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Part-2

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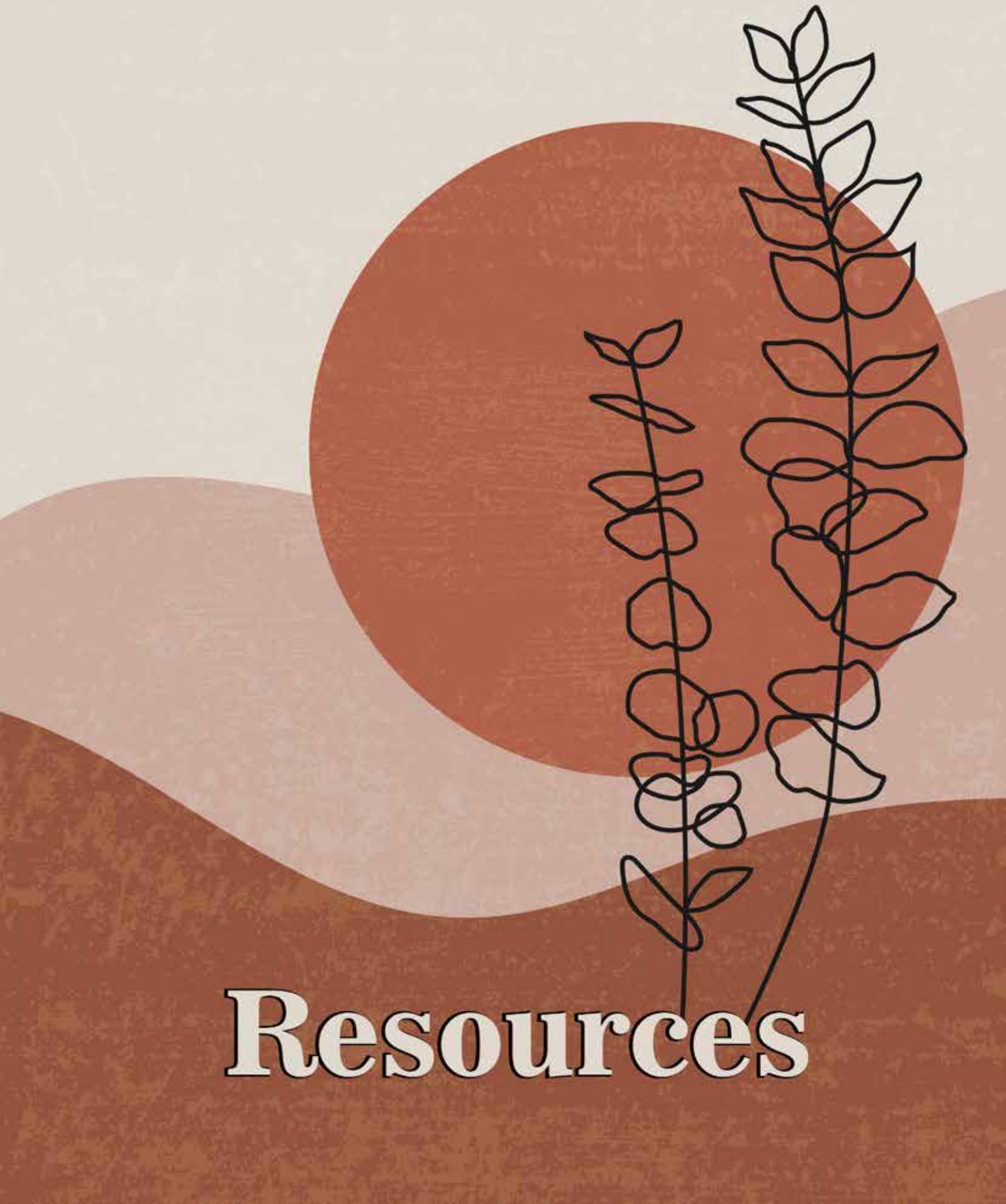


Resources

UNIT - 3

CHAPTER - 11 - LAND AND ITS DEGRADATION

11. Land and its Degradation

11.1. Introduction

11.1.1. Land

The Special Report on Climate Change and Land (SRCCL) by UN's Intergovernmental Panel on Climate Change's (IPCC) defines land as 'the terrestrial portion of the biosphere that comprises the natural resources (soil, near surface air, vegetation and other biota, and water), the ecological processes, topography, and human settlements and infrastructure that operate within that system'.

11.2. Land Degradation

11.2.1. Definition

Land degradation is defined as a **negative trend in land condition**, caused by **direct or indirect human-induced processes** including anthropogenic climate change, expressed as **long-term reduction or loss** of at least one of the following: biological productivity, ecological integrity, or value to humans.

The **resulting damage**, in terms of lost ecosystem goods and services, costs the world an estimated US$6.3 trillion a year equivalent to **8.3 percent of global GDP** in 2016 and jeopardizes the livelihoods of half a billion people who depend on forests and land resources.

As per Food and Agriculture Organisation (2011):

- Almost **one-quarter of the world's land area has been degraded** over the past 50 years because of soil erosion, salinization, peatland and wetland drainage, and forest degradation.
- More than **one-quarter of agricultural lands** are classified **as severely degraded.**

11.2.2. Types of land degradation on the basis of its severity

Land is degraded when it suffers a loss of intrinsic qualities, decline in its capabilities or loss in its productive capacity. On the basis of productive capacity of the land:

- **Slight degradation** refers to the condition where crop yield potential is reduced by 10%
- **Moderate degradation** refers to 10-50% reduction in yield potential
- **Severe degradation** the yield potential is lost more than 50% of its potential yield capacity (productive capacity).

Land degradation may be due to natural causes or human causes or it may be due to combination of both. It affects the entire natural environment, resulting in losses of ecosystem services that have far reaching effects on human welfare and the global economy. It also has a close connection with other major global issues, particularly climate change and biodiversity.

> **Desertification** is land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities leading to loss of productive ecosystem and biodiversity.

11.2.3. Processes of Land Degradation

- **Vegetation degradation:** It is observed mainly as deforestation / forest-blanks / shifting cultivation and degradation in grazing / grassland as well as in scrubland. Vegetation is an important factor in the protection of soil and soil fertility. Destruction of vegetation, most often by human activities accelerates soil degradation leading to desertification.

Student Notes:

- When soil loses vegetation cover, it becomes more susceptible to wind and water erosion.
- Removal of top soil by water or wind erosion results in **loss of organic material** leading to decrease in soil aggregation and stability, and hence soil fertility.
- The **water-holding capacity and the nutrient content of the soil are reduced** when organic material is lost, which is an additional strain on vegetation survival.

- **Water erosion:** Water Erosion is loss of soil cover mainly due to rainfall and surface runoff water.
  - The **sheet erosion** (mostly within agricultural lands) and **rills** are categorised in slight category
    - ✓ the narrow and shallow gullies are categorized as moderate erosion,
    - ✓ while the deep / wide gullies and ravines are classified as severe erosion.
  - In the context of desertification or land degradation, water erosion does not refer the river erosion.
- **Wind erosion:** Wind can erode the soil very selectively and intensively in three transporting method, namely Suspension, Saltation and Soil creep.
  - Soil is more vulnerable for wind erosion in conditions such as very sparse or no vegetative cover, increasing wind speed, loose, dry, fine or very light soil, smooth soil surface, large exposed area etc.
  - Wind erosion removes the topsoil, which is rich in all plant nutrients and bacterial activities. Removal of topsoil reduces the capacity of the soil to function and restricts its ability to sustain future uses.
  - Moreover, windblown dust or sand is deposited in cultivated land and buries the lands, thus reducing the production.
- **Water logging:** The severity of water logging is determined based on the period of time the water remains stagnant.
  - Several situations can be responsible for the rise in water table like Flood, salt-rich hard pans, excess irrigation, wrong drainage planning etc.
  - Waterlogging may lead to salinization also.
- **Salinity/Alkalinity:** Salinity or Alkalinity is fundamentally the chemical property of the soils. It occurs mostly in cultivated lands, especially in the irrigated areas.
  - Soil salinity refers to the water dissolvable salt present in soil. Salinity can develop naturally, or human-induced. The main causes are **excess evapotranspiration, drought, excess irrigation, increase in toxicity, and rise in ground water table**.
  - Salinity in dry lands occurs when the water table is between 2 to 3 meters from the soil surface. The salts from the groundwater are raised by capillary action to the surface of the soil. Over time, water evaporates, and the salt remains on the surface.
  - **Saline intrusion** i.e. the incursion of sea water into coastal soils occurs due to over-abstraction of groundwater.
  - Salinity in irrigated land can occur due to over irrigation and excess use of fertilizers and other chemicals.
- **Mass Movement:** The spontaneous downward movement of soil and rock under the influence of gravity (but without the dynamic action of moving fluids) is included under the general term Mass Movement.
  - The mass movement processes include all forms of down slope movement of soils, overburden, or bedrock under the direct influence of gravity.
  - Mass movement represents the spontaneous yielding of earth materials when gravitational force exceeds the internal strength of the material.
- **Frost Heaving:** Frost heaving is the process of ice lens formation beneath the soil surface during freezing conditions in the atmosphere. The ice grows in the direction of heat loss (vertically toward the surface), starting at the freezing front or boundary in the soil.

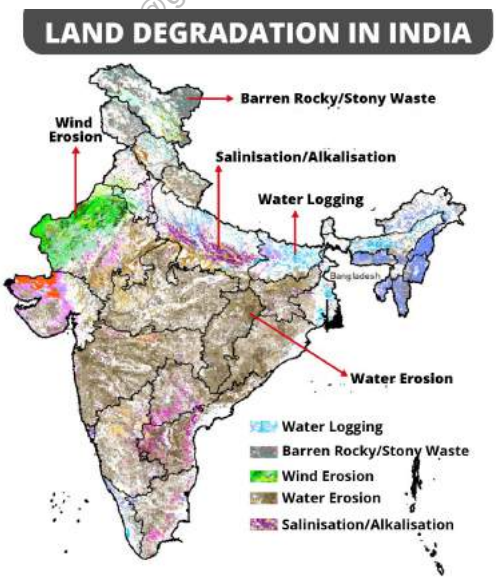
Student Notes:

- The growing ice is restrained by overlying soil, which applies a load that limits its vertical growth and promotes the formation of a lens-shaped area of ice within the soil.

- **Frost shattering:** Frost shattering is the essentially a process of mechanical weathering or breakdown of rocks due to regular fluctuation in temperature, around 0 degree Celsius, in joints or cracks in rocks.
- **Acidification:** Soil pH decline in agricultural systems can be attributed to the use of intensive farming practices such as continuous cropping, long term cultivation and the introduction of long-term annual pastures, which usually contain a legume. It has been found that acid inputs into the soil arising from the biological carbon and nitrogen cycles are the most significant in pastoral and crop systems
- **Land-use changes and unsustainable land management:**
  - **Agriculture** is the most significant driver of deforestation. Increasing demand for food and other agriproducts have put tremendous pressure on native forests in emerging and developing countries, causing deforestation and degradation.
  - Deforestation and land clearing are also taking place to cope up with urbanization and infrastructure development.
  - **Unsustainable timber harvesting and hunting pressures** are eroding the last remaining intact forests.
  - **Improper solid waste management** including ever increasing landfill sites and indiscriminate dumping contaminates surface and ground water supplies and further degrades land.
- **Other anthropogenic factors:**
  - **Industrial effluents:** A large number of industries discharge their metal containing effluents into fresh water without adequate treatment. Contaminated water when used for irrigation purpose affects soil quality and crop health of the agricultural system.
  - **Mining and quarrying:** Mining practices may result into erosion, formation of sinkholes and loss of biodiversity along with contamination of soil, groundwater and surface water by the chemicals emitted from mining processes.
  - **Brick Kilns:** Brick fields are mostly situated on river line fertile agricultural land, as it needs clayish, silty, and loamy soil with good texture. Removal of the fertile topsoil for brick making leaves the land infertile.

11.3. Land Degradation and India

- State of India's Environment 2019 shows that **30% of India's total geographical area** is being affected by land degradation.
- **82% of these degraded land lies in just nine states**: Rajasthan, Maharashtra, Gujarat, Jammu & Kashmir, Karnataka, Jharkhand, Odisha, Madhya Pradesh and Telangana.
- It shows **1.87 million hectares of land** in the country faced process of desertification between 2003-13 period.



11.3.1. Why should India be concerned about land degradation?

- India supports **18% of world population with only 2.4% of world's land area.**

- Though forests are one of the most important solutions to climate change, India has lost 1.6 million hectare of forest cover between 2000. It also has to fulfil its pledge to get 33% of its geographical area under forest cover by 2022.
- Up to 60% of land in India is under cultivation **contributing 14% to its GDP.** Therefore, it would be one of the most vulnerable countries to be affected by increasing extreme weather events caused by global warming.

Student Notes:

11.4. Impact of land degradation

Impacts on	Response on/through		Results in
1. Ecosystem services	Provisioning services	Ex.- Conversion of forestland into farmland	Increased food availability however reduced biodiversity and ground carbon storage
	Regulation services	Ex.- Water regulation services impact	Flooding, drought
	Cultural services	Local knowledge system, recreation, tourism	Directly impacted
	Supporting services	Ex.- Deforestation and expansion of extensive agriculture	Degradation of natural habitat.
2. Climate	Carbon sink		Higher carbon release in atmosphere
	Release of non-CO2 GHGs		Through increased rice cultivation, ruminant stocks and manure disposal results in higher release of CH4, N2O, and NH3 gases.
	Albedo change		Increased grazing, deforestation and forest fires results in albedo change impacting global radiative balance, net climate cooling/ warming.
3. Food Security and Poverty	Agricultural productivity		Annual productivity decline undermines sustainable development, food and water insecurity, involuntary human migration, even civil conflict.
	GDP		Negative and quite strong impact, however difficult to quantify.
4. Gender and Education	Increased timing requirement for Food production, Fuel wood collection, soil and water conservation		Missing schools, higher dropout rate, reduced child care time, reduced time for other work and for leisure activities.
5. Human Health	Indirect impact		Through climate change, biodiversity loss, agricultural productivity, etc.
	Direct impact		Chronic bronchitis and respiratory illness.

11.5. Methods of land reclamation and conservation

Forest and landscape restoration are not only about recovering the ecological functionalities of degraded terrestrial ecosystems. It is also about changing land-management practices in ways that sustain local economic growth. These efforts can be classified as active or passive.

- **Active restoration** includes reforestation, silvopastoral practices, forest conservation, agroforestry, and soil conservation practices
- **Passive restoration** requires the land to be set aside to recover naturally for a period of time, making it a difficult approach when the land is critical to local livelihoods.

Often, active restoration approaches cost more than passive restoration practices, and the cost of preventing land degradation is much lower than the cost of rehabilitating already severely degraded lands or physically replacing lost soil and nutrients. Following measures can be adopted for land reclamation and conservation:

LDN and Sustainable Development Goal

The 2030 Agenda for Sustainable Development, adopted by the United Nations in 2015, comprises 17 SDGs.

- **Goal 15** is of direct relevance to land degradation, with the objective to protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification and halt and reverse land degradation and halt biodiversity loss.
- **Target 15.3** specifically addresses LDN**.**

Other goals that are relevant for land degradation:

- Goal 2 (Zero hunger)
- Goal 3 (Good health and well-being)
- Goal 7 (Affordable and clean energy)
- Goal 11 (Sustainable cities and communities), and
- Goal 12 (Responsible production and consumption).

11.5.1. Sustainable Land Management (SLM)

SLM encompasses soil and water conservation measures, natural resources management and integrated landscape management, with the main goal to contribute to sustainable and rural development. SLM activities include:

- **Reforestation**: It refers to the re-establishment of forest through planting and/or deliberate seeding on land classified as forests.
- **Agroforestry:** It is a combination of both traditional and modern land-use systems, where trees are managed together with crops and/or animal production in agricultural settings
- **Assisted Natural Regeneration**: To accelerate natural successional processes by "removing or reducing barriers to natural forest regeneration such as soil degradation, competition with weedy species and recurring disturbances e.g. fire grazing and wood harvesting.
- **Terrace Cultivation**: In hills and mountains, crops are planted on graduated terraces built into the slope to minimise soil erosion and water loss.
- **Sand dune fixation**: It is a technique designed to prevent the movement of sand long enough to enable either planted or natural vegetation to establish itself.
- **Windbreaks:** They are based on linear planting of trees and shrubs to enhance crop production, control wind erosion, protect human and live stocks, and improve soil and water conservation.
- **Firebreaks:** It consists of gaps in vegetation that acts as barrier to slow down or stop the progress of wildfires.
- **The Zai technique**: It involves digging pits in the soil during pre-season to catch water and concentrate compost by adding manure to increase soil fertility. It is traditionally used in the Western Sahel to restore degraded drylands and to increase soil fertility.

11.5.2. Land Degradation Neutrality (LDN)

According to UNCCD, LDN is 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.

It can prevent Soil erosion, desertification, water scarcity, migration insecurity and income inequalities caused by land degradation. Thus, it helps in combating impacts of climate change.

India has adopted the goal of **achieving LDN by 2030** under Sustainable Development Goals.

11.5.2.1. Steps taken by India to achieve Land Degradation Neutrality

- **Comprehensive National Plan**- The National Action Plan (NAP) to combat desertification was launched in 2001 for 20 years. Its objectives are:
  - community based approach to development,
  - activities to improve the quality of life of the local communities,
  - awareness raising,
  - drought management preparedness and mitigation,
  - R&D initiatives and interventions which are locally suited,
  - Strengthening self-governance leading to empowerment of local communities.
- **Mapping of issue**- The ISRO and some other partners prepared the Desertification and Land Degradation Atlas (2016) of entire country using Indian remote sensing satellites data in GIS environment.
- **Mission Mode approach**- At the UNFCCC's CoP 2015 in Paris, India adopted a Bonn Challenge pledge to restore 13 million hectare of degraded land by 2020 and a further eight million hectare by 2030.
- **Sustainable land and Ecosystem Management (SLEM) Programme-** which is jointly implemented by Government of India and Global Environment Facility (GEF), aims to promote sustainable land and ecosystem management.
- **Initiatives launched**- Government has launched various schemes like Integrated Watershed Development Program, Per Drop More Crop, National Afforestation Program, National Green Mission, etc. which have components to tackle Land degradation.
- **Delhi Declaration**- India hosted the COP 14 to UNCCD in 2019 and adopted new targets.
  - India **raised its total area that would be restored from its land degradation** status, from 21 million hectares to 26 million hectares till 2030.
  - India has announced to set up a Centre of Excellence at the Forest Research Institute, Dehradun, for providing technical assistance to meet the challenges.

11.5.2.2. Government's broad approach towards addressing land degradation

- **Adoption of watershed approach**- planning based on micro-watersheds, use of remote sensing data and spatial data in planning at the micro-watershed level. E.g. Integrated Watershed Management Programme (IWMP)
- **Integrated treatment incorporating contouring, gully plugging, vegetative as well as engineering**-based solutions for soil moisture conservation, covering agricultural as well as non-agricultural lands. E.g. Fodder and Feed Development Scheme-its component of Grassland Development including Grass Reserves.

Student Notes:

- **Integrated farming-based approach-** e.g. National Afforestation Programme (NAP), National Mission for Green India (GIM), incorporating fodder and fuelwood supply, farm-forestry and agroforestry and silvi pastures (combination of trees, forage plants and livestock together as an integrated, intensively-managed system), stall feeding, improved chullahs etc.
- **Focus on water management**- aquifer recharge and water budgeting as well as crop planning. E.g. Command Area Development and Water Management (CADWM) programme, Soil Conservation in the Catchment of River Valley Project National Watershed Development Project for Rainfed Areas (NWDPRA).
- **Focus on social aspects**- e.g. Constitution of Watershed Committee under the Gram Sabha, Water User Association development, Social Audit under MGNREGA, Joint Forest Management (JFM) and Social Fencing by involving local communities.
- **Incorporation of livelihood related activities**- Development of micro-enterprises, involvement of Self-Help Groups (SHGs), programmes such as Mahila Kisan Sashaktikaran Pariyojana (MKSP) focusing on increasing capabilities women farmers with a view to increasing sustainability.
- **Adoption of climate-adaptation related solutions**- both with regard to floods and intense precipitation as well as temperature and moisture stress.
- **Increasing the role of Panchayati Raj Institutions (PRIs)-** and ensuring "convergence" between Government programmes and programmes executed by PRIs.
- **Schemes addressing desertification:**

Scheme	Under Ministry	Objectives
DROUGHT PRONE AREAS PROGRAMME (DPAP)	Ministry of Rural Development	to minimise the adverse effects of drought on production of crops and livestock and productivity of land, water and human resources ultimately leading to drought proofing of the affected areas.
DESERT DEVELOPMENT PROGRAMME (DDP)	Ministry of Rural Development	to minimise the adverse effect of drought and control desertification through rejuvenation of natural resource base of the identified desert areas.
National Watershed Development Project for Rainfed Areas (NWDPRA)	Ministry of Agriculture	to strengthen people's participation in project planning, implementation and monitoring by generating awareness programme on the programme measures of the scheme so as to transform watershed management as people's movement with tapering departmental support

11.6. Global Policy responses to land degradation

- The first international effort on tackling land degradation was the Stockholm UN Conference on Human Environment in 1972.
- **Rio Summit:** The 1992 United Nations Conference on Environment and Development (UNCED), also known as the Rio de Janeiro Earth Summit, recognized land degradation as a major challenge to sustainable development, and led to the establishment of the UNCCD, UNFCCC and CBD.
- **United Nation Convention to Combat Desertification:** Established in 1994, it is the ONLY legally binding international agreement linking environment and development to sustainable land management.
    - The new UNCCD 2018-2030 Strategic Framework is the most comprehensive global commitment to achieve Land Degradation Neutrality (LDN).
    - The **COP 14 of UNCCD** held in Delhi, 2019 concluded around four points:
        - ✓ **first,** that land restoration is the cheapest solution to slow climate change;
        - ✓ **second,** regulations and incentives rewarding investment in land restoration are economically sensible;
        - ✓ **third,** as climate change exacerbates dry land areas, drought preparedness and management need to become a priority;

Student Notes:

- ✓ **and last,** ensuring that there is a gender balance, youth are engaged and land rights are protected should be priorities. India also agreed to recover 26 million hectares of degraded land.

United Nations Convention to Combat Desertification (UNCCD)

- The Convention addresses specifically the arid, semi-arid and dry sub-humid areas, known as the drylands.
- **India became a signatory** to UNCCD on October 14, 1994, and ratified it on December 17, 1996.
- **10-Year Strategy of the UNCCD (2008-2018):** It was adopted in 2007 to forge a global partnership to reverse and prevent desertification/land degradation and to mitigate the effects of drought in affected areas in order to support poverty reduction and environmental sustainability.
- The UNCCD is particularly committed to a **bottom-up approach**, encouraging the participation of local people in combating desertification and land degradation.
- **UNGA declared 2010 to 2020 the United Nations Decade for Deserts and the Fight Against Desertification**

- **Reducing emissions from deforestation and forest degradation (REDD+):** It is a mechanism developed by Parties to the UNFCCC. It creates a financial value for the carbon stored in forests by offering incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable development. REDD+ goes beyond simply deforestation and forest degradation and includes the **role of conservation, sustainable management of forests and enhancement of forest carbon stocks**.
  - **The aim of REDD+ is to encourage developing countries to contribute to climate change mitigation efforts by:**
    - ✓ **Reducing greenhouse gas emissions** (GHG) by slowing, halting and reversing forest loss and degradation
    - ✓ **Increasing removal of GHGs** from the earth's atmosphere through the conservation, management and expansion of forests.

Forest Carbon Partnership Facility

- It is a global partnership of governments, businesses, civil society, and indigenous people's organizations
- It focuses on reducing emissions from deforestation and forest degradation, forest carbon stock conservation, the sustainable management of forests, and the enhancement of forest carbon stocks in developing countries, activities commonly referred to as REDD+.
- The FCPF supports REDD+ efforts through two separate but complementary funds.
  - **The FCPF Readiness Fund** helps countries set up the building blocks to implement REDD+.
  - **The FCPF Carbon Fund** pilots results-based payments to countries that have advanced through REDD+ readiness and implementation and have achieved verifiable emission reductions in their forest and broader land-use sectors.

