tetrachloride:** It is a cheap, highly toxic solvent. Used in manufacture of synthetic rubber, the production of pesticides and pharmaceuticals.
- **Methyl Chloroform:** Used as cleaning solvent for clothes and metals, and a propellant in a wide range of consumer products, such as correction fluid, dry cleaning sprays, spray adhesives) and other aerosols.
- **Trichloroethane:** A versatile, all-purpose solvent.
- **Hydrochlorofluorocarbons (HCFCs):** Developed as an interim replacement for CFCs. Much less harmful than CFCs. But have high global warming potentials.
- **Nitrous Oxide (N₂O):** It can gradually reach the middle of the stratosphere, where it is photolytically destroyed to yield nitric oxide which in turn destroys ozone.
- **Sulphuric Acid Particles:**
 - The most prominent acid used in various industries
 - These particles free chlorine from the molecular reservoirs, and convert reactive nitrogen into inert forms thus preventing the formation of chlorine reservoirs.

2) SCIENCE OF OZONE DESTRUCTION

- **Through Chlorine atoms**
 - The molecules of CFCs when exposed to UV radiation break up, thus freeing chlorine atoms. A free chlorine atom reacts with an ozone molecule to form chlorine monoxide (ClO).
 - The depletion of ozone is catalytic ((ClO) further combine with an atom of oxygen to form O₂ and Cl. This Cl can further react with O₃ and the cycle continues. Thus, a single chlorine atom can destroy thousands of ozone molecules)
- **Bromine atoms**
 - Each bromine atom destroys hundred times of more ozone molecules than what a chlorine atom does.
 - » Bromine + Ozone ---> Bromine monoxide + Oxygen
 - » Bromine monoxide + Chlorine Monoxide ---> Oxygen + Bromine + Chlorine
- **Nitric Oxide (NO)**
 - Nitric oxide also catalytically destroys ozone
 - » Nitric Oxide (NO) + Ozone (O₃) -> Nitrogen dioxide (NO₂) + Oxygen (O₂)

» Nitrogen dioxide (NO_2) + monoxide (O) \rightarrow Nitric Oxide (NO) + oxygen (O_2)

3) EXTENT OF MAXIMUM DAMAGE OF OZONE LAYER

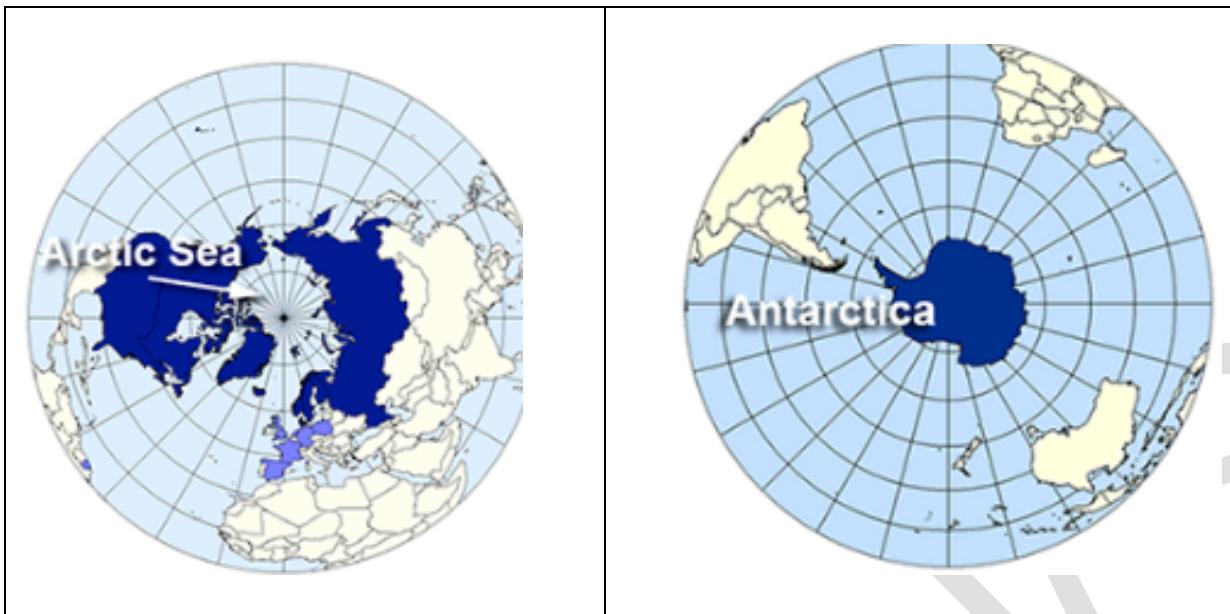
In 2000, the areas of Antarctic Ozone hole reached a record **of 29 million sq km**