- **The Johannesburg World Summit on Sustainable Development (WSSD)** in 2002 was another milestone, reaffirming the political support of the international community for the UNCCD and designating Global Environment Facility as the funding agency for the its implementation.
- **Creation of an LDN fund** to invest in bankable projects on land rehabilitation and sustainable land management worldwide including sustainable agriculture, sustainable livestock management, agroforestry, etc.
- UNCCD releases **the Global Land Outlook** which demonstrates the central importance of land quality to human wellbeing, assesses current trends in land conversion, degradation and loss, identifies the driving factors and analyzes the impacts etc.
- **The Land for Life Programme** was launched at UNCCD Conference of the Parties (COP) 10 in 2011 to confront the challenges of land degradation and desertification.
- **The Bonn Challenge**: It is an international afforestation commitment under a global effort to bring 150 million hectares of world's deforested and degraded land into restoration by 2020 and 350 million hectares by 2030.

Student Notes:

- **Aichi Targets**: While land management and restoration are the primary focus of the UNCCD, they are also essential to the CBD, for instance through the Aichi Targets no. 5 (reduce habitat loss and degradation), no. 7 (sustainable farming and forestry) and no. 14 (ecosystem restoration).
- In 2019, the UN General Assembly declared the **UN Decade on Ecosystem Restoration** 2021-2030 (which is co-led by FAO and UNEP), which is expected to shine additional spotlight on land restoration and mobilise financial resources.

11.7. Way Forward

To reduce land degradation, the increasing pressures on land resources should also be reduced. In this context**, Global Land outlook by UNCCD** outlines certain pathways that producers, consumers, governments and corporations can follow to stabilize and reduce pressure on land resources:

- **Multifunctional landscape approach:** Prioritizing and balancing different stakeholder needs at a landscape scale while identifying those land uses in Land-use planning that best meet the demands of people towards safeguarding biodiversity.
- **Farming for multiple benefits**: The agricultural practices should be shifted in a way to support a wider array of social, environmental, and economic benefits and optimize the most desirable suite of ecosystem services from food production activities.
- **Managing the rural-urban interface:** Cities designed for sustainability in the wider landscape can reduce environmental costs of transport, food, water, and energy, and offer new opportunities for resource efficiency.
- **Creating an enabling environment** to scale local successes into large-scale through stakeholder engagement, land tenure, gender equality, and the availability of sustained investment and infrastructure.
- **No net loss of healthy and productive land** by providing incentives for the sustainable consumption and production of natural resources. E.g. incentivizing reduction in the current levels of food waste and loss. Roughly one third of the food produced in the world gets lost or wasted accounting for 4.4 billion tons of annual greenhouse gas emissions.

Reversal of land degradation is important for countries for not just economic gains but also for the achievement of SDGs and Paris agreement goals. Therefore, other than the conservation of degraded lands in rangeland, mining areas, wetlands etc., there is a need to recognize the key role of Land managers, including indigenous people and local communities in the design, implementation and evaluation of sustainable land management practices. Also, perverse incentives that promote degradation, e.g. subsidies that reward overproduction must go away.

11.8. UPSC Previous Year Questions

Mains

1. Causes of soil erosion and its control in India (2005)
2. Examine the cause and the extent of 'desertification' in India and suggest remedial measures. (2012)

Prelims

1. Consider the following pairs: (2014)
Programme/Project Ministry
1 Drought-Prone Area Programme: Ministry of Agriculture
2. Desert Development Programme: Ministry of Environment and Forests
3. National Watershed Development Project for Rainfed Areas: Ministry of Rural Development
Which of the above pairs is/are correctly matched?
(a) 1 and 2 only (b) 3 only (c) 1, 2 and 3 (d) None

Solution: (D)

Student Notes:

2. What can be the impact of excessive/inappropriate use of nitrogenous fertilizers in agriculture? (2015)
1. Proliferation of nitrogen fixing microorganisms in soil can occur.
2. Increase in the acidity of soil can take place.
3. Leaching of nitrate to the ground water can occur.

Select the correct answer using the codes given below.
(a) 1 and 3 only (b) 2 only (c) 2 and 3 only (d) 1, 2 and 3

Solution: (C)

3. With reference to 'Forest Carbon Partnership Facility', which of the following statements is/ are correct? (2015)
1. It is a global partnership of governments, businesses, civil society and indigenous peoples.
2. It provides financial aid to universities, individual scientists and institutions involved in scientific forestry research to develop eco-friendly and climate adaptation technologies for sustainable forest management.
3. It assists the countries in their 'REDD+ (Reducing Emissions from Deforestation and Forest Degradation+)' efforts by providing them with financial and technical assistance.

Select the correct answer using the code given below.
(a) 1 only (b) 2 and 3 only (c) 1 and 3 only (d) 1, 2 and 3

Solution: (C)

4. Which of the following statements is/are correct?(2016)
Proper design and effective implementation of UN-REDD+ Programme can significantly contribute to
1. protection of biodiversity
2. resilience of forest ecosystems
3. poverty reduction

Select the correct answer using the code given below.
(a) 1 and 2 only (b) 3 only (c) 2 and 3 only (d)1, 2 and 3

Solution: (D)

5. Which of the following is/are the advantage /advantages of practising drip irrigation? (2016)
1. Reduction in weed
2. Reduction in soil salinity
3. Reduction in soil erosion

Select the correct answer using the code given below.
(a) 1 and 2 only
(b) 3 only
(c) 1 and 3 only
(d) None of the above is an advantage of practising drip irrigation

Solution: (C)

6. What is/are the importance/importances of the 'United Nations Convention to Combat Desertification'? (2016)
1. It aims to promote effective action through innovative national programmes and supportive inter-national partnerships.
2. It has a special/particular focus on South Asia and North Africa regions, and its Secretariat facilitates the allocation of major portion of financial resources to these regions.

3. It is committed to bottom-up approach, encouraging the participation of local people in combating the desertification.

Select the correct answer using the code given below.

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

Solution: (C)

7. With reference to agricultural soils, consider the following statements (2018)

1. A high content of organic matter in soil drastically reduces its water holding capacity.
2. Soil does not play any role in the sulphur cycle.
3. Irrigation over a period of time can contribute to the salinization of some agricultural lands.

Which of the statements given above is/are correct?

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

Solution: (B)

11.9. Vision IAS Previous Years Questions

1. Mentioning the regions which are effected, analyse the reasons for salinization of arable land in India. Also enumerate measures that should be adopted to reduce salinization and control soil degradation.

Approach:

- First mention the region in India which are affected by salinization.
- Explain the reasons for the salinization of arable land in India.
- Suggest measures to reduce salinization and control soil degradation.

Answer:

Salt affected soils occur across the length and breadth of India covering 16 States/Union Territories in about 6.74mha area. The maximum salt affected soils are in Gujarat (2.22 m ha) followed by Uttar Pradesh (1.37 m ha).

Over 1.25 million ha of soils in the coastal tract of India are afflicted with the problems of salinity.

There are 4 major tracts in India where salinity problem is acute:

1. The arid tract of Rajasthan and Gujarat,
2. Semi-arid alluvial tracts of Punjab, Haryana and Uttar Pradesh,
3. The arid and semi-arid tracts of Southern States, and
4. The coastal alluvium.

Causes of soil salinity in India

- High rainfall and impeded drainage contribute to the serious problems of deep-water submergence and water logging.
- In the arid and semi-arid regions, salts rise due to capillary action of evaporating groundwater, leading to salinity.
- The problems of excess amounts of salts and high water tables are more serious in the irrigated semi-arid and arid regions and these problems have most often been attributed to large-scale introduction of irrigation into areas which were hitherto unirrigated and faulty on-farm water management such as inadequate drainage measures.
- The use of marginal quality groundwater resources without appropriate soil, crop and irrigation management strategies poses considerable risks, in terms of the development of salinity, sodicity, ion-specific toxicity, and nutrient imbalances in soils.

Student Notes:

- Cheap provision of electricity and lack of policies prescribing a cost on irrigation water has further deteriorated the situation.
- Coastal regions are vulnerable due to sea water infiltrations during storm surges/Tsunamis. Intrusion of sea water in aquifers due to intense pumping of ground water along coastal areas is another threat.
- The state of Haryana faces the problem of water table rise in more than 2.8 million ha out of its 3.8 million ha arable land mainly in the central and north-western part of the state. The area under the influence of water table rise is largely in brackish and saline groundwater.
- In addition to the salts contributed by groundwater, canal water supply of about 1.05mha adds to the existing salinity problem through seepage.

The problem is likely to assume serious dimensions in future with the anticipated rise in sea level of 1 m due to global warming. Such a scenario will have serious consequences as the coastal saline area might increase several folds.

Measures to control soil salinity

- Disposal of saline drainage effluent is a major constraint in areas with poor quality groundwater and without any natural outlet. In semi-arid and arid areas, artificial drainage and subsurface drainage is an effective measure.
- Reuse of drainage effluent for irrigation is the most appropriate option for increasing crop productivity and also to maintain leaching of salts in the root zone.
- Modification of cropping patterns to suit the agro-climatic conditions (sustainable and climate smart agriculture) is the long term solution to address salinity.
- Gypsum can help in reclaiming sodic soils.

2. The socio-economic and ecological consequences of soil degradation are far-reaching. Discuss. Suggest measures that can be taken to restore soil fertility and arrest soil degradation.

Approach:

- Briefly explain soil degradation.
- Elaborate on the socio-economic and ecological consequences of soil degradation.
- Suggest measures to restore soil fertility and arrest soil degradation.

Answer:

Soil degradation is defined as a change in the soil health status resulting in a diminished capacity of the ecosystem to provide goods and services for its beneficiaries. It includes loss of organic matter, decline in soil fertility/structural condition, erosion, adverse changes in salinity, acidity or alkalinity, and the effects of toxic chemicals, pollutants, excessive flooding/overgrazing/mining.

Soils are a fundamental natural resource, and are the basis for all terrestrial life. Soils provide a range of functions upon which humans depend, such as food production, water regulation, a physical basis for construction etc.

Socio-economic consequences of soil degradation include:

- Loss of Productivity and arable land: It leads to reduced income for the farmers which have implication for the economy as a whole, threat to food security, higher production costs; it also hampers poverty reduction especially when agriculture is the dominant occupation.
- Infrastructure damage: Degraded pastures may lead to floods and landslides thus imposing significant costs to land, property and human life, cost of treating siltation of reservoirs etc.

Student Notes:

- Rise in natural disasters: such as mud flows, floods, droughts and aridity.
- Increased land reclamation costs: cost of afforestation, de-salinization etc.
- Rise in inequalities: Reduced income in the absence of other alternatives to livelihood aggravate inequalities for families completely dependent on soil.

Ecological consequences:

Soil provides various ecological services like nutrient cycling, carbon storage and habitat for living organisms. Soil degradation threatens these services and has other undesirable consequences like:

- Sedimentation and eutrophication of waterways and reservoirs: leading to water pollution.
- Soil compaction and surface sealing: It will affect the percolation capacity of soil, thus, affecting recharge of groundwater
- Soil contamination (including effects of toxic chemicals and pollutants) – This affects nutrients in food crops.
- Loss of biodiversity: soil degradation may involve perturbation of microbial communities, disappearance of the climax vegetation and decrease in animal habitat.

Measures that can be taken to restore soil fertility and arrest soil degradation are:

- Afforestation: it restores the carbon cycle, binds the soil and prevents soil erosion while facilitating soil formation.
- Tackling salinization: by improving irrigation efficiency, using gypsum to reduce salinization.
- Improved Agricultural practices: Conservation tillage (makes minimal changes to the soil's natural condition), strip farming, crop rotation, contour farming, rational use of fertilizers and pesticides, moving towards organic farming; preventing slash and burn agriculture, promoting soil testing to ascertain the nutrient requirement of the farm , agro-ecological farming etc.
- Improved data management and coordination between various stakeholders.
- Land use planning for agriculture, settlement and industry.

Soil degradation threatens world food security and various ecological services especially in the face of growing population and global climate change and needs to be tackled in earnest.

3. Identify the regions being impacted by desertification in India. Bringing out the major reasons for it, analyse the effectiveness of steps taken to combat it.

Approach:

- Write a basic definition of desertification in introduction.
- Then try to bring out areas/regions being impacted by it in India.
- Then elaborate some of the major reasons for increasing desertification in India.
- Finally give the steps take so far in combating it and analyse the effectiveness of those steps.

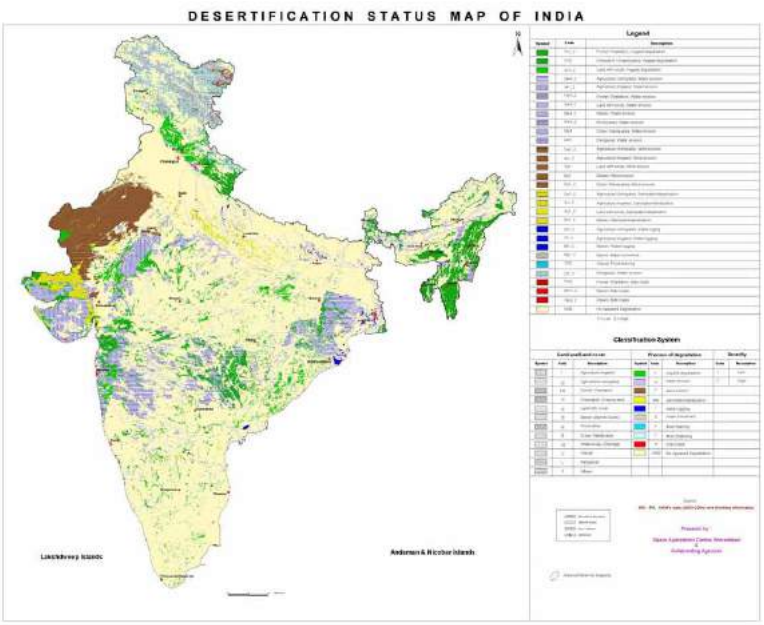
Answer:

Desertification is land degradation in arid, semi-arid, and dry sub-humid areas resulting from various factors, including climatic variations and human activities.

In India, a rough estimate by environmental reports tells that nearly 30% area i.e. 96.4 MHA out of 328.72 MHA is degraded or facing desertification. In eight states, Rajasthan, Delhi, Goa, Maharashtra, Jharkhand, Nagaland, Tripura and Himachal Pradesh- around

Student Notes:

40% to 70% of land has undergone desertification.
Twenty-six out of Twenty- nine states have reported an increase in the area undergoing desertification in the past 10 years.



Desertification occurs due to both anthropogenic and natural factors which can be summarized as the following**:**

- **Soil erosion due to land and water**: It is responsible for around 16% of desertification in India. Even mining leads to erosion of soil nutrients.
- **Vegetation destruction by deforestation and overgrazing** to accommodate the need of growing population, accelerates desertification.
- **Farming Practices**: Agricultural activities in the vulnerable ecosystems along with excess use of water, fertilizers and pesticides leads to erosion of nutrients, increase in salinity resulting into desertification.
- **Urbanization and land development projects**: These put huge pressure on land which is expected to grow further in future.
- **Climate Change**: As the days get warmer and periods of drought become more frequent, desertification becomes more and more eminent.

India being a signatory to UNCCD has taken many steps to combat desertification such as: National Action Programme to Combat Desertification, Integrated Watershed Management Programme, National Afforestation Programme, Fodder and Feed Development Scheme etc.

However, the gradual increment of desertification shows that steps taken by the government have not been very effective. This can be attributed to reasons such as shortage and weakness of institutional and human capacity, lack of dedicated funds, need of coordination among concerned ministries, disproportionate attention to planning than implementation etc.

Thus, government intervention needs to be streamlined with equal focus on both curative and preventive measures, which needs to be then periodically reviewed to check the impact on desertification.

4. What do you understand by the term Land Degradation Neutrality? Highlight its significance and the steps required to achieve it.

Approach:

- In the introduction, define Land Degradation Neutrality (LDN).
- Elaborate its principles.
- Point out the significance of LDN.
- Mention the steps needed to achieve it.

Answer:

Student Notes:

According to United Nations Convention to Combat Desertification (UNCCD), **Land Degradation Neutrality** (**LDN**) is a state whereby the amount and quality of land resources, necessary to support ecosystem services and enhance food security, remains stable or increases within specified temporal and spatial scales. The concept of LDN has already been adopted as part of the 2030 Agenda for Sustainable Development and is enshrined in SDGs highlighting its global nature.

Principles for LDN:

LDN represents a **paradigm shift in land management policies and practices**. It is a unique approach that counterbalances the expected loss of productive land with the recovery of degraded areas.

Significance of Land Degradation Neutrality

- **Saving economic costs**: The economic costs of Desertification, Land Degradation and Drought (DLDD) globally are estimated at USD 490 billion per year. For India, it costs about 2.54% of its GDP i.e. $47 billion in 2014-15.
- **Mitigation and adaptation to climate change**: Halting and reversing land degradation can transform land from being a source of greenhouse gas emissions to a carbon sink.
- **Strengthening the resilience of rural communities:** 40% of the world's degraded lands are found in areas with the highest incidence of poverty, which remains overwhelmingly rural. LDN would enhance their resilience by improving the provision of vital ecosystem services by preventing soil erosion, desertification, loss of biodiversity etc.
- **Meeting increased demands**: By 2030, the demand for food, energy, and water is expected to increase by at least 50%, 45% and 30% respectively. These needs will not be met sustainably unless we conserve and restore the productivity of our land.

Steps required for achieving it

- **Multifunctional landscape approach:** Taking into account different stakeholders, in land-use planning must be done at landscape level that best meet the demands of people towards safeguarding biodiversity.
- **Farming for multiple benefits**: The agricultural practices should be shifted in a ecologically sustainable way to support a wider array of social, environmental, and economic benefits.
- **Managing the rural-urban interface**: Designing sustainable cities keeping in mind the peripheral regions can reduce environmental costs of transport, food, water, and energy.
- **No net loss of healthy and productive land:** This can be done by providing incentives for the sustainable consumption and production of natural resources. For e.g., incentivizing reduction in the current levels of food wastage.

Student Notes:

- **Creating an enabling environment:** Local successes should be scaled into large-scale ones through stakeholder engagement, land tenure system, and the availability of sustained investment and infrastructure.
- **Creating an evidence base**: It would help in tracking the LDN goal progress, monitoring unwanted externalities and assessing the impact of actions during restoration.

For achieving Land Degradation Neutrality, programmes at international level (Land for Life Programme by UNCCD) and national level (Rashtriya Krishi Vikas Yojana, Pradhan Mantri Krishi Sinchayee Yojana etc.) need to be integrated for mitigating the concerns over desertification, land degradation and drought problems from a long-term perspective.

Student Notes:

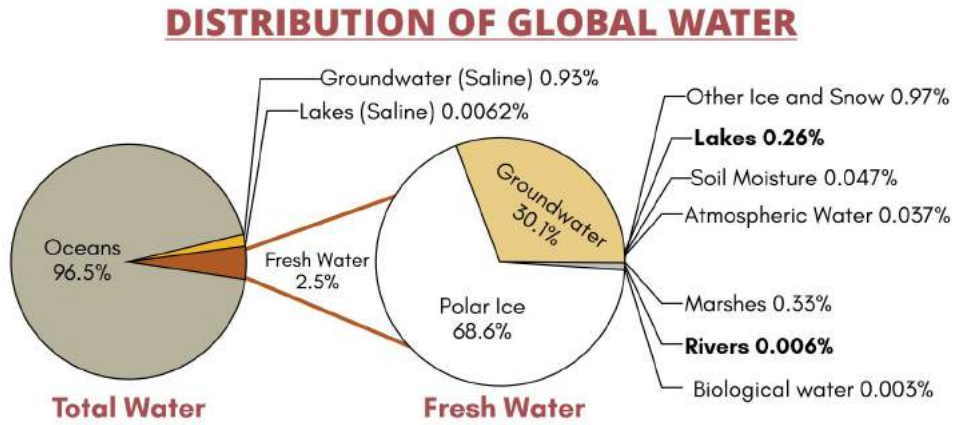
CHAPTER - 12 - WATER AND ITS CONSERVATION

12. Water and its Conservation

12.1. Global Distribution of Water

Water **covers 71% of earth's surface**. 96.5% of earth's total water is salt water and is found in the oceans. Only 3.5% of earth's water is available as Fresh Water. Out of which, over 68% is locked up in ice and glaciers, 30% of freshwater is in the ground and only about 2% is in lakes, rivers, streams, and clouds, etc.

Though water is a renewable resource, but fresh water is finite. Fresh water is a scarce resource in many parts of the world including India. It is under increasing pressure as a result of pollution of water sources and increasing demand of the growing population. Worldwide consumption of water has increased sixfold. This is more than twice the rate of population growth.



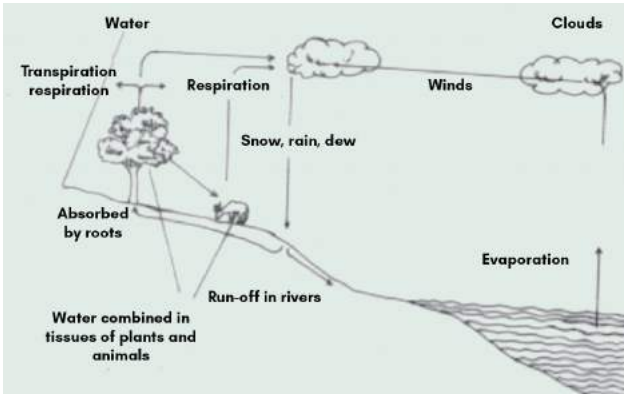
12.2. Global Circulation of water/Hydrological Cycle:

The three main processes involved in the hydrological cycles are –

- evaporation and evapotranspiration
- precipitation and
- surface runoff.

12.2.1. Evaporation and evapotranspiration:

- Evaporation is the **phase change of liquid water into vapour or gas on heating.** The oceans, seas and other water bodies like lakes, rivers and streams provide **about 90% moisture** to the atmosphere through evaporation each day. This heat is provided by the sun.



- **About 10%** of the water in the atmosphere comes from **transpiration i.e. a process through which plants loose large quantities of water through their leaves**.
- Some portion of water vapour enters the atmosphere through **sublimation**, a process by which water changes from solid state that is ice, directly into vapour without changing into liquid form.

These three processes together provide all the water to the atmosphere and are called evapotranspiration.

12.2.2. Precipitation

After water enters the lower atmosphere, it is carried upwards by the rising air currents. High up in the atmosphere the air cools and loses its capacity to hold water vapour. As a result, the excess water condenses i.e. changes from vapour to liquid and forms cloud droplets. The droplets ultimately grow in size and cause precipitation. These are four major types of precipitation namely drizzle, rain, snow and hail. Thus, most of the water is returned to the oceans and on land in the form of rain, snow, hail etc.

12.2.3. Surface runoff:

When precipitation falls over land, it travels through various routes. Some of it evaporates back into the atmosphere; some of it enters the ground and is stored as ground water. The rest of the water moves as surface runoff into streams and rivers and ultimately flows into the ocean or other water bodies from where it enters the cycle again.

Ground water is found in two layers of the soil:

- **Zone of aeration** where the gaps are filled with water air as well as water.
- **Zone of saturation** where the gaps are completely filled with water.

Boundary between these two zones is known as the **water table**, which rises or falls as the level of ground water increases or decreases. This water is discharged either directly or indirectly into the rivers and seas by way of springs.

As water continually evaporates, condenses and precipitates, the rate of evaporation and rate of precipitation at a global level is equal and the total amount of water vapour in the atmosphere is approximately the same over time. But evaporation over the continents is less than precipitation while the converse is true over the oceans.

12.3. Why conservation of water is required?

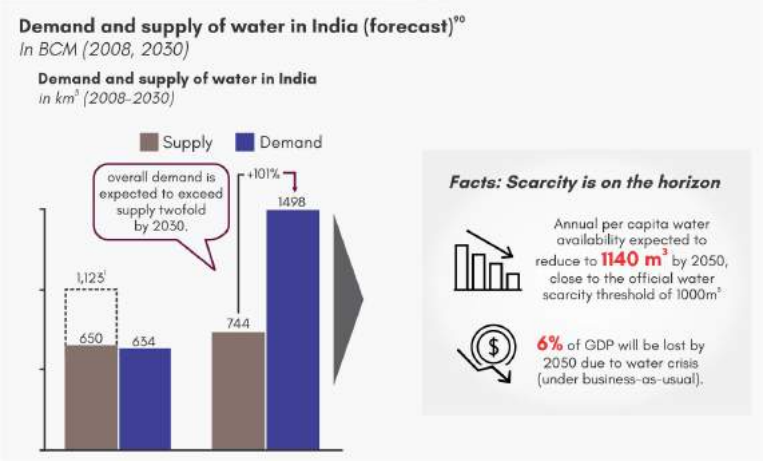
- **Limited availability of Fresh Water:** Almost all (97%) of Earth's water is undrinkable salt water that is unsuitable for drinking and most other human uses. Much of the remaining 3% is frozen in glaciers (slow moving mass of ice) and ice in the North and South Poles.
- **Uneven distribution:** Fresh water is distributed unevenly on Earth's surface. Some regions have abundant freshwater resources and others are arid (dry) deserts where water is scarce.
- **Water depletion:** Though water is a renewable resource in a general sense, local and even regional water supplies can run dry from overuse. The risk of water depletion has heightened multiple times due to climate change and global warming.
- **Pollution:** The world's freshwater resources are getting increasingly polluted with organic waste, pathogens, fertilizers and pesticides, heavy metals, and emerging pollutants.
- **Water demand:** Global water use has increased by a factor of six over the past 100 years and continues to grow steadily at a rate of about 1% per year with increasing population, economic development and shifting consumption patterns.
    - The Organisation for Economic Co-operation and Development (OECD) projected that water demand would increase by 55% globally between 2000 and 2050.
    - The world could face a 40% global water deficit by 2030 under a business-as-usual scenario.
- **Impact of Climate Change on Water**
    - **Water availability and stress:** Changes in precipitation and temperature will directly affect the terrestrial water budget. Evaporation from the land surface (except from driest region) is expected to increase because of rising air temperatures. The combined impact of changes in precipitation and evaporation will also determine future trends in soil moisture and groundwater, with potential consequences for the frequency and severity

of soil moisture drought spells. There will also be global reduction in snow and ice cover which in long run will decrease the baseflow of streams. Such changes are likely to exacerbate the water stress.

- **Water Demand:** The combined effects of growing populations, rising incomes, changing consumption patterns and expanding cities will see demand for water rise significantly. Global warming will further exacerbate this trend, as water demand tends to increase with temperature.
- **Water infrastructure:** Because of dwindling water supply due to global warming, the scale of investment will have to be significantly increased for not only construction of new infrastructure but also for the maintenance and operations of the existing stock, in order to improve their efficiency and reduce water losses.

12.4. Status of water in India:

- **Increasing demand**: India is home to nearly **17% of world's population** but has only **4% of the world's freshwater resources**. Further, the best estimates indicate that India's water demand will exceed supply by a factor of two by 2030. Estimates suggest ~INR 20,00,000 crores in investments are required to bridge the expected water supply gap by 2030.



- **Lack of access to clean water**: About 82% of rural households in India do not have **individual piped water supply** and 163 million live **without access to clean water** in their vicinity.
- **Per capita water availability:** Indians are water-stressed people. In 1951, per capita water availability was 5,177 cubic meters. In 2011 Census figures, this came down to 1,545 cubic metres -- a decline of about 70 per cent in 60 years.
- **Pollution**: 70% of India's surface water is contaminated.
- **Low average per capita water availability**: Approx. 820 million people of India living in twelve river basins across the country have per capita water availability close to or lower than 1000 cubic metre, which is the official **threshold for water scarcity**. India as a whole is categorized as water stressed nation and per capita availability is expected to reduce further to 1341 m^3 by 2025 and 1140 m^3 by 2050 close to the official water scarcity threshold.
- **Dependency upon ground water**: The **annual utilizable water resources** in the country are 690 BCM from surface sources and 447 BCM from groundwater. In spite of possessing surface water resources, India is highly dependent on groundwater resources for day to day survival.
  - India uses the **largest amount of groundwater** but is also the **third largest exporter of groundwater.**
  - About 60% of the irrigation needs, 85% of rural drinking water needs and 50% of urban needs are met through groundwater.
- **Day Zero situation**: The day when a city's taps dry out and people have to stand in line to collect a daily quota of water. Cities like Chennai, Shimla, Udupi and Mangaluru are on the verge of becoming cities which would have a 'Day Zero' situation soon like Cape Town in South Africa
- **Paradoxical situation of flood and droughts**: On the one hand, the low-lying areas are getting **submerged** due to rise in ocean water and on the other hand, **drought**s are becoming a common phenomenon in highly populated regions. In India, during 1996-2015, nearly 19

million and 17.5 million people annually were simultaneously affected by floods and droughts, respectively.

Student Notes:

12.5. Water scarcity in India and related implications:

12.5.1. Social and Political Risks

Depleting access to clean water impacts food security and health, and can cause social unrest and political instability. Key risks under this category include food security and the carrying capacity of urban centres.

12.5.1.1. Risk to food security

- About 74% of the area under wheat cultivation and 65% of the area under rice cultivation faces significant levels of water scarcity.
- Groundwater resources, which account for 62% of irrigation water are declining in 52% of the cases and highlight a serious water concern for the agriculture sector.
    - **Key reasons for this decline** include a lack of well-considered water pricing for agricultural use, energy subsidies that promote over-extraction, and sub-optimal matching of crops with the agro-climatic and water zones in states.
    - Further, our international trade in agricultural commodities is contributing to large quantities of virtual water loss through the export of water-intensive crops. India ranks as the **third-largest exporter of groundwater** through virtual water trade i.e. through agricultural exports.
        - ✓ India exported more than 10 trillion litres of embedded or virtual water through the export of ~37 lakh tonnes Basmati rice in 2014-15, alone, which could have been used to grow much larger quantities of other crops such as wheat or millet that have far less water requirements.
    - Increasing consumer preferences for high-value crops and dairy and meat products, which require significantly higher amounts of water for production, will only further exacerbate the country's food security challenges.
    - Climate change will also contribute to these challenges as increasing temperature levels, floods, and droughts create unfavourable environmental conditions for cultivation and impact crop productivity

Inefficient CROPPING PATTERN in India that leads to water crises:

- According to an **ICRIER study**, 230 **water guzzling crops like sugarcane and paddy** are grown in states like Maharashtra, Uttar Pradesh (UP) and Punjab, using up lakhs of litres of irrigation water per hectare.
- **Maharashtra** grows 22% of the total sugarcane output in the country and **nearly 100% of the sugarcane crop is grown through irrigated water** here, while parts of the state are already facing severe water crisis.
- Punjab, the third largest producer of rice in India, grows paddy using nearly 100% irrigation cover, of which 80% comes from ground water source. As a result, while Punjab tops the table in land productivity, it uses more than three times the water than Bihar and more than twice the amount of water than West Bengal, to produce one kg of rice.

Suggestions: India needs to manage its international export of virtual water and also ensure that crop production patterns within the country, across different states, are aligned to regional water availability.

- MSPs and Subsidies on a water intensive crop must take in to account the declining water table in the region.
- There should be increased emphasis on adoption of water efficient technologies, management systems, farmer education, and advisory services etc., for enabling improvement in water resource management.
- India should also consider developing an **agricultural water export Index** to track virtual water.
- India should invest in scaling up micro-irrigation to increase coverage and sustainability.

12.5.1.2. Risk of exceeding the carrying capacity of urban centers

- India's urban population is expected to reach 600 million by 2030. Estimates suggest that the demand-supply gap for the domestic sector will stand at ~50 BCM in 2030, with the **demand expected to double by that time.**
- As of 2014, no major city in India supplied 24x7 water to its entire urban population and only 35% of urban households in India have piped water in their dwelling as the primary source to support drinking water needs.

Data related issues which impact policy formulation:

- **Limited coverage:** Detailed data is not available for several critical sectors such as domestic and industrial water use, for which data is only available at the aggregate level and lacks the level of detail required to make informed policy decisions and allocations.
- **Unreliable data:** The data that is available is often of inferior quality, inconsistent, and unreliable due to the use of outdated methodologies in data collection. For example, estimates on groundwater are mostly based on observation data from 15,640 wells, while there are 30 million groundwater structures in the country.
- **Limited coordination and sharing:** Data in the water sector exists in silos, with very little horizontal and vertical data sharing across the value chain of water (from source to consumption to wastewater utilization), thereby reducing efficiencies.

- Also, migration to major urban cities continues, and additional stress is put on the already insufficient water resources and inadequate infrastructure.
- As of 2015, India treated only 30% of the wastewater generated in the country. Lack of adequate infrastructure in cities to handle their own wastewater will add to the problem, and improper solid waste management may even lead to contamination of remaining groundwater resources.

Suggestions: State and city governments should consider water resource availability in the region while creating city plans and providing permits for new establishments, and restrict any development activities that are not sustainable in terms of water management. For example: The American Planning Association (APA) has introduced water related policy guidelines in its charter to promote sustainable development in cities and treats water as a critical and essential element in infrastructure planning.

12.5.2. Economic Risks

As the water crisis worsens, production capacity utilization and new investments in capacity may both decline, threatening the livelihoods of millions, and commodity prices could rise steeply for consumers due to production shortages. Such circumstances can lead to economic instability and disrupt growth. Key risks that lie ahead in India's case have been presented below:

12.5.2.1. Risk to sustainable industrial activity:

- Industrial activity accounts for ~30% of GDP contribution. Estimates suggest that **industrial water requirement will quadruple between 2005 and 2030.**
- It is possible that this shortage will drive up the cost of water and lead to a disproportionate impact on the Small-to-Medium Enterprise (SME) and Micro, Small and Medium Enterprise (MSME) segment.
- Worst affected industries are likely to include water-intensive sectors such as food & beverages, textiles, and paper and paper products. Amongst these, the textiles industry alone contributes 4% towards India's GDP and accounts for 17% of the country's foreign exchange earnings.
- 39% of the portfolio of Indian banks is exposed to sectors that face high levels of operational water risk, including agriculture and allied activities (13.3%), power (6.8%), and basic metal and metal products (4.8%). Water scarcity would lead to rise in NPAs.

Suggestions: Industrial water quotas, tradable permits (can be developed, where water entitlements and allocations are provided to industrial units annually, and they can freely trade

their water quotas to maximize outputs and income by optimizing water use.), and **water availability linked licenses** (. Industrial water use can be optimized by giving permits that put caps on water consumption by each user) can help in optimizing water usage in scarce regions and minimize the water supply deficit. For example: The **water market system in Australia's Murray-Darling Basin** (It allows buying and selling of water entitlements and allocations amongst different users based on their own preferences and creates incentives for water to be moved to higher-value uses). ESG (Environmental, social and Governmental) compliance checks by banks can also act as effective tools to encourage sustainable use and effective water management amongst the companies that seek external funding for operations.

Student Notes:

12.5.2.2. Risk of energy shortages

- 70% of India's thermal power plants are likely to face high water stress by 2030, severely hampering India's energy production and economic activity.
- Thermal power constitutes more than 80% of India's total utility power generation and 90% of them rely on fresh water sources for cooling. Thus, decline in Fresh water resources will threaten the sector as well as create power shortages.

Suggestion:

- Shifting to alternatives such as solar and wind energy can reduce reliance on thermal power plants and create additional energy sources that are not heavily reliant on water for production.
- The establishment of new thermal power plants should be away from water-scarce regions.
- In addition to this, there is also a need to improve the water-use efficiency amongst the existing thermal plants, which can be supported through adoption of modern technologies by these producers.
- Example: Desalination plants which can create additional sources of water for human use and the floating Solar PV systems which can reduce the natural rate of evaporation and support conservation of water.

12.5.3. Environmental Risks

12.5.3.1. Risk of biodiversity destruction

The rich biodiversity of India faces a serious threat from human activities undertaken in pursuit of creating additional water sources. Red flags have already been raised over the cumulative impact of climate change, increasing temperatures, and human engineering of hydrological flows through dam construction and river diversion.

- Building dams on rivers slows down the water flow, leading to sedimentation and reduction in nutrients carried by the rivers whereas linking rivers can change salinity levels and monsoon patterns. Such changes in water composition and environmental factors can seriously harm the local flora and fauna that thrive on these water resources.

Suggestion: Undertaking smaller projects in more locations rather than a large project being executed in a single geographical region. The cumulative environmental footprint of such smaller projects might be lower compared to a large project. Example: The **US-Mexico Colorado river agreement** (where through collaborative action by the two nations the Colorado river's natural flow has been revived within five years of the agreement, and the river reached its natural destination for the first time after 16 years. Conservation groups in the region have also undertaken large-scale tree plantation activities to reestablish habitats and support resuscitation of bird populations and wildlife in the region).

12.5.3.2. Risk of desertification

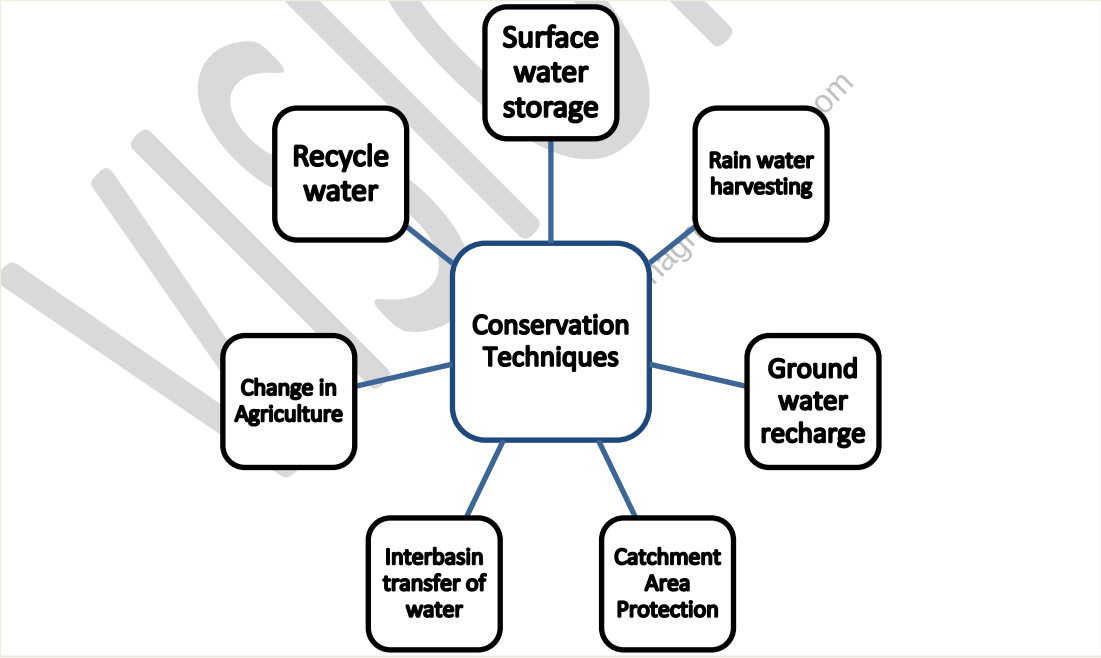
- Water management and desertification have a two-way relationship. Extensive groundwater extraction contributes to loss of vegetation cover, which eventually leads to desertification.

Increasing desertification and land degradation diminish green cover, which reduces the land's capacity to recharge groundwater and regional water tables.

- Water erosion, which is a loss of soil cover due to rainfall and surface run-off, is responsible for ~11% of desertification making it the biggest cause of desertification in India.
- There are also perverse incentives that promote complacency on desertification and degradation close to urban areas—degraded land is easier to acquire for infrastructure and construction projects than fertile agricultural land.
- The cost of land degradation has been estimated at ~2% of India's 2014-15 GDP. Land degradation can also cause up to 4% losses in Agricultural GDP in the future for India which could drive food prices up.

Suggestion: Increasing green cover can help widen the reach of these conservators of the local ecosystem and curb desertification. Example: China's 'Great Green Wall' initiative has reduced sandstorm by 20% and desertification by nearly 5000 miles.

12.6. Different methods of water conservation:



12.6.1. Catchment Area Protection or Watershed Management:

Watershed is an area that contributes water to a stream or a water body through run-off or underground path. It is the region from which surface water draws into a river, a lake, wet land or other body of water is called its watershed or drainage basin. Its productivity is improved through:

- Development of **small water harvesting structures** such as low-cost farm ponds, nalla bunds, check-dams, percolation tanks and other ground water recharge measures. For example: The **Ralegan Siddhi project** where the rural people under the guidance and leadership of good, enlightened and honest persons constructed a series of 31 check dams and nala bunds which has created about 282,000 cubic metre water storage capacity that has resulted in increased availability of ground water.
- **Renovation** and augmentation of water sources, desolation of village tanks for drinking water/irrigation/fisheries development etc.
- **Afforestation** including block plantations, agro-forestry and horticultural development, shelterbelt plantations, sand dune stabilization etc.
- **Pasture development** either by itself or in conjunction with plantations.
- Land development including **in-situ soil and moisture conservation measures** like contour and graded bunds fortified by plantation, bench terracing in hilly terrain, nursery rising for fodder, timber, fuel wood, horticulture and non-timber forest product species.
- **Drainage line treatment** with a combination of vegetative and engineering structures.
- **Repair, restoration and up-gradation** of existing common property assets and structures in the watershed to obtain optimum & sustained benefits from previous public investments.
- Crop demonstrations **for popularizing new crops/varieties** or innovative management practices.
- Promotion and propagation of **non-conventional energy/ saving devices**, energy/ conservation measures, and bio fuel plantations etc.

In India, **PM Krishi Sinchai Yojana** and World Bank assisted **Neeranchal Watershed Program** is designed for Catchment Area Protection.

12.6.2. Methods and techniques for ground water recharge

Water has been harvested in India since antiquity. The evidences from Dholavira show that water was harvested even during Harappa period. In ancient Tamil Nadu as well, rain water harvesting was done by the Chola Kings. The rain water harvested from the Brihadeswara temple was collected in Shivaganga tank. Traditional rainwater harvesting is still prevalent in rural areas in the form of surface storage bodies like lakes, ponds, irrigation and temple tanks, etc. Some other famous techniques used for:

Urban Areas	Rural Areas
Roof Top Rain Water / run off harvesting through • Recharge Pit • Recharge Trench • Tube well • Recharge Well	Rain Water Harvesting through • Gully Plug • Contour Bund • Gabion Structure • Percolation tank • Check Dam/ Cement Plug/ Nala Bund • Recharge shaft • Dug well Recharge • Ground Water Dams/Subsurface Dyke

Traditional Water Conservation System	State	Type
Jhalaras	Jodhpur(Rajasthan)	Stepwell
Talab bandhi	Bundelkhand (UP), Udaipur (Raj.)	Lake
Bawaris	Rajasthan	Stepwell
Taanka	Thar desert region of Rajasthan.	cylindrical paved underground pit
Ahar Pynes	South Bihar	Ahars are reservoirs with embankments on three sides that are

		built at the end of diversion channels like pynes. Pynes are artificial rivulets
Johad	Called madakas in Karnataka and pemghara in Odisha	Small earthen check dam
Panam Keni	Wayanad (Kerela)	Special type of well
Khadins	Jaisalmer (Rajasthan)	Embankment
Kund	western Rajasthan and Gujarat	Saucer-shaped catchment area
Baoli	Rajasthan, Delhi, Gujarat	Stepwell
Bhandara Phad	Maharashtra	Check dam
Buldhana Pattern	Buldhana district , Maharashtra	Storage type
Tamswada pattern	Nagpur and Wardha , Maharashtra	Storage type
Zings	Ladakh	Small tanks
Kuhls	Himachal Pradesh	Channels
Zabo	Nagaland	Channels
Jackwells	Shompen tribe of the Great Nicobar Islands	Wells
The Ramtek model	Maharashtra	Tanks
The Pat system	Jhabua district of Madhya Pradesh	Channels
The Eri system	Tamil Nadu	Tanks

12.7. International Policy Frameworks

12.7.1. Water Convention

The convention on the Protection and use of **Transboundary Watercourses and International Lakes**, 1996 (**serviced by the United Nations Economic Commission for Europe**) is a unique international legal instrument and intergovernmental platform which aims to ensure the sustainable use of transboundary water resources by facilitating cooperation. Initially negotiated as a regional instrument, it has been opened up for accession to all UN Member States in 2016. India is not a party to the convention.

12.7.2. Sustainable Development Goal 30 and Water

Given water's role in mitigating and adapting to climate change, water can also play a connecting role both across the **SDGs** and across policy frameworks such as the **Paris Agreement**.

12.7.3. Paris Agreement and Water

- Although water **is not mentioned** in the Paris Agreement per se, it is an essential component of nearly all the mitigation and adaptation strategies – from carbon storage in terrestrial ecosystems, to emerging clean energy technologies, to adapting to extreme weather events.

- Water is identified as the **number one priority** for most of the INDC's adaptation actions and is directly or indirectly related to other priority areas as well e.g. disaster risk reduction because most identified hazards are also water-related (flood, drought, desertification, etc.).

12.7.4. Sendai Framework for Disaster Risk Reduction 2015–2030 and Water

While water is seldom mentioned in the Sendai Framework itself, water flows through each of the priorities for action and is central to all seven targets.

- Floods and storms account for nearly 90% of the most severe natural disasters.
- Water-related hazards are particularly sensitive to even small shifts in climate, so that the frequency, magnitude and intensity of these hazards are shifting over time.
- Recognition of the clear linkages between water, climate change and disaster predate the Sendai Framework. Since 2007, the UN High-level Experts and Leaders Panel on Water and Disasters (HELP) has been working to raise awareness about the connections between water and disasters and strives to bridge the gaps between their respective policy communities.

Sendai framework (2015-2030)

- Non-binding framework adopted by UN in 2015.
- It comprises of 7 standard global targets and four priorities for action designed to achieve "the substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries".
- Earlier strategies aimed at disaster relief. This framework shifts its focus to preparedness and prevention of disasters.

River water rules

- **Riparian nations:** Nations across which, or along which, a river flow. **The upper-riparian nations** initially base their claims on ***absolute territorial sovereignty,*** typically claiming the right to do whatever they choose with the water regardless of its effect on other riparian nations. **Downstream nations**, on the other hand, generally begin with a claim to the ***absolute integrity of the river,*** claiming that upper-riparian nations can do nothing that affects the quantity or quality of water that flows in the watercourse. Therefore, an agreement or settlement is required.

Rule of equitable utilisation:

- **Under Article 5 of the United Nations Convention on the Non-Navigational Uses of International Watercourses (UN Convention), all watercourse nations shall participate in the use, development, and protection of an international watercourse in an equitable and reasonable manner. The right to participate includes both the right to utilize the watercourse and the duty to cooperate in its protection and development.**
- **No-Harm Rule:** Under Article 7 of the UN Convention, watercourse nations, in utilizing an international watercourse must take all "appropriate measures" to prevent the causing of significant harm to other watercourse nations. If significant harm nevertheless is caused to another watercourse nation, the nation whose use causes such harm must, in the absence of agreement for the use, take all appropriate measures to eliminate or mitigate the harm and provide adequate compensation if required.

12.8. India's policy framework

- **Institutional Governance:** Creation of a **new Ministry of Jal Shakti** for dealing with all matters relating to water at one place in an integrated manner to enable better decision-making for surface water projects and allocation.
- **Groundwater Bill:** The drafting and discussion of a **model Groundwater Bill in 2017** that defines groundwater as being held **"in trust"** by the government and specifies a decentralized structure for its governance.
- **Pradhan Mantri Krishi Sinchai Yojana (PMKSY):** The major activities taken up under this flagship scheme is:
  - Adoption of micro-irrigation techniques (to enable efficient on-farm water use by farmers)

Student Notes:

- Its watershed development component i.e. WDC-PMKSY include ridge area treatment, drainage line afforestation, soil and moisture conservation, rain water harvesting, horticulture, and pasture development etc.

- **Mission Water Conservation:** The Ministry of Rural Development, Ministry of Water resources and Ministry of Agriculture has developed an actionable framework for Natural Resources Management (NRM), titled "Mission Water Conservation" to ensure gainful utilization of funds. The Framework strives to ensure synergies in MGNREGA, PMKSY, WDC-PMKSY and Command Area Development & Water Management (CAD&WM), given their common objectives. Types of common works undertaken are water conservation and management, water harvesting, soil and moisture conservation, groundwater recharge, flood protection, land development, Command Area Development & Watershed Management
- **Establishment of Composite Water Management Index:** This establishes a national platform in the public domain which provides information on key water indicators across states. It helps in monitoring performance, improving transparency, and encouraging competition, thereby boosting the country's water achievements by fostering the spirit of "competitive and cooperative federalism" amongst states.
  - The Index comprises nine themes (each having an attached weight), covering groundwater and surface water restoration, major and medium irrigation, watershed development, participatory irrigation management, on-farm water use, rural and urban water supply, and policy and governance. The themes and their respective weights are displayed below :
  - For the CWMI, the reporting states were divided into three special groups—non-Himalayan states, North-Eastern and Himalayan states, and Union Territories (UTs) to account for the different hydrological conditions across these groups.

CENTRAL GROUND WATER AUTHORITY

- Central Ground Water Authority has been constituted under **Section 3 (3) of the Environment (Protection) Act, 1986** to regulate and control development and management of ground water resources in the country.