4) POLAR STRATOSPHERIC CLOUDS AND OZONE DEPLETION

- What is Polar Stratospheric Cloud?
 - PSCs, also known as nacreous clouds (or mother of pearl, due to its iridescence), are clouds in the winter polar stratosphere at altitude of 15 - 25 kms. They contain water, nitric acid and/or sulfuric acid.
- Role in ozone depletion
 - Situation without PSCs
 - » **Chlorine** released by the breakdown of CFCs exists initially as pure chlorine or as chlorine monoxide but these two react further to form compounds Chlorine nitrate and HCl that are stable (inactive chlorine)
 - » The stable compounds HCl and ClONO_2 reservoirs of chlorine, and therefore for chlorine to take part in reactions of any sort, it has to be freed.
- Role of PSCs: Activating chlorine and absorbing nitrogen
 - Ice particles of the PSC provides substrates for chemical reaction which frees chlorine from its reservoirs. Usually, the reaction between HCl and ClONO_2 (Chlorine Nitrate) is very slow, but this reaction occurs at a faster rate in the presence of suitable substrate which is provided by the stratospheric clouds at the poles.
 - $\text{HCl} + \text{Chlorine Nitrate} \rightarrow \text{Cl}_2$ (Molecular chlorine) + HNO_3 (Nitric Acid)
 - PSCs not only activate chlorine, but they also absorb reactive nitrogen. If nitrogen oxides were present they would combine with chlorine monoxides to form a reservoir of chlorine nitrate (ClONO_2).

5) WHY IS OZONE DEPLETION PREDOMINANT OVER ANTARCTIC (AND NOT ARCTIC) AND OTHER AREAS WHICH PRODUCE MORE OZONE?

1. Antarctic is more cold than arctic: The Antarctic stratosphere is **much colder**. The low temperature enables the formation of PSCs, below 20 km.
 - Why Antarctic is colder than Arctic?



2. Stability of Vortex is longer here

- The vortex is a ring of rapidly circulating air that confines the ozone depletion in the Antarctic region.
- The longevity of the Antarctic vortex is another factor, enhancing favorable conditions for the depletion of ozone.
- The vortex in Antarctic remains, in fact, throughout the polar winter, well into midspring whereas the vortex in the Arctic disintegrate by the time of polar spring (March-April)

6) ENVIRONMENTAL IMPACT OF OZONE DEPLETION: IMPACT OF UV-B RADIATION ON LIVING AND NON-LIVING THINGS ON EARTH

- Decrease in the quantity of total-column ozone tend to cause increased penetration of solar UV-B radiation (290-315 nm) to the earth's surface. It has profound effect on human health, animal plants, microorganisms, material, and air quality.
 - i. **Effect on Human and Animal Health**
 - Eye disease, skin cancer and infectious morbidity
 - In susceptible (light skinned colored) population UV-B radiations is the key risk factor for development of non-melanoma skin cancer (NMSC).
 - ii. **Effects on terrestrial plants and Aquatic Ecosystem**
 - Physiological and developmental process are affected
 - iii. **Effects on biogeochemical cycles**
 - Alternates both source and sinks of greenhouse and chemically important trace gases
 - iv. **Effects on air quality**
 - **Higher photo dissociation rates of key trace gases** that controls the chemical reactivity of the troposphere.
 - Increase both production and destruction of ozone (O_3) and related oxidants such as hydrogen peroxide (H_2O_2), which are known to have adverse effect on human health, terrestrial plants, and outdoor materials.

- Can lead to increased production of particulates such as cloud condensation nuclei.
- v. **Effects on Materials**
- Synthetically occurring polymers and naturally occurring bio-polymers as well as other materials are adversely affected by solar UV radiation.
 - It increases photodegradation of these materials, limiting their life outdoors.

7) VARIOUS INITIATIVES TO CONTAIN OZONE DEPLETION

A) VIENNA CONVENTION

- **Background:** Signed in 1985 and came into force in 1988
- **Convention**
 - The objective of the convention was for countries to promote cooperation by means of systematic observations, research and information exchange on the effects of human activities on the ozone layer and to adopt legislative and administrative measures.
 - Did not contain legally binding controls and targets.
 - However, it set an important precedent. For the first time, nations agreed in principle to tackle a global environmental problem before its effects were felt or conclusively proven by science.
 - In 2009, the Vienna Convention became the first convention of any kind to achieve universal ratification.