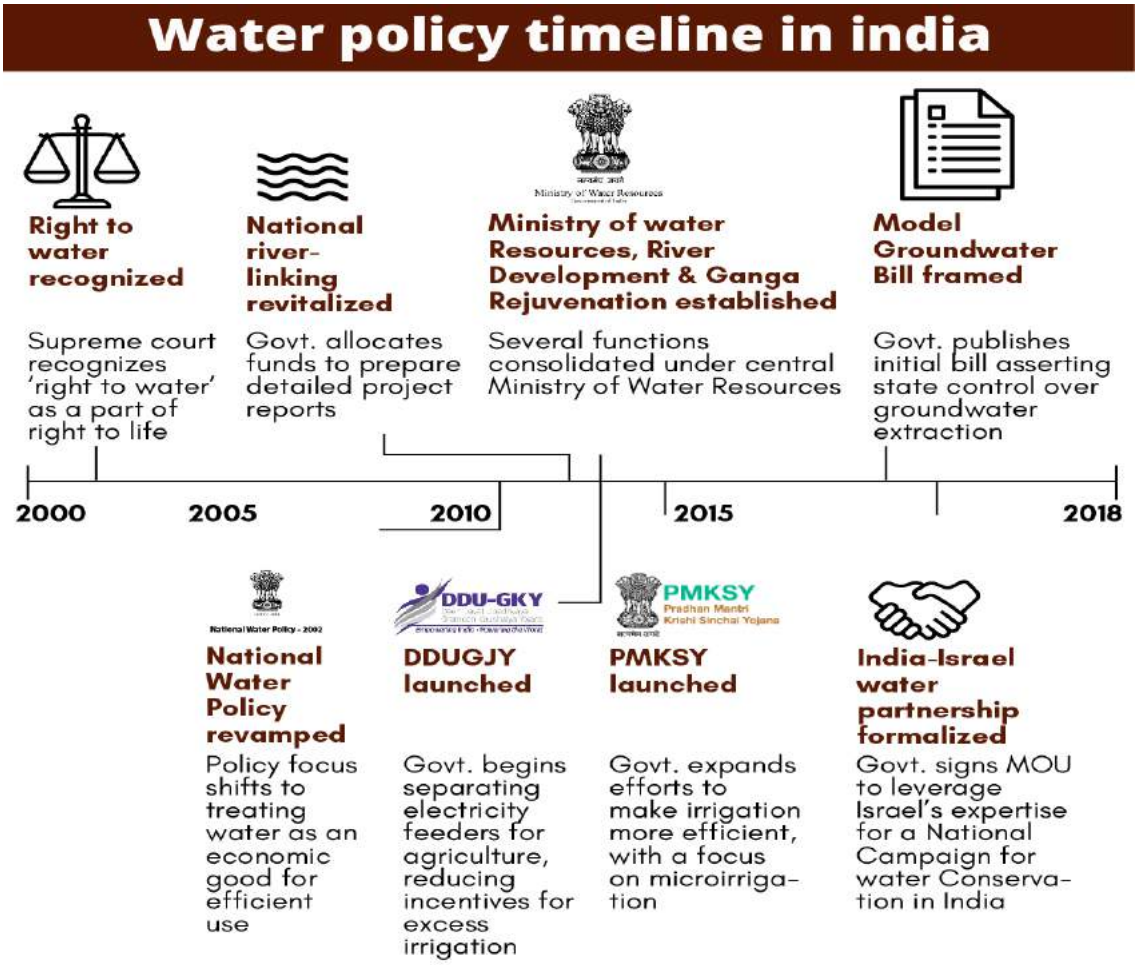
Powers & Functions:

- The Authority has been conferred with the following powers:
  (i) Exercise of powers under section 5 of the Environment (Protection) Act, 1986 for issuing directions and taking such measures in respect of all the matters referred to in sub-section(2) of section 3 of the said Act.
  (ii) To resort to penal provisions contained in sections 15 to 21 of the said Act.
  (iii) To regulate and control, management and development of ground water in the country and to issue necessary regulatory directions for the purpose.
  (iv) Exercise of powers under section 4 of the Environment (Protection) Act, 1986 for the appointment of officers.

No.	Themes	Weights
1	Source augmentation and restoration of waterbodies	5
2	Source augmentation (Groundwater)	15
3	Major and medium irrigation - Supply side management	15
4	Watershed development - Supply side management	10
5	Participatory irrigation practices - Demand side management	10
6	Sustainable on-farm water use practices - Demand side management	10
7	Rural drinking water	10
8	Urban water supply and sanitation	10
9	Policy and governance	15
	Total	**100**

Student Notes:

- **National Water Policy 2012:** The policy advocates rain water harvesting and conservation of water. It also suggests that conservation of river, river bodies and infrastructure should be undertaken in a scientifically planned manner through community participation. Further, encroachment and diversion of water bodies and drainage channels must not be allowed and wherever, it has taken place, it should be restored to the extent feasible and maintained properly.
    - In order to meet the present challenges in water sector, revision of National Water Policy 2012 has been envisaged by the Department of Water Resources, River Development and Ganga Rejuvenation, Ministry of Jal Shakti and a drafting committee has been constituted to revise the National Water Policy.
    - The new **National Water Policy 2020** will for the first time, focus on managing and conserving water resources in the country through Public Private Partnership mode and work on modalities to implement on-going programs.
    - The New Water Policy 2020 would be different from earlier policies as it would focus on 'water use efficiency' on the lines of 'energy use efficiency'.
- **Model Building Bye-Laws, 2016:** It recommends Rainwater Harvesting for all types of Building with plot size 100 m^2 or more.
- **Guidelines for ground water extraction:** The guidelines (effective from 1st June 2019) aim to ensure a more robust ground water regulatory mechanism in the country through system of **NOC** (No Objection Certificate) and user fee.
    - **For Industries**, the Concept of **Water Conservation Fee** (WCF), encouraging use **of recycled and treated sewage water**, provision of **action against polluting industries**, measures to be adopted to ensure **prevention of ground water contamination** in premises of polluting industries/ projects, mandatory requirement of **digital flow meters, piezometers and digital water level recorders** (with or without telemetry depending upon quantum of extraction), mandatory **roof top rain water harvesting** except for specified industries.
    - **For Drinking & Domestic use**, -request for NOC shall be considered only in cases where the water supply department / agency concerned is unable to supply adequate amount of water in the area.
    - **Flexibility to states**: States may suggest additional conditions/ criteria based on the local hydro geological situations which will be reviewed by CGWA before acceptance.
    - **Monitoring**: Monthly water level data shall be submitted to CGWA through the web portal.
    - **Exemption from requirement of NOC**: agricultural users, users employing non-energised means to extract water, individual households (using less than 1 inch diameter delivery pipe) and Armed Forces Establishments during operational deployment or during mobilization in forward locations
    - **Other exemptions (with certain requirements)** have been granted to strategic and operational infrastructure projects for Armed Forces, Defence and Paramilitary Forces Establishments and Government water supply agencies in safe and semi critical areas.
- **Atal Bhujal Yojana (Atal Jal), 2019:** It is a Central Sector Scheme started in 2019 for sustainable management of ground water resources with community participation in water stressed blocks of 7 states i.e. Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan and Uttar Pradesh.
- **Global Technology and Innovation Partnerships:** The formalization of a partnership with Israel, the world leader in water governance and conservation, to leverage Israeli experience and knowledge for water conservation in India.



12.8.1. Successful Models of Decentralized Water Management

Models	Aim	Approach
MUKHYA MANTRI JAL SWAVLAMBHAN ABHIYAN (MJSA), RAJASTHAN	Launched in 2016, it is a multi-stakeholder programme which aims to make villages self-sufficient in water through a participatory water management approach	technologies to identify water bodies for restoration, Gram Sabha responsible for budgeting of water resources, creation of Water conservation structures
NEERU-CHETTU PROGRAMME, ANDHRA PRADESH	To make Andhra Pradesh a drought-proof state and reduce economic inequalities	improving irrigation and focuses on ensuring water supply in drought-prone areas through adoption of scientific water management practices, Repair, renovation, and maintenance of irrigation assets
JALYUKT SHIVAR ABHIYAN, MAHARASHTRA	Launched in 2015-16 with the mission to make Maharashtra drought-free by 2019, and aims of making 5000 villages water scarcity free, every year.	Deepening and widening of streams, construction of cement and earthen stop dams, work on nullahs and digging of farm ponds. Geotagging of water bodies and use of a mobile application to enable web-based monitoring
MISSION KAKATIYA, TELANGANA	Launched in 2014, aims to restore over 46,000 tanks across the state and bring over 20 lakh acres land under cultivation	Development of minor irrigation structures, promoting community-based irrigation management, and restoration of tanks

SUJALAM SUFALAM YOJANA, GUJARAT	to increase water storage capacity by 11,000 lakh cubic feet through deepening of 13,000 lakes, check dams, and reservoirs which was achieved successfully by the state.	Deepening and desilting of water bodies
KAPIL DHARA YOJANA, MADHYA PRADESH	Unique scheme under the MGNREGA programme to develop irrigation facilities on private land of small and marginal farmers, through the construction of dug wells, farm ponds, check dams, etc.	Focuses on providing financial support to landholders without access to irrigation facilities and prioritizes marginalized communities to maximize impact
PANI BACHAO PAISE KAMAO, PUNJAB	break the water-energy nexus, under which farmers are being provided with a fixed electricity quota and receiving INR 4 per kilowatt hour for every unit of electricity saved through direct benefit transfers (DBTs)	Through electricity quota
JAKHNI VILLAGE, BUNDELKHAND, UTTAR PRADESH	Aims to make the village water self-sufficient	Construction of farm ponds, restoration/rejuvenation/restoration of water bodies, collection and utilization of grey water, raising of farm bunds, and intensive plantation of trees

12.9. UPSC Previous Year Questions

Prelims

1. On the planet earth, most of the freshwater exists as ice caps and glaciers. Out of the remaining freshwater, the largest proportion (2013)
(a) is bound in atmosphere as moisture and clouds
(b) is found in freshwater lakes and rivers
(c) exists as groundwater
(d) exists as soil moisture

Answer: (c)

2. Consider the following statements: (2015)
1. The Accelerated Irrigation Benefits Programme was launched during 1996-97 to provide loan assistance to poor fanners.
2. The Command Area Development Programme was launched in 1974-75 for the development of water-use efficiency.

Which of the statements given above is/are correct?
(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Answer: (b)

3. Which of the following practices can help in water conservation in agriculture? (2017)
1. Reduced or zero tillage of the land
2. Applying gypsum before irrigating the field
3. Allowing crop residue to remain in the field

Select the correct answer using the code given below:
(a) 1 and 2 only (b) 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Answer: (c)

Student Notes:

4. Consider the following statements: (2020)

1. 36% of India's districts are classified as "overexploited" or "critical" by the Central Ground Water Authority (CGWA).
2. CGWA was formed under Environment (Protection) Act.
3. India has the largest area under groundwater irrigation in the world.

Which of the statements given above is/are correct?

(a) 1 only (b) 2 and 3 only
(c) 2 only (d) 1 and 3 only

Answer: (b)

12.10. Vision IAS Previous Years Questions

1. National River linking project of India aims to transfer water from surplus regions to deficit parts of the country. Analyse.

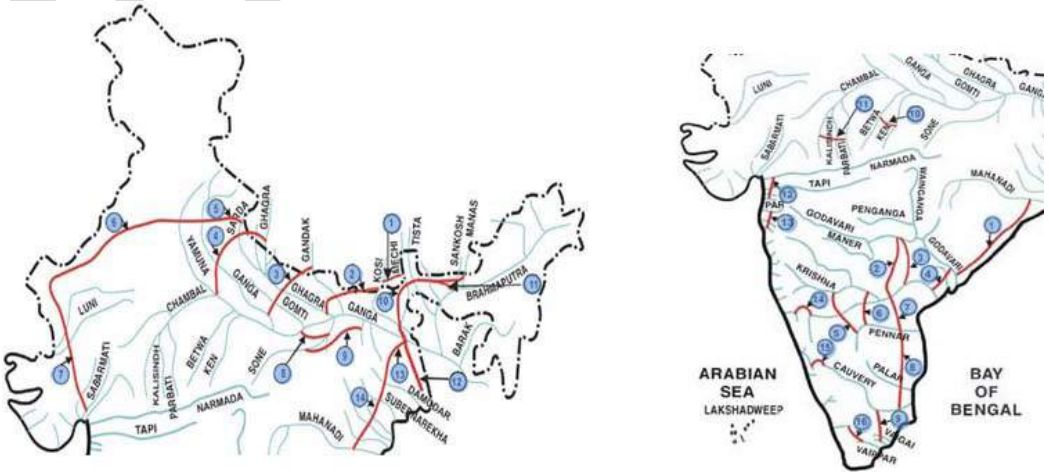
Approach:

- Describe regions which are surplus and deficit in water availability
- Discuss one or two linkages
- Counter arguments on linkages – ecological cost, economic cost etc.

Answer:

Large parts of states like Maharashtra, Andhra Pradesh, Rajasthan, and Karnataka are not only in deficit in rainfall but also subject to large variations, resulting in frequent droughts and causing hardship to the people and enormous loss to the nation. In summer months, rivers dry up and the ground water recedes. Regional variations in the rainfall lead to situations when some parts of the country do not have enough water even for raising a single crop. On the other hand excess rainfall occurring in some parts of the country creates havoc due to floods.

One of the most effective ways to reduce regional water imbalance, increase the irrigation, mitigate floods and droughts is the Inter Basin Water Transfer (IBWT) from the surplus rivers to deficit areas. National river linking project (NRLP) aims to build storage reservoirs on rivers with surplus water such as Brahmaputra, Ganga, Mahanadi, Godavari and west flowing rivers originating from the Western Ghats to transfer water to rivers that flows from water deficit regions of the country. NRLP aims to build 30 inter-linking projects, 3000 small and large reservoirs, 12500 km of canals to link 36 Himalayan and Peninsular rivers. For example, The Ken-Betwa link project envisages diversion of surplus waters of Ken basin to water deficit Betwa basin for irrigation, drinking water, tourism, fisheries and other purposes.



Proposed inter-river linkages under NRLP

Student Notes:

However, NRLP is criticized heavily on multiple grounds in spite of its great ambitions. The financial cost of the project is now estimated in lakhs of crores. Social and environmental cost would be enormous according to activists. A lot of land would have been required for this project, which would have displaced a lot many people. Some of the links have international implications, with a possible impact on countries like Bhutan, Nepal and Bangladesh. Experts claim that linkages at such a large scale may change heat map of Indian mainland which can affect the monsoon.

2. Discuss the impact of large dams on rivers and people. How are these addressed in various projects in India?

Approach:

- The impact of large dams on river and people can be discussed separately.
- Mention the initiatives taken to address the concerns in different projects in India.

Answer:

Impact of large dams on rivers:

- Dams, built to change natural flow regimes, are one of the most significant human interventions in the hydrological cycle.
- The most obvious effect of storage reservoirs is the permanent destruction of terrestrial ecosystems through inundation.
- The most common downstream effect of large dams is that variability in water discharge over the year is reduced.
- The hydrology of the river (both at the site of the dam and downstream) is changed due to dams.
- Hydraulic characteristics of the river and water quality is also changed.
- River bank erosion and delta erosion
- Dams also affect the total volume of runoff.
- Changes in sediment transport have been identified as one of the most important environmental impact of dams.
- Damming a river can alter the character of floodplains.
- Dams affect the plankton component of the river system.
- Changes in water temperatures.
- Big dams lead to earthquakes, which are termed as Reservoir Induced Seismicity.

Impact of large dams on people:

- Enforced resettlement
- Loss of habitats and species
- Ecological disturbances due to which productivity is reduced and people are affected.
- Deforestation and long term climate impacts.
- Cultural heritage sites lost through dam construction, loss of social capital.
- Disputes regarding water sharing.
- Depletion of natural resources.
- Impacts on livelihood opportunities.

India has witnessed many such dam related problems. Sardar Sarovar Dam project is one such example.

Government initiatives to resolve the issues related to dams:

- Providing proper rehabilitation packages.
- Providing appropriate employment opportunities.

Student Notes:

- Providing adequate compensations to those who lost their lands.
- Establishing Grievance Redressal Authority to look after the problems of affected people.
- Introduction of PPP model to involve people in developmental activities.
- Establishing infrastructural developments in affected areas.

3. Examine the reasons for depleting groundwater levels and acute groundwater stress in some regions of India. What measures should be taken to check groundwater exploitation and ensure recharge of aquifers in water stressed areas?

Approach:

- Use some recent facts to highlight the problem
- Mention causes such as urbanisation, agriculture, power subsidies, etc.
- Discuss preventive measures such as rationing, awareness, reutilisation, etc.

Answer:

Per capita fresh water availability in India has decreased sharply from 3000 cubic meters to about 1200 cubic meters in past 50 years. Internationally, countries with less than 1750 cu-m availability are categorized as water stressed and those with less than 1000 cu-m as water scare. Depletion and contamination of groundwater, which is the major source of fresh water, is the most prominent reason.

In India north western and south eastern region are most affected areas of ground water depletion.

Reasons:

- Groundwater is the most easily available source of irrigation where aquifers are rich. High amount of inputs required in Green Revolution areas, coupled with free power which incentives pump and tube-wells is the major cause of depleting groundwater.
- Climatically unsuitable crops, such as rice in northwest India are water guzzling.
- Variability and unpredictability of monsoon compels the farmers to depend on groundwater. This results in pushing the water table deeper.
- Scarcity of surface water resources, especially in urban conglomerates where there is large population pressure.
- Concrete roads and buildings prevent recharge of groundwater from surface run-off, leading to depletion.
- Quality of surface water – polluted surface water due to industrial waste and domestic waste lead to exploitation of ground water for consumption.
- Absence of legal framework —lack of regulation to use ground water resources gives free access to its exploitation.
- Lack of technology – poor treatment facility to reuse water, wasteful flood irrigation, etc.

Measures:

- At field level
  - More efficient irrigation systems such as drip or sprinkler
  - Climatically suitable crops, low-water consuming crops
  - Improved discharge efficiency through use of quality electrical pumps and delivery pipes.
- Micro level mapping of groundwater resources and dissemination of information. Generating awareness can prevent abuse. Enable civil society participation for behavioural changes.

Student Notes:

- Manage the demand – Groundwater in India is a private and under-regulated market, and does not have the benefits that transparent, embedded markets can bring. Monetising groundwater can bring in more efficiency in its utilisation.
- Regulate, recharge and reuse - Need national effort towards these goals. Institutions such as the Central Ground Water Board along with its state counterparts can provide impetus to rational utilisation, recycling, reuse, conservation and recharge.
- Conservation of natural water bodies like lakes, wetlands, ponds etc.
- Integration of water credit region to water deficit region of surface water resources (river linking).
- Utilise concept of water shed management and dry land farming.
- Planned and efficient urbanisation with effective rainwater harvesting mechanism.
- Waste treatment before disposal into water bodies or into ground.
- Urban waste water, which is nutrient rich can be utilised for irrigation purposes in vicinity market gardening areas, as is being done in Rajkot, Gujarat.

4. Water should be treated as an economic commodity whose full costs must be recovered from users, so as to ensure efficiency in service provision. In this context, discuss the viability of PPP model of water supply and management in India. Also, highlight the challenges that can arise in implementing the same.

Approach:

- Write the importance of water pricing in improving the efficiency of usage.
- Discuss the need of private participation in water supply and management.
- Write challenges in implementation.

Answer:

The water is a scarce resource and is in huge demand. The pricing of water is increasingly seen as an acceptable public policy to encourage responsible use of water and expanding its supply. This has potential to make water more accessible, healthier and more sustainable over the long term.

By treating water as an economic commodity, the private sector can play crucial role in the form of Public-Private Partnership (PPP) in water supply and management.

Need of Investment: The ULBs are responsible for urban water supply and sanitation but they lack enough financial resources**.** Large investments are needed to develop and upgrade water supply, treatment and distribution networks in India. The PPP model can bring much needed investment.

Skills: The PPP model will allow private sector skills to be brought into service design and delivery, operational control, labor management and equipment procurement.

Service Delivery: The private sector participation will bring needed professionalism in service delivery. It will improve the quality of service provided to people.

The challenges in implementing PPP model in water supply and management are follows:

- **Regulation**: The independent regulator is required with adequate staff to regulate water prices and ensure efficient service delivery
- **Social good**: The water is a social good and Right to water has been recognised as a fundamental right and therefore it is the sovereign duty of government to ensure that every human being is assured of access to adequate and safe water. That is the reason why PPP projects have not taken off with considerable success in this sector.
- **Local Bodies**: The institutions of local governance are not sufficiently empowered – finance and governance to ensure accountability of private sector

- Reliable data, inflation – adjusted tariffs, and appropriate risk allocation is required to facilitate PPP model in this sector
- **Investment:** The water supply requires huge amount of capital investment in infrastructure such as pipe networks, pumping stations and water treatment works. At present, the balance sheets of corporate and banks are over stretched for this investment.
- **Experience:** The past experience of PPP model in creating big urban infrastructure projects such as Mumbai Metro, New Delhi Airport Metro shows there is need to frame better contracts.

Though these are enormous challenges, the bottom line is that all the citizens are need to be provided adequate, safe, efficient and affordable water. The government has already recognized the need of involving private sector in water resource as objective in National Water Policy, 2002 and JNNURM.

5. What is watershed management? What are its advantages over the conventional approaches? Discuss the measures required to improve effectiveness of watershed management programmes.

Approach:

- Explain Watershed and then Watershed Management.
- Mention some conventional approaches and its advantage over them.
- Discuss the measures needed to improve effectiveness of its programmes.

Answer:

Catchments of large rivers are called river basins and are large in area. Catchment of small rivers and rills are often referred to as watershed. Basins and watersheds are marked by unity. What happens in one part of the watershed directly affects the other parts and unit as a whole. Hence it is accepted as the most appropriate level of planning and management.

Watershed management studies the relevant characteristics of a watershed aimed at sustainable distribution of resources, augmentation of water, conserve and improve the land, reduce floods, check soil erosion and recharge ground water among others with the involvement of communities, government agencies and experts. Since, watersheds are basins of small rivers they often lie in dry and arid regions, hence their effective management becomes very important.

Conventional approaches include Wastelands Development, Drought Prone Areas development, Desert Development etc. These approaches worked in isolation, focusing on the problem of land management or water management in dry and arid regions. However, the watershed management is a holistic approach as evident by the Integrated Watershed Management Programme (IWMP). It has following advantages:

- Integration of various area development programmes.
- Entails involvement of primary stakeholders in the form of grassroots community organisations.
- Institution & capacity building by setting up institutional mechanism at State, District, Project and Village levels and to build capacities of stakeholders.
- Rather than isolated benefits holistic benefits include increase in availability of surface water & groundwater, changes in cropping pattern from one to two crops annually, increase in fodder availability, increase in milk yield, increase in agricultural productivity.

Student Notes:

The effectiveness of watershed management programmes can be further enhanced by taking following steps:

- Focus on potential for restoration rather than on poverty.
- Improving land use capacity.
- Emphasis on preventive, cost-effective, long-lasting approaches.
- Promoting self-perpetuating practices that are taken up by the communities easily and lastingly like water harvesting.
- Focus on income generation.
- Focus on key institutional and policy changes.
- Using farmers' feedback and learning from experience.
- Increasing accountability of development organizations.

6. The prevailing water crisis in the country is not about the unavailability of water rather the mismanagement of available resources. Do you agree? Discuss the short-term and long-term socio-economic impacts of the water crisis on India.

Approach:

- In the first part, give statistics of water availability in India and comment whether the unavailability of water is due to mismanagement.
- Then highlight the consequences of water scarcity in India both in short and long term.

Answer:

India accounts for 4 per cent of world's water resources and about 16 per cent of population. Total water available from precipitation annually is about 4,000 cubic while surface water and replenishable groundwater is 1,869 cubic km. However, due to high population per capita availability is still low. Added to this, due to mismanagement we are facing a severe water crisis:

Agriculture: As a free resource ground water is over-exploited leading to decrease in water table, over-utilization of subsidized fertilizers led to seeping of impurities into water bodies, growing of water-intense crops in water starved regions led to water shortage.

Pollution: India has failed to strictly regulate industries leading to industrial waste flowing into water bodies and seriously contaminating rivers, lakes etc.

General Utilization: Subsidized or free water provided by the government has led to overuse and misuse by people.

Water Harvesting: While India receives major water through monsoons concentrated in summers, practice of water harvesting is very limited.

Socio-economic impact of water crisis:

Short term

- It can lead to food inflation, which will affect the poor.
- It can lead to crop failures, lower agricultural output which can lead to farmers' indebtedness, distress sale and suicides as happened in Maharashtra and Andhra Pradesh recently.
- Mushrooming of water-mafia and corruption, which will put economic pressure on people at bottom of development ladder.