B) MONTREAL PROTOCOL

- Once the scientific observation confirmed the ozone hole, governments recognized the need for stronger measures to reduce production and consumption of several CFCs and halons.
- Thus the Montreal protocol was signed in Sep 1987. It is an international treaty designed to protect the ozone layer through reduction of production and consumption of ODS. It came into force in 1989.
- **Key features**
 1. It required all parties to eliminate the production and import of nearly 100 substances that deplete the ozone layer, in accordance with agreed timelines.
 2. Special provisions for developing countries -> grace period of 10-15 years.
 3. Multilateral funds - a financial mechanism to help qualifying developing countries to phase out their consumption of ozone depleting substances.
 4. It required parties to report annually on production, import and export of ODSS.
 5. Precludes parties from trading ozone-depleting substances with non-parties.
 6. Requires regular assessments to enable parties to make informed decisions with the most up to date information.
- **Chemicals covered**
 - The Montreal protocol controls nearly 100 chemicals, grouped in the following categories:
 - CFCs
 - Halons
 - Carbon tetrachloride (CTC)
 - HCFC
 - Methyl Chloroform
 - Methyl Bromide

- It has been ratified by 197 parties making it first and only universally ratified protocol in UN history.
- **Impact of Montreal Protocol**
 - It has also been a highly successful international arrangement, as it has phased-out more than 98% of the ODS which was part of its main mandate by 2021. The remaining ODS are HCFCs which are in the process of being phased out.
- **What has India done under the Montreal Protocol**
 - India has already phased out CFCs, and CTC.
 - In Jan 2020, India also achieved complete phaseout of Hydrochlorofluorocarbon (HCFC)-141 b, which is a chemical used by foam manufacturing enterprise and is one of the most potent ODS after CFCs.
 - It is mainly used as a blowing agent in the production of rigid polyurethane (PU) foams.
 - Currently India is engaged in the phase-out of production and consumption of other Hydrochlorofluorocarbons (HCFCs) with an accelerated phase out schedule as per the Montreal Protocol.
 - India's current plan will result in 60 percent phase out of HCFCs by Jan 1, 2023.

C) KIGALI AMENDMENT TO MONTREAL PROTOCOL

- **About Kigali Agreement to Montreal Protocol.**
 - During the 28th Meeting of Parties (MoP) of the Montreal Protocol in 2016, Kigali Agreement was finalized.
 - Kigali agreement refers to an amendment to the 1989 Montreal Protocol to eliminate planet-warming HFC gases.
 - » It calls for phasing-out of HFCs, a set of 19 gases in Hydrofluorocarbon family that are used extensively in air-conditioning and refrigerant industry.
 - These gases are not ozone depleting but are thousands of times more dangerous than carbon dioxide in causing global warming.
 - Currently, they may have a small contribution in global warming, but with increase in the use of Air-Conditioning and Refrigeration, its contribution will be huge. Some estimates show that if the growth in the use of HFCs continue at the current rate, their contribution to global warming may reach 19% by 2050.
 - » **Why put the target in Montreal Protocol and not UNFCCC?**
 - Montreal Protocol is much more successful than the UNFCCC and have fairly good track record in controlling various kinds of emissions.
 - **Legally binding commitments**
 - » Rich and industrialized countries bring down their HFC production and consumption by at least 85 percent by 2036 compared to their annual average values in the period 2011-13 starting from 2019.
 - » A group of developing countries (more than 100) including China, Brazil and South Africa are mandated to reduce their HFC use by 80 percent of their average value in 2020-22 by the year 2045 starting from 2024.

- » India and some other developing countries - Iran, Iraq, Pakistan, and some oil economies like Saudi Arabia and Kuwait - will cut down their HFCs by 85 percent of their values in 2024-26 by the year 2047 starting from 2028.

- **The Parties to the amendment agreed to provide financing for HFCs reduction**
- **Significance:**
 - Fight Climate Change; CBDR to ensure developmental needs of countries like India; Target approach to better monitor progress
- **India's decision to ratify the Kigali Amendment (Aug 2021)**
 - Union Cabinet has decided to ratify the Kigali agreement. It comes close on the heels of similar decisions by the USA, and China - the world's largest producers and consumers of HFCs.
 - India has also announced that it will draw up a national strategy for phase-down of HFCs by the year 2023 in "consultation with all industry stakeholders". India will also amend the existing domestic laws that govern the implementation of the Montreal Protocol by the middle of 2024 to facilitate the HFC phase-down.
 - **Note-1:** India's reductions have to begin only after 2028
 - **Note-2:** By July 2021, **122 countries have ratified** the Kigali Agreement.