Student Notes:

Long run

- It leads to serious food security problems as agriculture, animal husbandry and aquaculture will be affected.
- Polluted water can lead to water-borne diseases, which puts financial pressure on the poor.
- People will be forced to migrate from the water scarce areas to water intense areas.
- Water crisis will further intensify the class based social cleavage as only haves can pay for the luxury of water.
- Water crisis will sharpen regional disparities intensifying regionalism.
- Water intense industries will be impacted leading to unemployment and lower growth rate.
- Water crisis will lead to loss of biodiversity and communities/employment based on that will be affected.
- Social harmony will be impacted which will threaten the democracy itself.

Hence, it is imperative that the management of water is prioritized by the government, NGOs and people. Water harvesting, watershed management, judicious use of ground water, reducing pollution of water resources is the need of the time. Awareness about schemes like Namami Gange, PMKSY must be heightened and such conservation schemes be strictly implemented to prevent the augmentation of the existing crisis further.

7. Enumerate the features of "Namami Gange" programme. How does it differ from the previous programmes taken to clean the River Ganga?

***Approach**:*

- Present the salient feature of Namami Gange programme.
- Mention previous action plans to Clean Ganga and contrast Namami Gange with them.

***Answer**:*

Namami Gange" programme integrates the efforts to clean and protect the River Ganga in a comprehensive manner. The programme has a budget outlay of Rs. 20,000 crore for the next 5 years.

Namami Gange Programme stresses on improved coordination mechanisms between the various Ministries/Agencies of the central and state governments. Marking a major shift in implementation, the government is focusing on involving people living on the banks of the river to attain sustainable results.

Over 1,632 gram panchayats on the banks of Ganga will be made open defecation-free by 2022.

Under the aegis of National Mission for Clean Ganga (NMCG) & State Programme Management Groups (SPMGs) States and Urban Local Bodies and Panchayati Raj institutions will be involved in this project.

In Namami Gange programme, river centric urban planning process will facilitate better citizen connects, through interventions at Ghats and River fronts. Coverage of sewerage infrastructure will be expanded in 118 urban habitations on banks of Ganga. Development of rational agricultural practices & efficient irrigation methods will be encouraged.

Student Notes:

Namami Gange will focus on pollution abatement interventions, namely interception and diversion and treatment of waste water flowing through open drains via

- bio-remediation
- appropriate in-situ treatment
- use of innovative technologies
- sewage treatment plants (STPs)
- effluent treatment plant (ETPs)

Government plans to provide for operation and maintenance of the assets for at least a 10-year period and adopt a PPP/SPV approach for pollution hotspots. Under this plan, Central government also plans to establish a four battalion-strong Ganga Eco-Task Force, a Territorial Army unit.

Previously Schemes such as Rajeev Gandhi Ganga Action Plan has been launched and re-launched from time to time, but without any qualitative as well as quantitative result.

So Namami Gange Programme has a comprehensive plan which the earlier programmes were not able to undertake.

8. State the factors which have led to India being categorized as a water-stressed nation. Also, identify sustainable solutions for averting the crisis at hand.

Approach:

- Briefly discuss about water stress.
- State the factors responsible for making India a water-stressed nation.
- List the sustainable solutions for avert this crisis.

Answer:

Recently, a NITI Aayog report highlighted India is suffering from 'worst water crisis' in its history with 60 crore people facing high to extreme water stress. With about 4 per cent of the water resources of the world, India should have been a water-adequate nation. However, India has turned into a water-stressed nation. A country is water-stressed if average annual per capita water availability is less than 1,700 cubic meters. For India, it was 1545 cubic meters in 2011.

Among G20 countries, India has the largest water withdrawal, while its water productivity is the second lowest in the group. This situation is due to a combination of factors:

- **Population pressure**:, It has been projected that per capita availability may reduce further to 1341 cubic meters in 2025 and as low as 1,140 by 2050. This scenario mirrors water-scarcity condition where per-person availability is less than 1,000 cubic metres.
- **Groundwater overexploitation:** Due to over-extraction by farmers, subsidised electricity and inefficient irrigation practices.
- **Weak and irregular monsoon** coupled with poor rain water harvesting infrastructure.
- **Reduction in traditional water recharging areas** due to encroachment, increased concretization and modern construction methods that ignores traditional ground water recharging mechanisms.
- **Lack of efficient water management and distribution** of water between urban consumers, agriculture sector and industry coupled with indiscriminate use of water due to low awareness about it.

- **Poor water quality**: Due to lack of urban water-treatment facilities, sewage and wastewater drainage into traditional water bodies, release of chemicals and effluents into rivers, streams and ponds, use of fertilisers and pesticides etc.
- **Lack of on-time de-silting** operations in large water bodies that can enhance water storage capacity during monsoon.
- **Poor Water Governance:** Due to compartmentalisation of water into ground and surface and division of water resources based on state boundaries hinders holistic long term water management.

As a result, NITI Aayog predicted that 40% of population will have no access to drinking water by 2030 and 21 cities will run out of groundwater by 2020, affecting 100 million people and an eventual 6% loss in country's GDP.

Since, country's water demand is projected to be twice the available supply by 2030, it is imperative to adopt the following sustainable strategies:

- **Participative groundwater management:** The government should empower local groups with knowledge and real-time information on the status of groundwater so as to manage extraction in a cooperative way. For e.g. Mexico's efforts at cooperative management of groundwater.
- **Watershed development** through community-based efforts which helps in increasing soil moisture and recharges groundwater. For e.g. Ralegaon Siddhi in Maharashtra, efforts by 'Tarun Bharat Sangh' in Alwar District of Rajasthan.
- **Urban and industrial water management**: Adequate sewage treatment facilities must be constructed and state pollution control boards should be strengthened to enforce effluent standards among polluting industries
- **Adequate regulatory mechanism** that finds the right balance between the needs of development and environment, protecting ecological integrity of the nation's rivers, lakes, wetlands and aquifers, as well as coastal systems.
- **Adopting basin approach** in water management. For, this Mihir Shah Committee's report must be implemented.
- **Increasing storage in reservoirs** by enlarging the capacity of existing reservoirs, by making new reservoirs and by reducing sedimentation.
- **Domestic and industrial water** use can be reduced by cutting leakage in distribution and by improving water recycling facilities. Industrial and residential habits must be changed through awareness about water scarcity, using tools such as water budget, water audit etc.
- **Improving Irrigation efficiency** by switching from flood irrigation to sprinklers or drips etc.
- **Increasing the capacity or numbers of desalination plants** can help in countering the problem in coastal areas. For e.g. technology transfer from Israel.

9. What do you understand by Integrated Water Resources Management (IWRM)? How does National Water Policy, 2012 try to promote IWRM?

Approach:

- Explain the meaning, principles and components of IWRM.
- Mention the provisions of National Water Policy, 2012 promoting IWRM.

Answer:

IWRM is a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems.

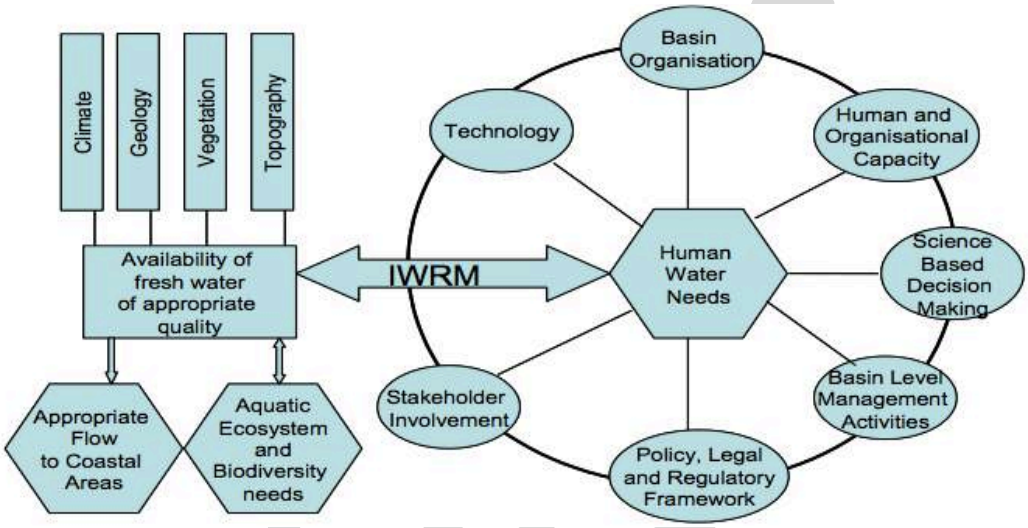
Student Notes:

It is a holistic approach that seeks to integrate the management of the physical environment within that of the broader socio-economic and political framework. It involves applying knowledge from diverse disciplines and stakeholders to develop a comprehensive, participatory planning and implementation tool for managing and developing water resources.

Principles of IWRM:

- economic efficiency
- environmental sustainability
- social equity, including poverty reduction

Components of IWRM:



National Water Policy, 2012 tries to promote IWRM in the following ways:

- **Common integrated perspective for water resource planning**: One of the basic principles of the policy is that planning, development and management of water resources need to be governed by common integrated perspective considering local, regional, state and national context.
- **Multi-disciplinary institutions**: The departments/organizations at Centre/State Governments levels should be restructured and made multi-disciplinary to fulfil the needs of IWRM.
- **Promotes principles of IWRM**: It highlights having an environmentally sound basis, keeping in view the human, social and economic needs, in line with the principles of IWRM.
- **Inter-state coordination**: It mentions the need for a comprehensive legislation for the optimum development of inter- State rivers and river valleys to facilitate inter-State coordination.
- **River basin approach**: It talks about ensuring scientific planning of land and water resources taking basin/sub-basin as unit with unified perspectives of water in all its forms (including precipitation, soil moisture, ground and surface water) and ensuring holistic and balanced development of both the catchment and the command areas.
- **Efficient utilization of water**: It highlights the need to plan, manage and regulate utilization of water resource through demand management strategies, establishment of basin authorities and giving them with appropriate powers to regulate usage, promoting micro-irrigation etc.
- **Information system:** All water related data, should be integrated with well-defined procedures and formats to ensure online updation and transfer of data to facilitate development of database for informed decision making in the management of water

Student Notes:

- **Managing water resource as a community resource**: It calls for water needs to be managed as a common pool community resource that is held by the State under the public trust doctrine to ensure equitable and sustainable development for all.

In light of the NITI Aayog's report mentioning India facing its worst water crisis and the demand of potable water outstripping supply by 2030, IWRM is the philosophy that needs to be followed both in letter and spirit.

10. Managing water related issues in India requires convergence in policy making, implementation and monitoring. In this context, comment on the significance of the creation of Ministry of Jal Shakti.

Approach:

- Briefly explain about the water crisis existing in India.
- Explain the issue of convergence in managing water related issues.
- Discuss how newly formed Jal Shakti Ministry would bring convergence in these policies.
- Conclude by mentioning some futuristic plans under the ministry to facilitate this convergence.

Answer:

According to the NITI Aayog report, nearly 600 million Indians face "**high to extreme water stress,'' while** 75% households do not have drinking water on their premises. Apart from it there are issues of overexploited water resources, contaminated groundwater, polluted rivers etc. Also the country's water demand is likely to double by 2030, indicating that there will be a 6% loss in India's GDP by 2050. That is why it is necessary to manage the available water efficiently. However, it becomes difficult due to lack of convergence at several levels.

Problem of convergence in managing water related issues:

- **In policy making:** As per seventh schedule of Indian constitution, water is a State subject and regulation and development of inter-state rivers and river valleys is a Union subject. Therefore, making a holistic policy related to water becomes tough. Also, until recently there were several Central ministries which dealt with different issues of water in a piecemeal manner. For instance, the Ministry of Environment and Forest is entrusted with conservation of most rivers in the country. Similarly, urban water supply is looked after by the Ministry of Housing and Urban Affairs and micro-irrigation projects come under the Ministry of Agriculture.
- **In implementation and monitoring:** There is a lack of coordination between the state agencies and implementation bodies at district levels, such as in the case of watershed development. For instance, under the Namami Gange Program, the Ministry of Water Resources signed MoUs with 10 other ministries to synergise activities, but there are concerns over the success of the project. Similarly, water is also being managed under two separate heads i.e. surface water and groundwater. Surface water is managed by the Central Water Commission or CWC and the groundwater is managed by the Central Groundwater Board or CGWB.

This fragmentation results in duplication of efforts by different agencies and in process negates the overall effectiveness of the programmes. Therefore, a new Ministry of Jal Shakti has been formed by merging two ministries - Ministry of Water Resources, River Development & Ganga Rejuvenation and Ministry of Drinking Water and Sanitation. It will be helpful in following ways:

Student Notes:

- All the water-related policy formulation, implementation and monitoring will be done by a single ministry. The ambit of the Ministry encompasses issues ranging from international and inter-states water disputes, the Namami Gange project, the flagship initiative to clean the Ganges, its tributaries and sub-tributaries and provide clean drinking water.
- Since all water projects are complementary to each other, single ministry will have integrated data management system. It will help create water availability data from various resources on both quality and quantity at a single platform.
- In this effort, the ministry has launched Jal Shakti Abhiyan. Covering 256 districts across the country, this mass movement will focus on five aspects i.e. water conservation and rainwater harvesting, renovation of traditional and other water bodies, reuse of water and recharging of structures, watershed development, and intensive afforestation.

Recently, the government has also finalised a committee chaired by Mihir Shah to draft a new National Water Policy. A National Bureau of Water Use Efficiency will also be set up. It would also create consensus with the states over acceptance of hydrological boundaries, rather than administrative or political boundaries as a basis of water governance structure in the country. These initiatives of Ministry of Jal Shakti will help in efficient management of water related issues in India.

11. In India, ancient and medieval storage structures such as the step wells, are not only magnificent in their conception, architecture and ornamentation but also hold a lesson for contemporary water concerns. Discuss with examples.

Approach:

- Briefly describe the reason behind the development of traditional storage structures in India.
- Discuss the ancient and medieval storage structures, highlighting their unique features.
- Conclude by linking it with contemporary water concerns in India.

Answer:

Both floods and droughts were regular occurrences in ancient and medieval India due to which various traditional water harvesting techniques developed that reflect the geographical peculiarities and cultural uniqueness of the various regions.

Ancient and medieval water storage systems are unique not only in their conception and design but also in their aesthetic appeal. These include:

- **Stepwells/baolis:** Baolis are wells in which the water is reached by descending a step of stairs. These stepwells typically have beautiful arches, carved motifs and sometimes, rooms on their sides. Examples **Rani ki Vav** in Gujarat, **Agrasen ki Baoli** in Delhi etc.
- **Canal construction:** Canals were constructed by the Harappan people to support irrigation, water transport etc. In the medieval era, Firoz Shah Tughlaq constructed a **'double system of canals'** from Yamuna to Sutlej to support the newly founded city of Hissar-i-Firoza. Similarly, Chola rulers constructed several canals along the Kaveri river such as the **Uyyakondan canal,** which is currently being restored**.**
- **Tank irrigation system:** Huge tanks such as the **Sivaganga tank** and **Cholagangam tank** were built by the Chola kings to collect and store water. Also, the **Eri (tank) system** of Tamil Nadu, help in flood-control, prevent soil erosion and wastage of runoff during periods of heavy rainfall, and recharge groundwater.
- **Johads:** These are small earthen check dams constructed in an area with naturally high elevation on three sides that capture and store rainwater.

Student Notes:

- **Talabs/Pokhariyan:** These are reservoirs that store water for household consumption and drinking purposes. For example, construction of **pokhariyan ponds at Tikamgarh** in the drought-prone Bundelkhand region.
- **Ahar Pynes:** They are traditional floodwater harvesting systems indigenous to **South Bihar**. Ahars are reservoirs with embankments on three sides and Pynes are artificial rivulets. In relatively low rainfall regions in South Bihar, ahar pynes are used for paddy cultivation.
- **Jhalaras:** Jhalaras are typically rectangular shaped stepwells built in ancient times that have tiered slopes on three or four sides, which collect the subterranean seepage of an upstream reservoir or a lake. For example, **Mahamandir Jhalara** of Jodhpur.
- **Zings:** These are small tanks found in **Ladakh** that collect melting glacier water. A network of guiding channels brings water from the glacier to the tank.
- **Zabo system:** This traditional water harvesting system of **Nagaland** combines water conservation with forestry, agriculture and animal care. Rainwater that falls on forested hilltops is collected by channels that deposit the run-off water in pond-like structures created on the terraced hillsides.

As India grapples with rapid urbanisation, increased water usage and pollution, the quantity and quality of surface and groundwater are under threat. Thus, attempts should be made to revive the aforementioned ancient and medieval water storage systems, which are both cost-effective and environment friendly.

Student Notes:

CHAPTER - 13 – ENERGY RESOURCES AND THEIR CONSERVATION

13. Energy Resources and their Conservation

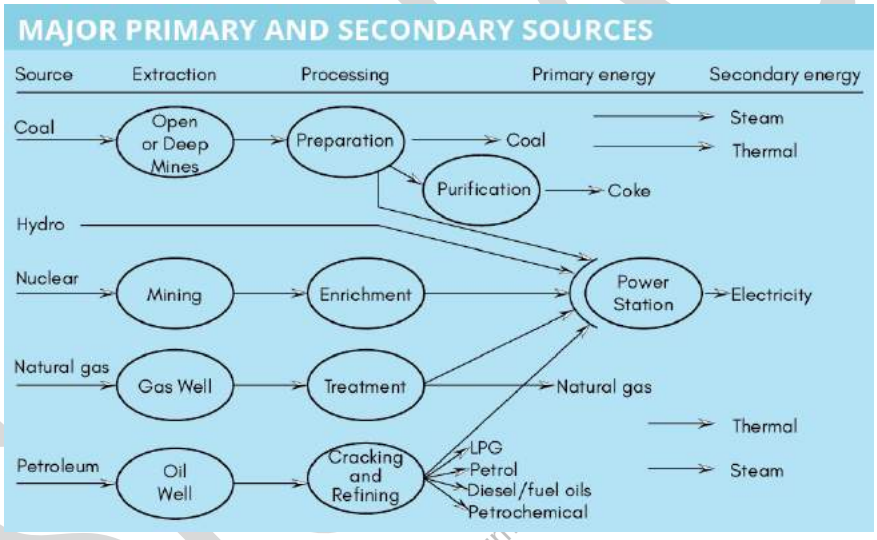
13.1. Introduction

Energy is one of the major inputs for the economic development of any country. In the case of the developing countries, the energy sector assumes a critical importance in view of the ever-increasing energy needs requiring huge investments to meet them.

13.2. Classification of Energy

- Primary and Secondary energy
- Commercial and Non-commercial energy
- Renewable and Non-Renewable energy

13.2.1. Primary and Secondary Energy



Primary energy sources are those that are either **found or stored in nature**. Common primary energy sources are **coal, oil, natural gas, and biomass (such as wood)**. Other primary energy sources available include nuclear energy from radioactive substances, thermal energy stored in earth's interior, and potential energy due to earth's gravity.

Primary energy sources are mostly converted in industrial utilities into **secondary energy sources**. For example, coal, oil or gas converted into steam and electricity. Primary energy can also be used directly. Some energy sources have non-energy uses, for example coal or natural gas can be used as a feedstock in fertiliser plants.

13.2.2. Commercial Energy and Non-Commercial Energy

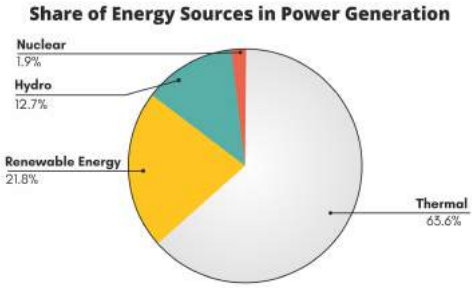
Commercial Energy: The energy sources that are available in the market for a definite price are known as commercial energy e.g. electricity, coal and refined petroleum products. Commercial energy forms the basis of industrial, agricultural, transport and commercial development in the modern world. In the industrialized countries, commercialized fuels are predominant source not only for economic production, but also for many household tasks of general population.

Non-Commercial Energy: The energy sources that are not available in the commercial market for a price are classified as non-commercial energy such as firewood, cattle dung and agricultural wastes, which are traditionally gathered, and not bought at a price used especially in rural households. These are also called traditional fuels. Non-commercial energy is often ignored in energy accounting.

Student Notes:

13.2.3. Renewable and Non-Renewable Energy

Renewable energy is energy obtained from sources that are essentially inexhaustible. Examples of renewable resources include wind power, solar power, geothermal energy, tidal power and hydroelectric power. The most important feature of renewable energy is that it can be harnessed without the release of harmful pollutants.



Non-renewable energy is the conventional fossil fuels such as coal, oil and gas, which are likely to deplete with time.

13.3. Renewable or Non-conventional Sources of Energy

We get renewable solar energy directly from the sun and indirectly from moving water, wind and biomass. They are widely available and potential source of clean and limitless sources of energy.

13.3.1. Solar Energy

Solar energy is abundant, everlasting and available free of cost. Direct use of solar energy can be used through various devices broadly directed into two types of systems:

- **Solar Thermal Power systems or Concentrating Solar Power systems:** They generate solar power by using **mirrors or lenses** to concentrate a large area of sunlight onto a receiver. Electricity is generated when the concentrated light is converted to heat (solar thermal energy), which drives a heat engine (usually a steam turbine) connected to an electrical power generator or powers a thermochemical reaction.
- **Solar Photovoltaic:** Solar energy can be converted directly into electrical energy (direct current, DC) by photovoltaic (PV) cells commonly called **solar cells**. Photovoltaic cells are made of silicon and other materials. When sunlight strikes the silicon atoms, it energizes and causes electrons in the semiconductor to flow, creating an electrical current. India is the world's largest market for solar cells.

13.3.1.1. India and Solar Energy

India is endowed with vast solar energy potential. About 5,000 trillion kWh per year energy is incident over India's land area with most parts receiving 4-7 kWh per sq. m per day. National Institute of Solar Energy has assessed the **country's solar potential of about 748 GW** assuming 3% of the waste land area to be covered by Solar PV modules.

India has achieved 5th global position in solar power deployment by surpassing Italy. Solar power capacity has increased by more than 11 times in the last five years from 2.6 GW in March, 2014 to 30 GW in July, 2019. Presently, solar tariff in India is very competitive and has achieved grid parity.

Key challenges facing the growth and development of PV Technology in India:

- **Cost and T&D Losses:** Initial cost of developing the technology is very high and therefore unable to compete on the same scale as other energy generation technologies. Adding to the cost are T&D losses that at approximately 40 percent make generation through solar energy sources highly unfeasible.
- **Land Scarcity:** Per capita land availability is very low in India, and getting dedicated of land for exclusive installation of solar cells is difficult. Also, Land allotment & PPA signing is a long procedure under the Generation Based Incentive scheme.
- **Funding** of initiatives like National Solar Mission is a constraint given India's inadequate financing capabilities. The finance ministry has explicitly raised concerns about funding an ambitious scheme like NSM.

Student Notes:

- **Regulatory concerns:** Complexity of subsidy structure & involvement of too many agencies like MNRE, IREDA, SNA, electricity board and electricity regulatory commission makes the development of solar PV projects difficult.
- **Limited availability for local market:** Manufacturers are mostly focused on export market that buys Solar PV cells and modules at higher prices thereby increasing their profits.
- **Weather Dependent**: Solar panels are dependent on sunlight to effectively gather solar energy. Therefore, a cloudy and rainy day can have a noticeable impact on the energy system.
- **Grid-connectivity:** Solar energy has to be used right away or it can be stored in large batteries i.e., off-the-grid solar systems. Integrating solar energy with grid is a difficult and costly procedure.

Issues in Solar Manufacturing in India

- **Overdependence on low-cost imports**- India met 92.11 per cent requirement of its solar equipment through imports in 2017-18. China is the largest supplier of solar equipment accounting for about 89 per cent of India's total imports of solar cells in 2017-18.
- **Lack of a manufacturing base** for Poly-silicon, Ingots/wafers, the upstream stages of solar PV manufacturing chain, which is a very energy intensive process. Most Indian companies are engaged in only module assembly or wafer manufacturing and module assembly.
- **Higher cost of production**- due to lack of integrated set up, economies of scale & modern technology.
    - Also, the domestic manufactures have to borrow at higher interest rates, compared to foreign manufacturers, pushing up their cost of production.
    - Thus, the price of solar equipment produced in the country is not competitive as compared to that of foreign manufacturers.
- **Government's attempts faced different challenges**
    - India's attempt to provide a leg-up to local manufacturers through **Domestic Content Requirement** was thwarted when World Trade Organisation overruled the local sourcing requirements on imports placed by the Government.
    - In 2018, India imposed a **Safeguard Duty on imported solar panels**.
        - ✓ While imposition of this duty was aimed at incentivising domestic manufacturing, it led to an increase in tariffs, resulting in the cancellation of many solar auctions.
        - ✓ But, for Indian manufacturers, protection from the safeguard duty soon disappeared since Chinese panel manufacturers also reduced the module prices.
- **Other regulatory issues-** such as high cost of land/ electricity, low-capacity utilization, and lack of skilled workforce.

Potential of Solar Manufacturing in India:

- **Employment generation:** It has a potential to create 50,000 direct jobs and at least 125,000 indirect jobs in the next 5 years.
- **Reduction in imports**: Domestic solar manufacturing can save USD 42 bn. in equipment imports by 2030, besides providing equipment supply security.
- **Domestic demand**: India's large demand (planned solar power growth) in the coming years is the perfect opportunity to build a domestic manufacturing base for equipment (panels and cells) and scale them up much like China did.
    - According to the Ministry of New and Renewable Energy (2018), India has an annual solar cell manufacturing capacity of about 3 GW while the average annual demand is 20 GW.
- **Expanding overseas market:** India has taken a lead in the International Solar Alliance (ISA), which will help in the transfer of solar technologies across members. o India also sees this as an opportunity for the domestic solar industry to find inroads in some of the smaller and untapped markets like Africa and South America.

Student Notes:

13.3.1.2. Steps taken by India to promote Solar energy

- India's Manufacturing Policy recognizes solar manufacturing as an industry with 'strategic importance'. In the solar panel manufacturing sector, the Indian government allows 100% foreign investment as equity and it qualifies for automatic approval.
- **National Solar Mission, 2010:** Its objective is to establish India as a global leader in solar energy by creating the policy conditions for solar technology diffusion across the country as quickly as possible. The Mission targets installing 100 GW grid-connected solar power plants by the year 2022 in line with **Paris agreement.** In order to achieve the above target, Government of India have launched various schemes like Solar Park Scheme, VGF Schemes, CPSU Scheme, Defence Scheme, Canal bank & Canal top Scheme, Bundling Scheme, etc.:
  - **Solar Park Scheme** for setting up of over 50 Solar Parks and Ultra Mega Solar Power Projects targeting over 40,000 MW of solar power projects.
  - Scheme for setting up of Grid-Connected Solar PV Power Projects by the **Central Public Sector Undertakings (CPSUs)** and the Government of India organisations with Viability Gap Funding (VGF).
  - **VGF Scheme** for setting up of 5000 MW of Grid Connected Solar PV Power Projects through SECI, which has a separate component of 1000 MW for N-E states.
  - **Grid Connected Solar Rooftop Scheme:** For achieving cumulative capacity of 40,000 MW from Rooftop Solar (RTS) Projects by the year 2022.
  - **Pradhan Mantri Kisan Urja Suraksha evam Utthan Mahabhiyan Yojana (PM-KUSUM):** It is a scheme for farmers for installation of solar pumps and grid connected solar and other renewable power plants. The scheme aims to add solar and other renewable capacity of 25,750 MW by 2022 with financial support from centre.
- **Development of Solar City Programme:** A total of 60 cities/towns are proposed to be supported for development as "Solar/ Green Cities". At least one city in each State to a maximum of five cities in a State may be supported by the Ministry of New and Renewable Energy.
- A 25 percent capital subsidy for solar manufacturing units is available under the **'Modified Special Incentives Package Scheme' (M-SIPS).**

Significance of ISA

- Ensure Energy Security
- Integration of Global South and Global North
- To Solve Global Energy Poverty as according to International Energy Association (IEA), there are more than "600 million people without access to electricity" in Sub-Saharan Africa.
- Creation of an Alternative Electricity Energy Grid Based on solar energy among various countries, to overcome a financial constraint in tapping solar energy.

Intended Nationally Determined Contributions (INDCs):
Its target is to achieve about 40 percent cumulative electric power installed capacity from non-fossil-fuel based energy resources and to reduce the emission intensity of its GDP by 33 to 35 percent from 2005 level by 2030.

International Solar Alliance, ISA:

It is an initiative jointly launched by India and France in 2015 on the sidelines of COP-21 of UNFCCC in Paris and officially established in 2017. It is a first treaty based international intergovernmental organization headquartered in India.

The membership to ISA is open **all members of the United Nations.** Through this initiative, the countries share the collective ambition:

- To address obstacles that stand in the way of rapid and massive scale-up of solar energy
- To undertake innovative and concerted efforts for reducing the cost of finance and cost of technology for immediate deployment of competitive solar generation; and

Student Notes:

- To mobilise more than 1000 Billion US Dollars of investments by 2030 and to accelerate the development and deployment of over 1,000GW of solar generation capacity in member countries.

The ISA has established five key programmes of action:

- Scaling up solar applications for agricultural use
- Affordable finance at scale
- Scaling up solar mini grids
- Scaling up solar rooftop
- Scaling up solar e-mobility and storage

Other facts related to ISA:

- All costs relating to the running of the ISA will be funded through voluntary contributions of member-countries, partner countries, partner organisations and Strategic Partners.
  - Funding under ISA is also been exempted to be treated as a foreign source of funding for Indian NGOs and other entities under the FCRA.
- The ISA Secretariat has launched:
  - A Solar Technology Application and Resource – Centre (iSTAR-C) to support capacity building efforts in the ISA member countries.
  - The ISA Solar Award (Kalpana Chawla Solar Award) to recognize solar scientists doing extraordinary work across ISA member countries.
- ISA has also been developing a Common Risk Mitigating Mechanism (CRMM) for de-risking and reducing the financial cost of solar projects in the ISA member countries.

International Renewable Energy Agency

- It is an intergovernmental organization, principal platform for international co-operation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy.
- Promotes the widespread adoption of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy.
- India is a member country of IRENA.

Indian Renewable Energy Development Agency Limited (IREDA)

- It is a Mini Ratna (Category – I) Enterprise under the administrative control of **Ministry of New and Renewable Energy (MNRE).**
- It is a Public Limited Government Company established as a **Non-Banking Financial Institution** in 1987.
- It is engaged in promoting, developing and extending financial assistance for setting up projects relating to new and renewable sources of energy and energy efficiency/conservation.
- IREDA has been notified as a "Public Financial Institution" under the Companies Act, 1956 and registered as Non-Banking Financial Company (NFBC) with Reserve Bank of India (RBI).

Measures, which needs to be taken:

- India needs a **solar manufacturing strategy**, on the lines of the Automotive Mission Plan (2006-2016), which is credited with making India one of the largest manufacturers of automobiles in the world. A right policy framework with well-defined objectives will help India set up a robust PV manufacturing ecosystem.
- Focus on **large-scale public procurement**- The government can call out bids for solar power plants with the requirement that these be made fully in India. This will not violate any WTO commitment.
- **Cluster Approach**- Globally, manufacturing bases are being planned as integrated solar industrial clusters with strong Government support. A SEZ that focuses only on integrated module manufacturing could be planned to create a conducive environment.
- Ideas which can be adopted from China
  - Develop '**Solar Champions'**- in a systematic manner through massive subsidies, low interest loans, grants and easy access to land and utilities.
  - The **Technology Top Runner Program**- which aims to achieve higher-efficiency solar products for 1.5 GW of next-generation PV technology. Through such targets, China is able to drive mass production of cells.

13.3.1.3. Wind Energy

The uneven absorption of the solar radiation by the earth's surface causes differences of temperature, density and pressure which produce air movements at local, regional and global levels powered by wind energy. The kinetic energy of the wind can be harnessed by converting it into mechanical energy or electrical energy using suitable devices such as turbine. Five nations - USA, China, Germany, India and Spain are the leading nations in terms of installed wind energy capacity.

Wind Energy in India

- As on 31st March 2019, India has the fourth highest wind installed capacity in the world with total installed capacity of 35.6 GW.
- The Government through National Institute of Wind Energy (NIWE) has installed over 800 wind-monitoring stations all over country.
- The recent assessment indicates a gross wind power potential of 302 GW in the country at 100 meter above ground level.
- Out of the total estimated potential more than 95% of commercially exploitable wind resources are concentrated in seven states i.e. Gujarat, Rajasthan, Maharashtra, Tamil Nadu, Madhya Pradesh, Karnataka and Andhra Pradesh.

Offshore wind power vs the onshore wind power

- Offshore wind power is the use of wind farms constructed in bodies of water, **usually in the ocean on the continental shelf**, to harvest wind energy to generate electricity. While, **Onshore wind** refers to **turbines** located on land.
- One of the primary reasons for moving towards off-shore projects is the lack of suitable wind turbine sites on land.
- Since **wind speed is higher**, the offshore wind power's electricity generation is higher per amount of capacity installed. Also, because of **consistent wind speed**, the effective use of wind turbine generating capacity will be higher at sea than on land.
- As these sites are located far from land, they **have less visual impact** which helps with public acceptance issues.
- The off-shore wind farms are usually **located near to the cities and load centres** thus transmission losses are minimised.
- The off-shore wind farms **have low global warming potential** per unit of electricity generated, comparable to that of onshore wind farms.

Challenges of Wind Power:

- **Competition with conventional generation sources on a cost basis.** Even though the cost of wind power has decreased dramatically in the past several decades, wind projects must be able to compete economically with the lowest-cost source of electricity, and some locations may not be windy enough to be cost competitive.
- **Good land-based wind sites are often located in remote locations, far from cities where the electricity is needed.** Transmission lines must be built to bring the electricity from the wind farm to the city.
- **Wind resource development might not be the most profitable use of the land.** Land suitable for wind-turbine installation must compete with alternative uses for the land, which might be more highly valued than electricity generation.
- **Turbines might cause noise and aesthetic pollution.** Although wind power plants have relatively little impact on the environment compared to conventional power plants, concern exists over the noise produced by the turbine blades and visual impacts to the landscape.
- **Wind plants can impact local wildlife:** Birds and bats get killed by flying into spinning turbine blades. Wind projects can alter the habitat on which they are built, thus impacting the biodiversity.

Steps taken by India to promote wind energy

- **National Offshore Wind Energy Policy, 2015:** The objective of this policy is to explore and promote deployment of Offshore Wind Farms in the Exclusive Economic Zone (EEZ) of the

country, including those under Public Private Partnership. Also, to promote Research and Development; create skilled manpower and employment and develop coastal infrastructure and supply chain to support heavy construction & fabrication work in the Offshore Wind Energy Sector.

- **National Wind Solar Hybrid Policy, 2018:** This policy essentially aims at establishing a structure on the basis of which large-scale wind-solar hybrid power projects can be promoted. Further, the objective of the policy is to optimise and improve the efficacy of the usage of transmission infrastructure and land, which in turn will mitigate inconsistencies associated with the generation of renewable power and help in attaining better grid stability. Apart from that, the policy will also stimulate the development of solutions and technological advancements in the field of wind-solar hybrid power generation.

13.3.2. Tidal Energy

It is harnessed while the tides are flowing in and out. The main criteria for a tidal power generation site are that the mean tidal range must be greater than 5 metres. A dam is built across the entrance to a bay or estuary creating a reservoir. As the tide rises, water is initially prevented from entering the bay. Then when tides are high and water is sufficient to run the turbines, the dam is opened and water flows through it into the reservoir (the bay), turning the blades of turbines and generating electricity. Again, when the reservoir (the bay) is filled, the dam is closed, stopping the flow and holding the water in reservoir when the tide falls (ebb tide), the water level in the reservoir is higher than that in the ocean. The dam is then opened to run the turbines (which are reversible), electricity is produced as the water is let out of the reservoir. La Rance in France is the biggest commercial power station (240 MW) operating in the world.

India and Tidal Energy

- As per estimates, India has a potential of 8,000 MW of tidal energy. This includes about 7,000 MW in the Gulf of Cambay in Gujarat, 1,200 MW in the Gulf of Kutch and 100 MW in the Gangetic deltas in the Sunderbans region of West Bengal.
- Despite the huge potential, India has no policy on tidal energy.
- Tidal energy cannot be presently harnessed on commercial basis due to high capital cost ranging from Rs. 30 crores to 60 crores per MW.

13.3.2.1. Hydropower Energy

Generation of electricity by using the force of falling water (Kinetic Energy) is called hydroelectricity or hydel power. The basic principle behind hydropower energy is the damming of rivers to create artificial waterfalls, sometimes natural waterfalls are also used. The falling water is used to turn the turbines that drive electrical generators. One of the greatest advantages of hydropower is that once the dam is built and turbines become operative, it is relatively cheap and clean source of energy.

India and Hydropower Energy

India is blessed with a rich hydropower potential. In the exploitable potential terms, India ranks fifth in the world. India has 3 major rivers: the Indus, the Brahmaputra, and the Ganga. It also has three major river systems i.e. central Indian, west flowing rivers of south India, and east flowing rivers of south India having a total of 48 river basins. The total potential from these river basins is 600TWh (Terawatt Hours) of electricity.

Large Hydro Energy

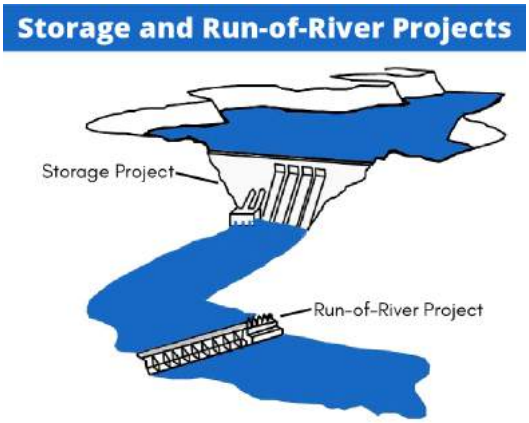
Hydro power plants of capacity more than 25 MW are classified as large hydro. It has four major advantages i.e. it is a source of green energy, has low variable cost, it is grid friendly and it can also can sub serve other purposes by irrigation, flood control, etc.

Hydroelectric projects can be classified on the basis of purpose, hydraulic features, capacity,

head, constructional features, mode of operation, etc. The main types are:

Student Notes:

- **ROR (Run of River):** There are not large reservoirs; a part of water flow is diverted to the plant which is adjacent to the river. After generation the flow is diverted back to the main flow through the tail race. This type of hydro plants requires a diversion dam and has unregulated water flow.
    - In recent years, run-of-the-river hydropower projects have emerged as a viable, low-impact alternative to existing large-scale projects. For instance, Baglihar Dam, Nathpa Jhakri and Shringar Hydropower Station, Ratle Hydroelectric Plant, Maheshwar Hydropower Plant and Kishanganga Hydroelectric Plant are all under ROR projects.



- **Dam Storage:** In these types of hydro plants, large reservoirs are created by the construction a sizeable dam across the river and the plants is situated at the toe of the dam. Here, water could be regulated to generate electricity depending upon the demand. For instance, Bhakra dam or Indirasagar dam.
- **Pumped Storage**: These types of plants have two reservoirs, one at the upstream of the power plant and one at the downstream. When there is low peak demand, the water from the reservoir situated downstream is pumped back to the upstream reservoir. For example, Srisailam, Tehri, Nagarjunasagar, Sardar Sarovar dams.

Recent steps taken by government to promote Large hydropower:

The identified hydropower potential of India is 1,45,000 MW. However, the current installed capacity of hydropower in the country stands at just 46,000 MW. Only about 10,000 MW of hydropower has been added in the last 10 years. The hydropower sector is currently going through a challenging phase and the share of hydropower in the total capacity has declined from 50.36% in the 1960s to around 13% in 2018-19.

However, India is committed to promote hydropower energy and reach an installed capacity of 70,000 MW by 2030. To reach this target following steps have been taken:

- Large Hydropower Projects (LHPs) have been declared recently as a Renewable Energy source.
- New LHPs will also be covered within non-solar Renewable Purchase Obligation.
- Steps to be taken for tariff rationalisation and budgetary support to be provided for flood moderation cost and cost of enabling infrastructure i.e. road and bridges etc. depending upon case to case basis.

Small Hydro Energy

In India, hydro power plants of 25MW or below capacity are classified as small hydro, which have further been classified into micro (100kW or below), mini (101kW-2MW) and small hydro (2-25MW) segments. Their estimated potential is of 21000 MW. The hilly States of India mainly Arunachal Pradesh, Himachal Pradesh, Jammu & Kashmir and Uttarakhand constitute around half of this potential. Other potential States are Maharashtra, Chhattisgarh, Karnataka and Kerala.

Small Hydropower Programme (SHP)

The objective of the SHP scheme is to encourage the State Government entities and Independent Private Producers (IPPs) to set-up new Small Hydro projects so as to realise the entire 21000 MW potential in phased manner. The immediate objective is to encourage IPPs to start work on new projects of aggregate capacity of 1000 MW, in addition to completing the ongoing projects, so as

to reach a cumulative capacity of 6000 MW by the year 2022. The scheme also envisages support to set-up watermills for electrical and mechanical applications in remote and far-flung areas.

Student Notes:

Challenges associated with Hydropower:

- **Lack of enabling infrastructure**- such as roads, bridges to access remote areas where such potential sites are available.
- Delay due **to land acquisition**- for dam, power house etc.
- Delay due to **environment and forest clearances**.
- **Rehabilitation and Resettlement**-which invite opposition from locals for employment, extra compensation etc. It also creates law and order problems like blasting, muck disposal.
- **Cultural/ Religious Issues**- sentiments attached with rivers
- **Political will-** lacks political traction due to long gestation period, Interstate issues, especially over Riparian rights. E.g. Mullaperiyar Dam (between Kerala and Tamil Nadu)
- **High Tariff of Hydro Projects**- as compared to other sources of power (conventional as well as renewable sources) mainly due to construction of complex structures which have long gestation period, unavailability of loans of lower interest rate & longer tenures, high R&R cost, infrastructure etc.
- **Financing Issues**- High cost of Finance and lack of long tenure funding for hydropower projects.
- **Levying of water cess** by the States- e.g. J&K

13.3.2.2. Biomass Energy

Biomass is a renewable energy resource derived from plants and animal waste. The energy from biomass (biomass conversion) is released on burning or breaking the chemical bonds of organic molecules formed during photosynthesis. Thus, biomass represents an indirect form of solar energy. Biomass fuels can be used directly or they can be transformed into more convenient form and then used.

- Biomass is an important source of energy and the most important fuel worldwide after coal, oil and natural gas.
- Biomass is renewable and is abundantly available on the earth in the form of firewood, agricultural residues, cattle dung, city garbage etc.
- Bio-energy, in the form of biogas, which is derived from biomass, is expected to become one of the key energy resources for global sustainable development.
    - Any biodegradable (that which can be decomposed by bacteria) substance can be fermented anaerobically (in absence of oxygen) by methane-producing (methanogenic) bacteria.
    - Cow dung or faeces are collected and put in a biogas digester or fermenter (a large vessel in which fermentation can take place).
    - A series of chemical reactions occur in the presence of methanogenic bacteria (CH_4 generating bacteria) leading to the production of CH_4 and CO_2. This process is called Methanogenesis.

INDIA and Biomass Energy

The current availability of biomass in India is estimated at about 500 million metric tonnes per year. India has estimated surplus biomass availability at about 120-150 million metric tonnes per annum covering agricultural and forestry residues corresponding to a potential of about **18,000 MW**. This apart, about 7000 MW additional power could be generated through bagasse-based bio-energy obtained through sugar mills.

The Ministry of New and Renewable Energy promotes installation of biogas plants by implementing two Central Sector Schemes under Off-Grid/distributed and decentralized Renewable Power:

- **New National Biogas and Organic Manure Programme (NNBOMP):** To provide clean cooking fuel for kitchens, lighting and meeting other thermal and small power needs of farmers/dairy farmers /users including individual households and to improve organic manure system based on bio slurry from biogas plants in rural and semi urban areas by setting up of small size biogas plants of 1 to 25 Cubic Metre capacity.

Petrocrops/Bio-diesel:

- These are hydrocarbon producing plants. They can be grown on land which are unfit for agriculture and not covered with forests. They can provide inexhaustible source of liquid energy.
- The plant species belonging to families Asclepiadaceae, Asteraceae, Anacardiaceae, Euphorbiaceae, Convolvulaceae, Caprifoliaceae, Lamiaceae, and Moraceae have shown potential of extracting hydrocarbons in an economically viable way.
- These plants provide Biocrude, a complex mixture of liquids, terpenoids, triglycerides, phytosterols waxes, and other modified isoprenoid compounds.
- Hydro cracking of biocrude can convert it into several useful products like gasoline (automobile fuel), gas oil and kerosene.
- Some potential Petro-crop species are Jatropha, Jojoba, Pongamia, Rapeseed, etc.

- **Biogas Power Generation (Off-grid) and Thermal energy application Programme (BPGTP):** To promote biogas based Decentralized Renewable Energy Sources of power generation (Off-Grid), in the capacity range of 3 kW to 250 kW or thermal energy for heating/ cooling applications from the biogas generation produced from Biogas plants of 30 M3 to 2500 M3 size.

GOBAR (Galvanizing Organic Bio-Agro Resources) DHAN scheme, 2018: It focuses on managing and converting cattle dung and solid waste in farms to useful compost, biogas and bio-CNG, thus keeping villages clean and increasing the income of rural households. It was launched under **Swachh Bharat Mission (Gramin)**.

Biomass Gasification: It is the process through which solid biomass material is subjected to partial combustion in the presence of a limited supply of air.

- Solid fuel is converted by a series of thermo-chemical processes like drying, pyrolysis, oxidation and reduction to a gaseous fuel called Producer gas.
- Producer gas consists mainly of carbon monoxide, hydrogen, and nitrogen.

13.3.2.3. Biofuel

Types of Biofuels: Depending upon sources of biomass, their limitations as a renewable source of energy, and their technological progress.

First generation biofuels: They are also known as conventional biofuels. They are made from sugar, starch, vegetable oil or animal fat. Processes such as fermentation, distillation and transesterification are used to produce primarily ethanol, and in smaller quantities, butanol and propanol.

- Ethanol has one-third of the energy density of gasoline.
- It burns cleaner than gasoline and therefore produces less greenhouse gases. Another 1st generation biofuel, called biodiesel, is produced when plant oil or animal fat goes through a process called transesterification.

Other than providing energy security, these biofuels also support agricultural industries and rural communities through increased demand for crops. However, it has following disadvantages:

- They pose a threat to food prices since the biomass used are food crops such as corn and sugar beet.
- It competes with food and animal feed thus increasing their prices.
- They have the potential to disturb biodiversity and create water scarcity in some regions.
- They require lots of land to grow.

- They also only provide a small benefit over fossil fuels in regards to greenhouse gases since they still require high amounts of energy to grow, collect, and process.
- First generation biofuels are also a more expensive option than gasoline, making it economically unfavourable.

Second generation biofuels: They include wood, organic waste, food waste, straw and farm residues and **specific biomass crops which are non-edible**. Thermochemical or biochemical reactions breakdown the lignin/glue in these plants to produce syngas (a mixture of carbon monoxide, hydrogen and other hydrocarbons). Hydrogen can be used as a fuel and the other hydrocarbons can be used as additives to gas oil. These biofuels don't compete between fuels and food crops and generate higher energy yields per acre than 1st generation fuels. They also allow for use of poorer quality land where food crops may not be able to grow. However, the technology is fairly immature and requires more energy and materials than the first-generation biofuel.

Third generation biofuels: They use **specially engineered crops such as algae** as the energy source. These algae are grown and harvested to extract oil within them. The oil can then be converted into biodiesel through a similar process as 1st generation biofuels, or it can be refined into other fuels.

Advantages of third generation biofuels:

- They are more energy dense than 1st and 2nd generation biofuels per area of harvest.
- They are cultured as low-cost, high-energy, and completely renewable sources of energy.
- Algae can grow in areas unsuitable for 1st and 2nd generation crops, which would relieve stress on water and arable land used. It can be grown using sewage, wastewater, and saltwater, such as oceans or salt lakes.

However, further research still needs to be done to further the extraction process in order to make it financially competitive to other petroleum-based fuels.

Fourth generation biofuels: They are simply a step further from the third-generation biofuels as they **use genetically modified algae and cyanobacteria to enhance biofuel production**. The feedstock is tailored **not only to improve the processing efficiency**, but it is also designed to **capture more carbon dioxide**, as the crop grows in cultivation. In this way, fourth generation biofuels are thought to contribute better to reducing GHG (greenhouse gas) emissions, by being **more carbon neutral or even carbon negative** compared to the other generation biofuels. They epitomize the concept of "**Bioenergy with Carbon Storage (BECS)**". This technology is still under development.

National Policy on Biofuels-2018:

To achieve energy security of the country, the government is targeting to **reduce** import dependence i.e. **usage of fossil fuels by 10% from 2014- 15 levels by the year 2022**. To achieve this target a five-pronged strategy has been adopted, among which National Policy on Bio-fuels-2018 is also included. Some of its important features are:

- Utilization of biofuels will be increased in the energy and transportation sectors of the country by promoting the production of biofuels from domestic feedstock.
- An indicative target of 20% blending of ethanol in petrol and 5% blending of biodiesel in diesel to be achieved by 2030.
- As per the policy biofuels have been categorised as follows:
    - **Bioethanol:** Fuels produced from materials that have sugar such as sugar cane, sugar beet, sweet sorghum, etc.; materials that have starch such as corn, cassava, rotten potatoes, algae, etc.; cellulosic materials such as bagasse, waste wood, agricultural/forestry residues, etc. or other renewable industrial waste.
    - **Biodiesel:** It includes methyl or ethyl ester of fatty acids derived from non-edible vegetable oil, acid oil, used cooking oil, animal fat and bio-oil.

Student Notes:

- **Advanced biofuels:** They include second-generation (2G) ethanol, drop-in fuels, algae-based 3G biofuels, bio-CNG, bio-methanol, dimethyl ether (DME) derived from bio-methanol, bio-hydrogen, drop-in fuels produced from municipal solid waste (MSW), etc.
- **Drop-in fuels:** These are fuels derived from biomass, agri-residues, MSW, plastic wastes, industrial wastes, etc. produced as per Indian standards that can be used in existing engines without having to modify their fuel distribution system.
- **Bio-CNG:** These fuels are purified form of biogas produced from agricultural residues, animal dung, food waste, MSW and sewage water but their composition and energy potential is comparable to fossil-based natural gas.

- As a part of the policy, the government will also undertake the steps to develop and commercialise the mentioned biofuels through various programmes such as Ethanol Blended Petrol Programme (EBP) and Biodiesel Blending Programme.
- The Ministry also plans on creating a 'National Biomass Repository' through a nation-wide appraisal program which will help ensure availability of biofuels produced from domestic feedstock.

PRADHAN MANTRI JI-VAN (JAIV INDHAN- VATAVARAN ANUKOOL FASAL AWASHESH NIVARAN) YOJANA

Details of the scheme

- The scheme under the MoP&NG will provide financial support to Integrated Bioethanol Projects using lignocellulosic biomass and other renewable feedstocks.
- 12 commercial scale and 10 demonstration scale Second Generation (2G) ethanol projects will be provided viability gap funding support over the next six years in two phases: Phase-I (2018-19 to 2022- 23) and Phase-II (2020-21 to 2023-24).
- It also seeks to increase Research & Development in this area.
- The ethanol produced by the scheme beneficiaries will be mandatorily supplied to Oil Marketing Companies (OMCs) to further enhance the blending percentage under Ethanol Blended Petrol Programme.
- Centre for High Technology (CHT), a technical body under the aegis of MoP&NG, will be the implementation Agency for the scheme.

Benefits of the scheme

- Reducing import dependence by way of substituting fossil fuels with Biofuels.
- Achieving the GHG emissions reduction targets through progressive blending/ substitution of fossil fuels.
- Addressing environment concerns i.e. air pollution caused due to burning of biomass/ crop residues and thus improving the health of the citizens.
- Improving farmer income by providing them remunerative income for their otherwise waste agriculture residues.
- Indigenizing of Second-Generation Biomass to Ethanol technologies.
- Creating rural & urban employment opportunities in 2G Ethanol projects and Biomass supply chain.
- Contributing to Swacch Bharat Mission by supporting the aggregation of non-food biofuel feedstocks such as waste biomass and urban waste.

13.3.2.4. Geothermal Energy

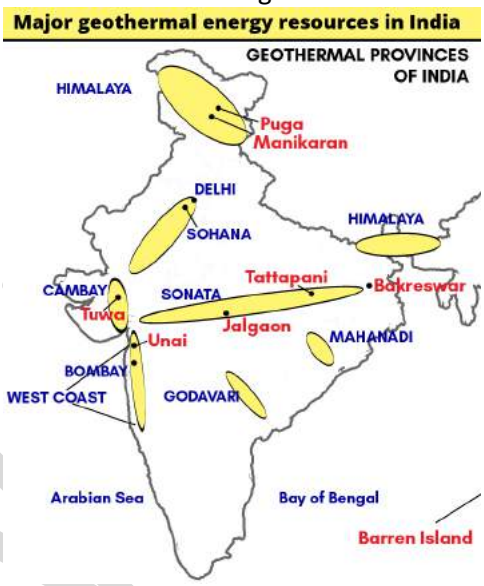
Geothermal energy is the natural heat of the earth. Earth's interior heat originated from its fiery consolidation of dust and gas over 4 billion years ago. It is continually regenerated by the decay of radioactive elements, that occur in all rocks. Major geothermal fields are situated in circum-pacific margins, rift zones of East Africa, North Africa, Mediterranean basin of Europe, and across Asia to Pacific. There are four major types of Geothermal energy resources.

- Hydrothermal
- Geopressurized brines
- Hot dry rocks
- Magma

Currently, only hydrothermal energy is being commercially used for electricity generation and for meeting thermal energy requirements.

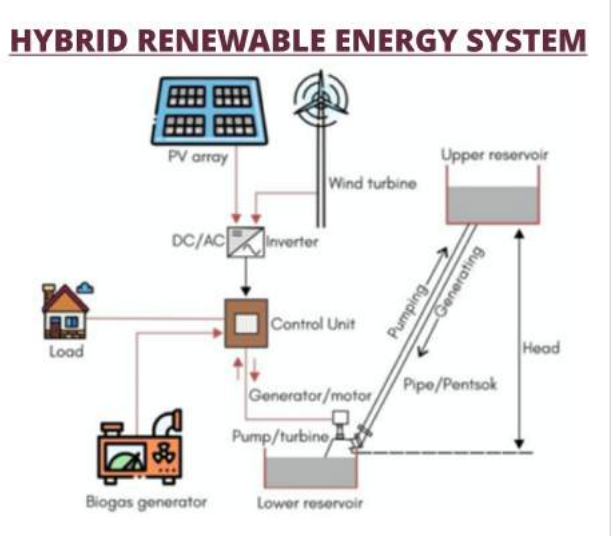
Geothermal Energy in India

- In India, North-western Himalayas and the western coast are considered geothermal areas.
- Geological Survey of India has already identified more than 350 hot spring sites, which can be explored as areas to tap geothermal energy.
- The estimated potential for geothermal energy in India is about 10000 MW.
- There are seven geothermal provinces in India i.e. the Himalayas, Sohana, West coast, Cambay, Son-Narmada-Tapi (SONATA), Godavari, and Mahanadi.
- The Puga valley in the Ladakh region has the most promising geothermal field.
- It is being used mainly for poultry farming, mushroom cultivation, and pashmina-wool processing, all of which need higher temperature.



13.3.2.5. Hybrid Renewable Energy

It usually comprises of two or more renewable energy sources combined in such a way to provide an efficient system with appropriate energy conversion technology connected together to feed power to local load or grid. There are different types of hybrid renewable energy systems like Biomass-wind-fuel cell, Photovoltaic-wind, Hydro-wind and Photovoltaic-Biomass etc.



National wind-solar hybrid policy:

The main objective of the Policy is to provide a framework for promotion of large grid connected wind-solar PV hybrid system for optimal and efficient utilization of transmission infrastructure and land and achieving better grid stability. It aims to encourage new technologies, methods and way outs involving combined operation of wind and solar PV plants.

- **Implementation strategy**
  - Configurations and use of technology
    - ✓ **Wind-Solar Hybrid- AC integration**: In this configuration the AC output of the both the wind and solar systems is integrated either at LT side or at HT side.
    - ✓ **Wind-Solar Hybrid- DC integration**: In this DC output of the both the wind and solar PV plant is connected to a common DC bus and a common invertor suitable for combined output AC capacity is used to convert this DC power in to AC power.
  - **New** Wind-Solar Hybrid Plants and **hybridisation** of existing wind/solar PV plants.

Student Notes:

- **Battery Storage**: Battery storage may be added to the hybrid project to reduce the variability of output power and higher energy output as well as to ensure availability of firm power for a particular period.

- **Regulatory requirements**: The Central Electricity Authority and CERC shall formulate necessary standards and regulations for wind-solar hybrid systems.
- **Standard and quality**: For wind turbines, solar modules and balance of systems, the technical guidelines issued by the Ministry from time to time for grid connected systems will be followed.
- **Incentives:** The Government will encourage development wind-solar hybrid systems through different schemes and programmes. All fiscal and financial incentives available to wind and solar power projects will also be made available to hybrid projects.
- **Research and development:** Government will support the technology development projects in the field of wind-solar hybrid systems. Besides, support will be provided for development of standards for hybrid systems.

Benefits of hybrid renewable energy parks

- **Enhanced and flatter power output**: Hybrid parks make power generation profile flatter over time compared to a pure wind or solar installation to eliminate rapid voltage and power fluctuations in the electrical grid, make power dispatch more schedulable.
- **Optimised use of the network**: Number of instruments connectable is limited and hence maximise the use of the existing network/instruments.
- **Continuous power supply**: The hybrid solar systems provide power continuously, due to integration of multiple renewable sources like solar, wind, hydro etc.
- **Efficient use of land:** Due to common use of land for different energy resources in hybrid energy parks improves land use efficiency.
- **Lower consumer price**: Lower investment, running and transmission cost in hybrid renewable energy parks will reduce the cost of power.
- **Reduced losses**: They are beneficial in terms of reduced line and transformer losses, reduced environmental impacts, increased system reliability, improved power quality and increased overall efficiency.

Concerns with hybrid renewable energy parks

- **High installation cost**: Initial investment for the installation of a hybrid renewable energy systems is high as compared to installation of pure wind or solar systems.
- **Grid security and stability**: These systems can be connected to a utility grid and often frequency mismatch arises between both systems leads to instability of the overall system.
- **Environmental impact:** There are concern about the impact of renewable energy parks on ecology and wildlife in the region.
- **Resource location:** Hybrid renewable energy plants require large areas of space, hence availability and acquisition of such large scale of land delaying the installation of parks.
- **Weather condition:** As energy generation from park is dependent on associated local weather and if favourable weather is not available then operating capacity of park becomes inefficient and unfeasible

(PROPOSED) Scheme for "Development of Wind Parks/ Wind-Solar Hybrid Park":

The Ministry of New and Renewable Energy has identified sites across seven states, Tamil Nadu, Andhra Pradesh, Karnataka, Telangana, Gujarat, Rajasthan and Madhya Pradesh to set up wind-solar hybrid parks.

- The capacity of each park proposed is around 500 MW and more but shall not be less than 50 MW.
- Centre will provide financial assistance for development of parks.

- State Government will select park developer and facilitate the park developer in acquisition/ leasehold of the identified site, in obtaining all statutory clearances.
- Wind Energy Park will provide a plug and play solution (availability of land, transmission, necessary infrastructure and necessary approvals) to the investors for installing wind/ wind-solar power projects.
- Jaisalmer Wind Park, Rajasthan with installed capacity of 1,064 MW is largest wind park in India.

13.3.2.6. Hydrogen Energy

When hydrogen gas burns in the air or in fuel cells, it combines with oxygen gas to produce non-polluting water vapour and fuel cells directly convert hydrogen into electricity. Widespread use of hydrogen as fuel would greatly reduce the problem of air pollution and danger of global warming because there will not be any CO_2 emission. The current global demand of hydrogen is 70 million tons per year, most of which is being produced from fossil fuels — 76% from natural gas and around 23% from coal, with the remaining from electrolysis of water.

- In India, hydrogen is being commercially produced in the fertilizer industry, petroleum refining and chemical industries and also as a by-product in chlor-alkali industries.
- Cleaner methods of hydrogen production chiefly constitute electrolysis, via chemical or photoelectrochemical routes.

Types of hydrogen depending upon process of extraction

- **Green hydrogen**: It is derived by electrolysis of water, separating the hydrogen atom within it from oxygen using renewable energy (such as wind, solar or hydro) that eliminates emissions during process.
- **Grey hydrogen:** Hydrogen derived using fossil fuels is called as grey hydrogen.
- **Blue hydrogen**: It is derived from natural gas through the process of steam methane reforming (SMR). SMR mixes natural gas with very hot steam, in the presence of a catalyst, where a chemical reaction creates hydrogen and carbon monoxide.

Hydrogen may be a clean source of energy but getting large amount of pure hydrogen for commercial purposes is a problem because hydrogen is present in combination with other elements such as oxygen, carbon and nitrogen thus hydrogen has to be produced from either water or organic compounds like methane etc. requiring large amounts of energy that is hydrogen as a fuel has to be produced using energy present. This is a very costly proposition. Producing hydrogen from algae in large scale cultures will be a good idea.

Advantages of hydrogen-based energy

- **Reduced imports**: Hydrogen as an efficient fuel helps to reduce crude oil import and its use as feedstock for ammonia production reduces India's fertilizer imports. o India is the world's third largest consumer of oil, for which country has to depend heavily on oil imports.
- **Non-polluting & decarbonizing:** The use of hydrogen can reduce the CO_2 related emissions significantly at the point of use and if green hydrogen is used then there is capability to decarbonize the entire value chain, enabling reduced emissions and climate change threats. o Hydrogen fuel cell leave only water vapour and heat as emissions and releases no greenhouse gasses.
- **Abundance:** Hydrogen can be produced locally from numerous sources like methane, gasoline, biomass, coal or water.
- **High efficiency**: Hydrogen is an efficient energy source, means that an automobile that utilizes hydrogen energy travels more miles than one with an equal amount of gasoline.
- **High energy density**: Hydrogen has the highest energy per mass of any fuel, it is 120 MJ/kg, almost three times more than diesel or gasoline.

- **Address energy requirement**: Hydrogen can provide linkages between energy supply and demand, in both a centralized or decentralized manner, thereby enhancing the overall energy system flexibility.

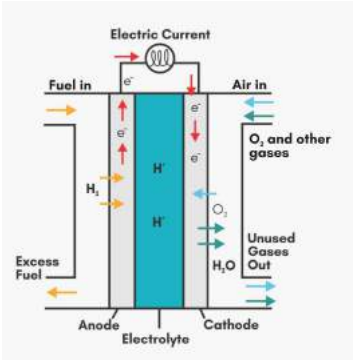
Challenges in growth of Hydrogen based economy

- **Energy intensive:** For e.g. green hydrogen requires a massive expansion of renewable generation to power the electrolysis plants that split water into hydrogen and oxygen.
- **Emissions:** Natural gas reforming process (methane reforming) to produce grey hydrogen requires a fossil-fuel and emits carbon monoxide and carbon dioxide. Hence, not climate friendly.
- **Storage:** Hydrogen is also hard to store, for storage it requires compression to 700 times atmospheric pressure, refrigeration to -253 degree Celsius. As well it can embrittle metal and is more explosive.
- **Additional costs:** In case of centralized production, the cost of hydrogen generation is lower due economies of scale but Transmission & Distribution (T&D) costs are higher, while in decentralized production say at the refuelling station (using on site electrolyser or reformer), the T& D costs are minimized but cost of production is higher.
- **Code of standard:** The biggest challenge to the commercialization of the hydrogen-based technologies is the requirement of code and standards to get a sort of consistency and encourage deployment.

Way forward

- Development of **code of standards** will help in dealing with Hydrogen vehicles in particular and help in progress of Hydrogen economy in a smoother way.
- Advanced **research and technology developments** are necessary to improve the efficiency of fuel cells, tolerant to impurities, use of non-precious metals as catalyst etc.
- Need to develop **safe and cost-effective** solid-state storage methods using development of carbon nanostructures to achieve the desired storage goals.
- Major R&D programmes should be introduced linking with applications which may have market acceptance. For this, large number of demonstrative projects should be supported by Department of Science & Technology in production, storage and application areas in addition to usual development projects.
- **Generation of hydrogen from renewable sources** should be encouraged and Government should explore policies for subsiding hydrogen price generated from renewable.

13.3.2.7. Fuel Cell Technology



Fuel cells are highly efficient power-generating systems that produce electricity by combining fuel (hydrogen) and oxygen in an electrochemical reaction or fuel cells are electrochemical devices that convert the chemical energy of a fuel directly and very efficiently into electricity (DC) and heat, thus doing away with combustion.

Hydrogen and phosphoric acid are the most common type of fuel cells, although fuel cells that run on methanol, ethanol, and natural gas are also available. The most suitable fuel for such cells is hydrogen or a mixture of compounds containing hydrogen. A fuel cell consists of an electrolyte sandwiched between two electrodes. Oxygen passes over one electrode and hydrogen over the other, and they react electrochemically to generate electricity, water, and heat. Compared to vehicles powered by the internal combustion engine, fuel cell powered vehicles have very high-energy conversion efficiency, (almost double that of currently used engines) and near-zero pollution as water vapour is the only emission. They can also be used to store energy to be used as needed. Fuel cells have been used in space flights and being introduced in electric vehicles for reducing urban air

pollution. **Recently (2020) India's first hydrogen fuel cell prototype car had a successful trial run.**

Student Notes:

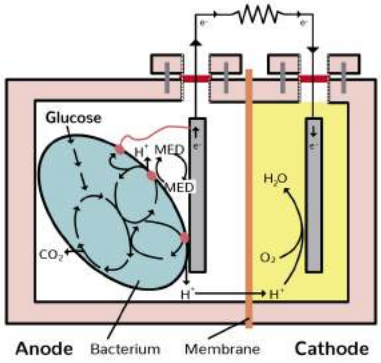
Microbial fuel cells

A microbial fuel cell (MFC) is a bio-electrochemical device that harnesses the power of respiring microbes to convert organic substrates directly into electrical energy.

- It transforms chemical energy into electricity using oxidation reduction reactions
- It relies on living biocatalysts to facilitate the movement of electrons throughout their systems instead of the traditional chemically catalyzed oxidation of a fuel at the anode and reduction at the cathode.
- It has various applications especially where there is low power requirement where replacing batteries may be impractical, such as wireless sensor networks, biosensors etc.

Working of Microbial fuel cells

- It works by allowing bacteria to oxidize and reduce organic molecules. Bacterial respiration is basically one big redox reaction in which electrons are being moved around.
- A MFC consists of an anode and a cathode separated by a cation specific membrane.
- Microbes at the anode oxidize the organic fuel generating protons which pass through the membrane to the cathode, and electrons which pass through the anode to an external circuit to generate a current.



13.3.3. Limitations of Various Alternative Sources of Energy

Source of energy/Fuel	Production	Advantages	Limitations
Solar energy	From natural sunlight	Environment friendly Ample or unlimited availability.	• Limited capacity for storage of sunlight. • Cloud cover may limit usefulness. • Collecting equipment expensive
Wind energy	Windmills with Fans for directing winds	No pollution Available for free Not available everywhere or intermittently available.	Fans of wind mills visual hazards for flying birds and aeroplanes (visual pollution).
Tidal energy	Harnessing tidal power by suitable structures	Free and clean	• Structures (plant) used for harnessing energy expensive. • Plant disrupts natural flow of estuary and concentrate pollutants in the area
Hydel power or Hydropower	Dams built on river for electricity generation	World's hydroelectricity capacity high	• Ecosystems behind dams disturbed. • Human settlements up rooted for building dam. • Habitat loss and consequent biodiversity loss. • Developmental cost high. • Fertile farmland lost and amount of nutrient rich silt on down river agricultural fields reduced.
Nuclear energy	Nuclear fission (splitting of atom) and Nuclear fusion	No air pollution Fuel efficient	• High cost of construction of nuclear plant. • Fear of security and nuclear accidents.

			• Problem of safe disposal of nuclear waste.
Geothermal energy	Wells drilled to trap steam which powers electrical generators. Steam naturally produced from underground water which gets heated due to very high temperature that region.	Environment friendly	• Steam contains Hydrogen Sulphide (H2S) having odour of rotten eggs. • Minerals in the steam corrosive to pipe lines and equipment causing maintenance problems. • Minerals in the water toxic to fish.
Biomass (1) Fuel wood	Cutting trees for fuel wood and burning them straight away	Cheap so popular in under developed and developing countries	• Comparatively low level of energy. • Bulky so difficult to transport. • Burning wood causes air pollution. • Destruction of forests to obtain fuel wood and so desertification. • Release lot of fly ash.
(2) Biomass conversion	Obtaining energy from chemical energy stored in biomass (or live material). Burned directly for cooking or to produce electricity converted to ethanol or methane (biogas)	Renew able energy	• May lead to food shortage because nutrients not returned to soil from biomass. • Growing maize for ethanol requires more energy expenditure than the amount of energy in the form of alcohol retrieved. • Land for growing food used for growing biomass for conversion into fuel.
Solid waste	Waste sorted and burnable material separated	• Decreases cost of fresh disposal • Reduces need for land fill sites	• Causes air pollution for burning releases CO2 and other gases. • Waste such as bleached paper and plastics have chlorine containing compounds which form. dioxins which are highly toxic and suspected to be carcinogenic.

13.4. Non-Renewable Energy Sources

These are a finite energy resource that means they are non-renewable resources and once consumed they are lost forever. There are three major forms of fossil fuels: coal, oil and natural gas and on worldwide basis they provide approximately 90% of energy consumed.

13.4.1 Thermal Energy

As of July 2020, India has a total Thermal installed capacity of 231.45 GW. Almost 86% of the thermal power is obtained from coal and the rest from Lignite, Diesel and Gas.

13.4.1.1. Coal

It is formed from plants and vegetation buried, 'in situ' or drifted in from outside to a place, which got covered by deposits of sediments. Coal is a solid fossil fuel and a sedimentary rock composed primarily of carbon. There are three basic grades of coal i.e. lignite (brown coal), bituminous (soft coal) and anthracite (hard coal).

13.4.1.2. Coal Supply in India

India has huge coal reserves, at least 84,396 million tonnes of proven recoverable reserves. This amounts to almost 8.6% of the world reserves and it may last for about 230 years at the current Reserve to Production (R/P) ratio. In contrast, the world's proven coal reserves are expected to last only for 192 years at the current R/P ratio. India is the fourth largest producer of coal and

lignite in the world. Coal production is concentrated in these states (Andhra Pradesh, Uttar Pradesh, Bihar, Madhya Pradesh, Maharashtra, Orissa, Jharkhand, West Bengal).

Student Notes:

Reasons for stress of Thermal Power Plants

- After the cancellation of 204 coal mines by the Supreme Court in 2014, many of the power **projects became stranded** without arrangements of adequate fuel supply. In addition, many projects were setup without firm coal linkages from Coal India Limited (CIL) leading to high cost of generation.
- **Slow growth in power demand**- Lower than anticipated growth in power demand coupled with a scenario of surplus supply has resulted in under-utilization of thermal power capacity. In addition to this low offtake/ difficulty in selling costlier power are also causing stress in thermal power projects.
- **Delayed payments by DISCOM's**- Delay in realization of receivables from DISCOMs impairs the ability of project developers to service debt in a timely manner and leads to exhaustion of working capital. In some cases, the DISCOM's have pressed for renegotiating terms of Power Purchase Agreement (PPA). This, coupled with non-payment of penalties / Late Payment Surcharges (LPS) is causing financial stress for such projects.
- **Inability of the promoter to infuse equity and service debt**- Many projects got delayed due to financial reasons and slow implementation by developers leading to project cost overruns.
- **Other Issues include** delay in disbursement / non-agreement amongst FIs, Delays in approval of working capital by lenders, Regulatory and contractual disputes, etc.

Steps taken by Government to tackle stress in Power Sector

- Fuel linkages under SHAKTI (Scheme for harnessing & allocating koyla transparently in India).
- Pilot scheme for procurement of 2500 MW power to address the problem of lack of Power Purchase Agreements (PPAs) in the country on competitive basis.
- Rationalization of Coal Escalation Index which will largely take care of the issues of under recovery of the generator's dues.
- Additional cost implication to meet the new environment norms shall be considered for being made pass through in tariff.
- Allowing pass-through of any change in domestic duties, levies, cess, and taxes imposed by the government.
- A new App **PRAAPTI** (Payment Ratification and Analysis in Power Procurement for Bringing Transparency in Invoicing of generators) has been launched to bring more transparency in the payment system by DISCOMs.
- Other steps include DISCOM reforms, Coal linkage rationalization, etc.

Recommendation of Cabinet committee to revive Thermal Power Plants:

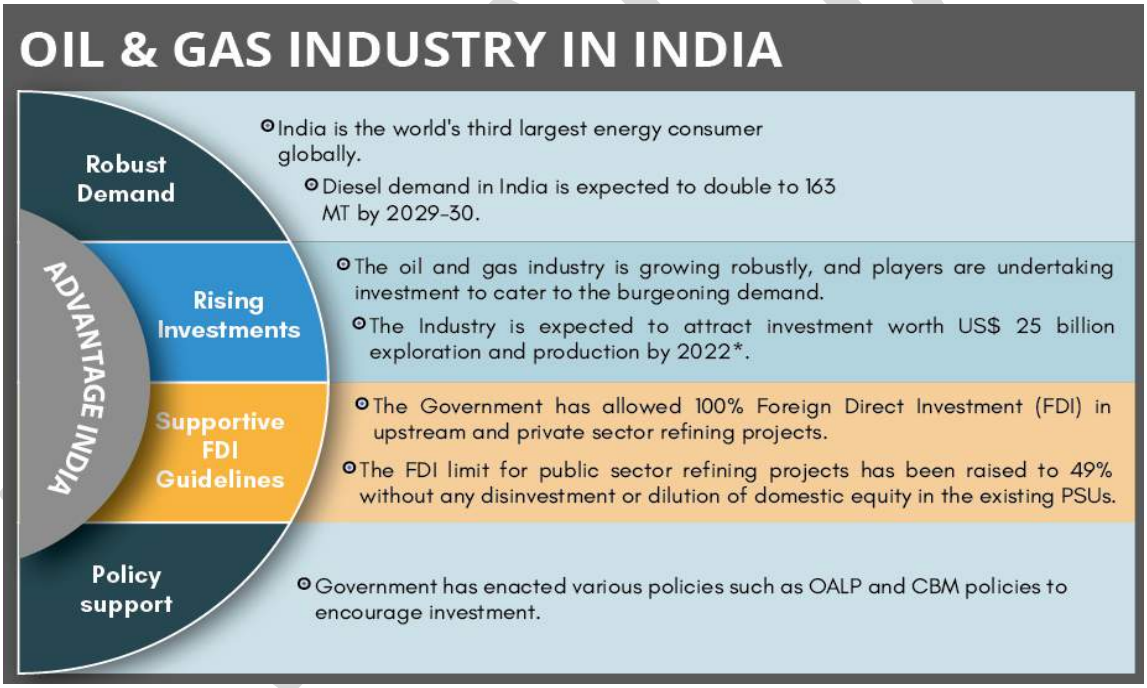
- **Recommendations for Coal Allocation/Supply**
  - **Coal linkage for short term PPA**: Linkage coal may be allowed to be used against short term PPAs and power be sold through Discovery of Efficient Energy Price (DEEP) portal following a transparent bidding process.
  - **Termination of PPAs**: A generator should be able to terminate PPA in case of default in payment from the DISCOM with the facility to use linkage coal for short term PPAs for a period of maximum of 2 years or until they and another buyer of power under long/medium term PPA, whichever is earlier.
  - **Procurement by nodal agency**: A nodal agency may be designated which may invite bids for procurement of bulk power for medium term for 3 to 5 years in appropriate tranches, against predeclared linkage by Coal India Limited (CIL).
  - **PSU as an aggregator of power**: National Thermal Power Corporation (NTPC) can act as an aggregator of power, i.e., procure power through transparent competitive bidding process from such stressed power plants and offer that power to the DISCOMs against PPAs of NTPC till such time as NTPC's own concerned plants/units are commissioned.

Student Notes:

- E-auction of coal: Ministry of Coal may earmark for power, at least 60 per cent of the e-auction coal, and this should be in addition to the regular coal requirement of the power sector.
- **Linkages to be provided at notified prices without bidding**: The generator should be required to bid only once, for the procurement of PPA and linkage should be granted at notified price without any further bidding, to the extent of incremental coal production.

- **Recommendations to facilitate sale of power of the stressed power plants**- Old and high heat rate plants not complying with new environment norms may be considered for retirement in a phased and timebound manner at the same time avoiding any demand/supply mismatch.
- **Recommendations on Regulatory & DISCOM payment issues**
  - Late Payment Surcharge be mandatorily paid in the event of delay in payment by the DISCOM.
  - PFIs providing the Bill Discounting facility may also be covered by TPA i.e. in case of default by the DISCOM, the RBI may recover the dues from the account of States and make payment to the PFIs.
- **Other recommendations**: PPAs, Fuel Supply Agreement and Long-Term Open Access for transmission of power, EC/FC clearances, and all other approvals including water, be kept alive and not cancelled by the respective agencies even if the project is referred to NCLT or is acquired by any other entity.

13.4.2. Petroleum or Mineral Oil



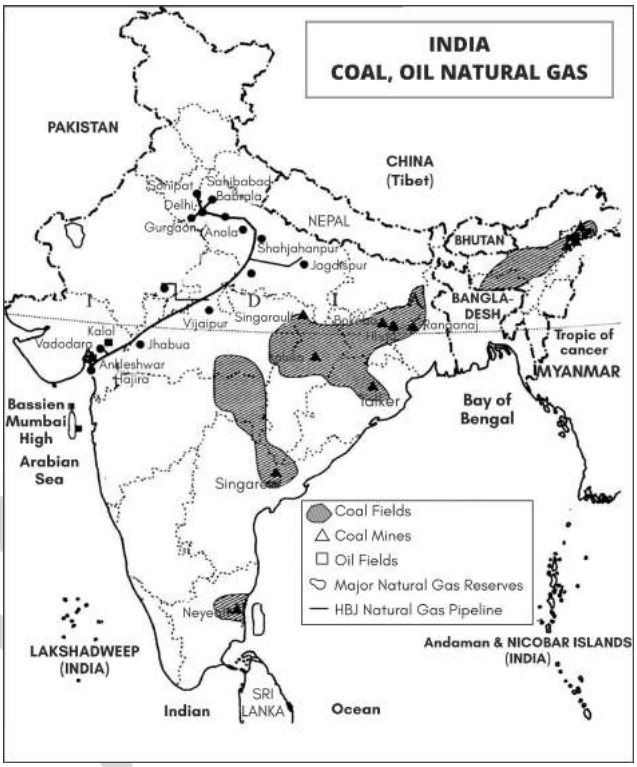
Oil and gas were formed from the remains of plants and animals that once lived in the sea. For over millions of years these remains remained buried under mud and rock under great pressure and at high temperatures. Under these conditions marine biomass gradually changed into oil and gas. Oil and gas are primarily found along geologically young tectonic belt at plate boundaries, where large depositional basins are more likely to occur.

Deposits of crude oil and natural gas are usually trapped together under the sea floor or earth's crust on land. After it is extracted, crude oil is sent to refineries where it is heated and distilled to separate it into components with different boiling points. The important components are gases, gasoline, aviation fuel, kerosene, diesel oil, naphtha, grease and wax and asphalt. Some of the products of oil distillation are called petro-chemicals which are used as raw material for the manufacture of pesticides, plastics, synthetic fibers, paints and medicines etc.

13.4.3. Natural Gas

Natural gas, primarily consist of methane, is often found above reservoirs of crude oil. It also contains smaller amount of ethane, propane and butane. Natural gas is a clear and environment friendly fuel and used directly for cooking purpose in homes. It can be supplied directly to the homes and factories through a network of underground pipelines thus eliminate the need for additional storage and transport. Natural gas burns with smokeless flame and on burning does not produce any poisonous gas or pollute the environment friendly gas.

- **Conventional natural gas**: It lies above most reservoirs of crude oil. This gas is used for the production of petrochemicals and fertilizers.
- **Unconventional natural gas:** It is found by itself in other underground reservoirs. When a natural gas field is tapped, propane and butane gases, present in natural gas are liquefied and removed as liquefied petroleum gas (LPG). LPG is stored in pressurized tanks or cylinders for use as cooking gas. At a very low temperature natural gas can be converted to liquefied natural gas (LNG).



13.4.3.1. Oil and Gas in India

Oil and gas sector is among the eight core industries in India and plays a major role in influencing decision making for all the other important sections of the economy. India's economic growth is closely related to its energy demand, therefore, the need for oil and gas is projected to grow more, thereby making the sector quite conducive for investment. India has been the fourth-largest Liquefied Natural Gas (LNG) importer since 2011 after Japan, South Korea, and China.

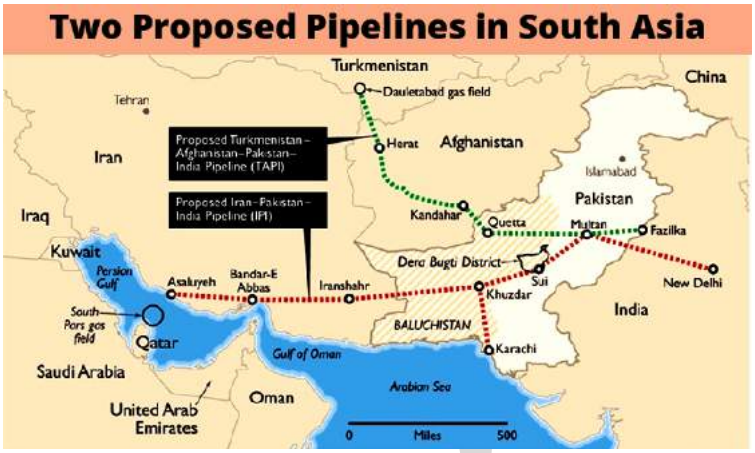
Security of gas supply

India's growing dependence on imported natural gas, reaching 43% of the total gas supply in 2016 compared to 29% in 2006, requires more attention from policy makers to assure the security of gas supply. Key factors that constitute natural gas security for India are:

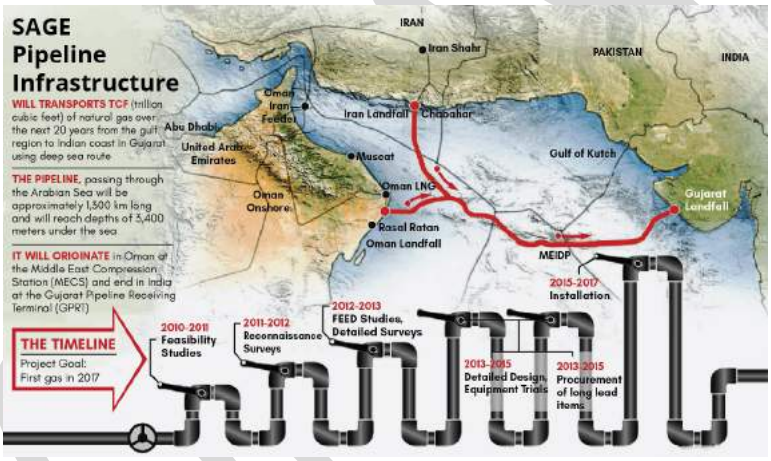
- **Domestic Gas production**: Gas supply security in India has been mainly a domestic supply issue, with a shortfall caused by the KG-D6 production shutdown and slower than expected development of the exploration and production sector over the past decade in spite of objectives to double domestic output.
- **The diversity of the gas and LNG import portfolio:** India is moving from being a diversified gas importer in 2018 to a diversified LNG importer, as LNG imports already cover around 50% of natural gas consumption in 2019. However, if additional imports of LNG are not sourced from a diverse set of producers, India risks moving closer to the exposed LNG importer category.
- **Emergency Response Strategy**: India has no dedicated policy or emergency response strategy to address an unexpected shortfall in, or disruption to the supply of, natural gas by acquiring additionally available LNG from the global markets. It also does not have any underground storage infrastructure as developed in USA, Canada and Europe.

Student Notes:

- **Pipeline import options:**
  - The Iran via Pakistan to India, **IPI Pipeline** was put on hold in 2008 following sanctions against Iran by the United States.
  - There are **geo-political concerns** over Turkmenistan via Afghanistan and Pakistan to India (TAPI Pipeline) as they cross through unstable transit regions of Afghanistan and Pakistan.



  - The Middle East to India Deepwater Gas Pipeline (MEIDP) from Oman to India proposed by the South Asia Gas Enterprise (SAGE) to bypass the EEZ of Pakistan and create a Gas Highway connecting the Gas-Rich Gulf & Middle East regions to India, is still pending.



Challenges:

- **Gas pricing:** The price of domestic gas is lower than that of (imported) LNG. For natural gas to compete in India, costs have to come down, including through rationalisation of subsidies for coal and LPG and adjustment of the GST. Since natural gas does not fall under the GST, gas consumption is taxed at several state and central government levels, in addition to the gas transport tariffs.
- **Market:** There is no trading hub yet in India. The creation of a gas hub would allow transparent price discovery on the basis of buyers and sellers interacting in an open market, and has the potential to remove the multiple price regimes in India.
- **Regulatory issues:** There is unclear regulatory oversight of midstream/downstream activities. Multiple agencies with overlapping functions exist such as PNGRB, the MoPNG, NITI Aayog and state-level authorities. There are frequent policy changes as well which deter investment.

Recommendations by NITI Ayog: The Government of India should,

- Foster the **creation of a liquid market** for natural gas in India, gradually moving from gas allocation and multiple pricing regimes to the creation of a gas hub.
- Strengthen and **clarify the roles and responsibilities** with regard to the regulatory supervision of natural gas market activities (upstream, midstream and downstream) to ensure a **non-discriminatory access regime** to pipeline capacity so that both LNG imports and new gas discoveries can find their way to markets and investment in gas transport and storage is encouraged.
- Ensure gas is treated on a **level playing field** with other fuels for taxation and is included under the GST, as the country strives to increase the share of gas in total energy supply.

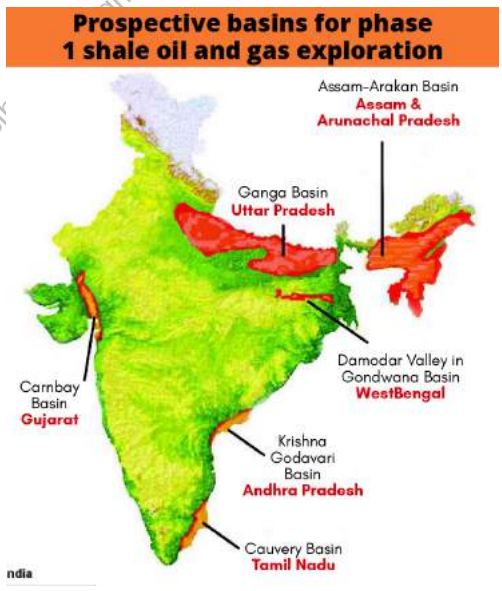
Student Notes:

Exploration and production policies:

To address production declines from mature basins, the GoI has taken several measures to enhance exploration and production (E&P) of oil and gas in the country:

- **Hydrocarbon Exploration and Licensing Policy (HELP):** Approved in March 2016 and implemented since July 2017, the HELP replaced the previous licensing policy, the New Exploration Licensing Policy (NELP), which was criticised for its narrow scope and long, burdensome procedures. The HELP unifies the permitting authority into a single register to grant licenses for E&P and covers both **conventional and non-conventional oil and gas resources.** It also introduced pricing and marketing freedom.
- **Open Acreage Licensing Policy (OALP):** The HELP introduced the OALP in 2017 to further encourage companies to seek permission for exploration of any block at any time by submitting an expression of interest. Previously, there were formal bidding rounds led by the GoI and E&P activities were limited to blocks approved by it.
    - Under the OALP I (concluded in 2018), II (concluded in 2019) and III (ran parallel with II), a total of 87 blocks covering an area of 118 280 km2 have been awarded so far; 61% of the blocks, equivalent to 51% of the awarded area, were won by private companies, mainly Vedanta (51 blocks), HOEC (1 block) and BP–RIL (1 block).
- **National Data Repository:** In support of the OALP, the government launched the National Data Repository in June 2017. It is a comprehensive archive of geo-scientific data for E&P activities. By allowing companies to access the data through an e-platform and consult relevant information, the government helped the interested parties in making bidding decisions.
- **Discovered Small Field Policy**: Launched in 2016 with an objective to tap unmonetized small oil/gas discoveries in India, Discovered Small Field provides an easy and low-risk investment option for interested parties to encourage E&P activities.
- **Enhanced recovery and unconventional hydrocarbons** are supported by the government's policy incentives, including systemic assessment of domestic fields with enhanced recovery potential, evaluation of enhanced recovery techniques, and fiscal incentives to alleviate the risk factors and costs associated with enhanced recovery projects.

The HELP marked an important transition from regulation to liberalisation of India's E&P sector; it is a very significant upstream reform of the fiscal regime. Despite this positive progress, India's growing oil demand is unlikely to be met by new production alone given the country's limited resource base.



13.4.4. Shale Gas

Shale gas is a form of natural gas (mostly methane), found underground in shale rock. It is classified as **'unconventional'** because it is found in shale, a less permeable rock formation than sandstone, siltstone or limestone in which **'conventional'** gas is found, and it is generally distributed over a much larger area. Shale gas and oil are usually found at depths of about 2500-5000 m.

Method of extraction

Shale fluid (a mixture of pressurized water, chemicals, and sand) is forcefully injected into the ground in order to break/fracture the low permeable rocks for unlocking the shale gas reservoir. This process is known as **fracking/Hydraulic fracking.**

- It involves deep vertical drilling followed by horizontal drilling.

Student Notes:

- It has to be noted that, fracking requires around 5-9 million litres of water per extraction activity.

Benefits of using Shale Gas:

- It is a clean fuel when compared to other fossil fuels. It emits only around half the CO2 emissions from Coal and almost no oxides of sulfur (SOx) and Nitrogen (NOx) or soot when burned.
- Can be used to make plastics, chemicals, fertilizers, and hydrogen.
- Shale gas could also decrease energy costs because massive shale gas production would likely cause a significant decline in natural gas prices.

Challenges associated with Shale gas:

- It contains 80-95% methane, a potent Green House Gas (GHG).
- Water pollution due to runoff of fracking chemicals.
- The shale fluid containing toxins including arsenic which is absorbed in the underground.
- Fracking has also been linked to earthquakes due to forceful injection of shale fluid that causes tremors.
- It consumes a huge amount of water and is bound to impact irrigation and other local requirements.
- Disposal of water used for fracking is another greater challenge as huge quantity need to be reprocessed before draining them out.
- Investments in fracking also likely to delay much-needed investments in renewable energy.

13.4.5. Coal Bed Methane

Coal bed methane (CBM) is a form of natural gas which can be recovered from coal deposits or coal seams (a coal deposit is a geographical location containing mineable accumulations of coal while a coal seam is entrapment of coal in underlying rock). The gas is formed during the natural conversion of plant material into coal, known as coalification. When coalification occurs, the coal becomes saturated with water and methane gas is trapped within it. CBM can be recovered from coal deposits and seams through drilling and extraction. It can be used in power generation, as a CNG fuel, as feedstock for fertilisers and for industrial uses such as in cement production, rolling mills, steel plants, and for methanol production.

Challenges associated with CBM:

- Methane is **a greenhouse gas** emitted through CBM.
- Extraction of CBM can result in ecosystem damage.
- CBM production behavior is complex and difficult to predict in the early stages of recovery.
- W**ater discharges from CBM development could potentially harm the downstream water sources.**

13.4.6. Nuclear Energy

Nuclear energy is the energy of the atomic nucleus. Radioactive minerals are used to generate nuclear energy through high technological methods. Similar to other minerals, availability of ore of radioactive material is finite and limited. However, a very small quantity of radioactive minerals can generate large amounts of energy.

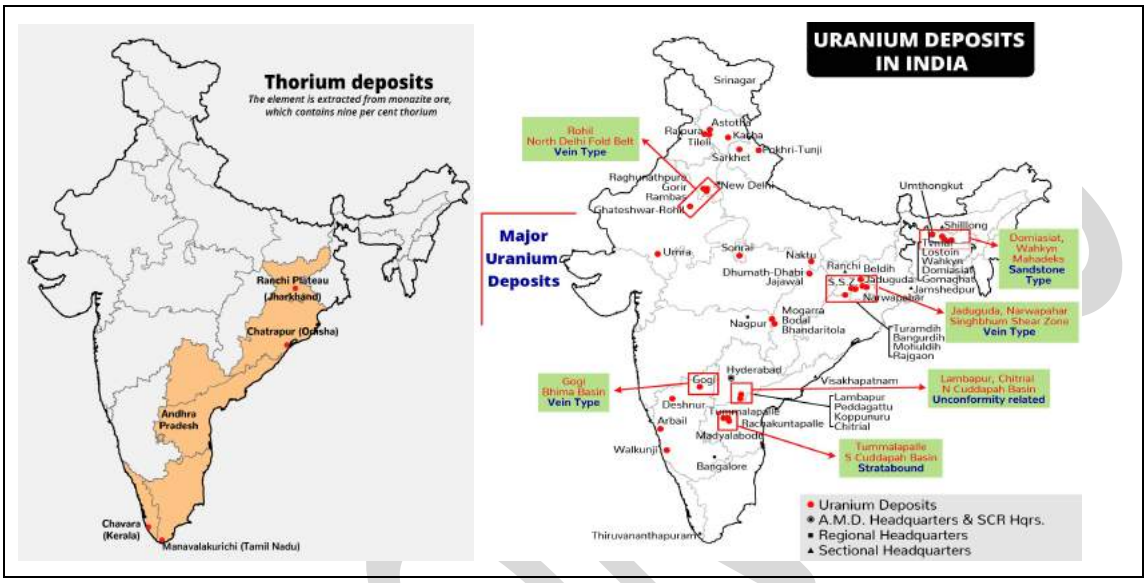
There are two methods which can be used to release energy from radioactive minerals:

- **Nuclear fission** – In this process, the nucleus of heavy atom namely of uranium (U 235) or plutonium (P 239) breaks apart into smaller fragments, releasing an enormous amount of energy.

- **Nuclear fusion** – In this process, small nucleus like those of isotopes of hydrogen, namely deuterium and tritium etc. fuse or join together to form heavier nuclei, releasing vast amounts of energy.

13.4.6.1. Location of Radioactive Mineral Ore in India

In India, monazite that is the main source of thorium, is found in commercial quantities on the Travancore coast between Kanya Kumari and Quilon, while uranite or pitchblende mineral of uranium is found in Gaya (Bihar), Ajmer (Rajasthan) and Nellore (Andhra Pradesh). Utilisation of radioactive minerals is expanding and investigations are being carried out on such deposits to provide definite indications of magnitude, and potential for exploitation.



13.5. Energy Conservation and its Importance

Coal and other fossil fuels, which have taken three million years to form, are likely to deplete soon. In the last two hundred years, we have consumed 60% of all resources. For sustainable development, we need to adopt energy efficiency measures. Today, 85% of primary energy comes from non-renewable, and fossil sources (coal, oil, etc.). These reserves are continually diminishing with increasing consumption and will not exist for future generations

13.5.1. Energy Conservation and Energy Efficiency

Energy Conservation and Energy Efficiency are separate, but related concepts. Energy conservation is achieved when growth of energy consumption is reduced, measured in physical terms. Energy Conservation can, therefore, be the result of several processes or developments, such as productivity increase or technological progress.

On the other hand, Energy efficiency is achieved when energy intensity in a specific product, process or area of production or consumption is reduced without affecting output, consumption or comfort levels. Promotion of energy efficiency will contribute to energy conservation and is therefore an integral part of energy conservation promotional policies.

Although, energy efficiency has been in practice ever since the first oil crisis in 1973, it has today assumed even more importance because of being the most cost-effective and reliable means of mitigating the global climatic change.

According to a BEE study the energy efficiency programs in India particularly PAT, UJALA and Standard and Labelling have led to a total cost savings worth nearly Rs.53,000 crore in 2017- 18 and contributed in reducing 108.28 Million Tonnes of CO_2 emission.

13.5.1.1. Challenges in Ensuring Energy Efficiency in India

- **Cross-subsidized electricity prices** are leading to wastage in residential and agricultural sectors
- **Limited information** about the benefits of energy efficiency investments and technologies.
- **Lack of enforcement** of standards, codes, and labelling.
- **Difficulty of measuring 'megawatts'** (or efficiency savings) in the context of project cash flows
- **Asymmetric risk/reward distributions** (mostly in the building sector for owner/investors versus tenants)
- **Competing objectives** in complex planning situations involving new investments and development
- **Inadequate investment** in supportive institutional mechanisms and human resources
- **High transaction costs** from legal, technical, and transactional complexities, like non-standardized deal structures and substantial technical content of project appraisal, development, and monitoring, etc.
- **MSME Sector:** The micro small and medium enterprises sector is one of the most important segments where overall energy consumption is quite high due to:
    - System inefficiency and less technology intervention.
    - Lack of energy efficiency implementation and compliance due to its unorganized nature, lack of awareness, lack of capital for upfront cost and lack of baseline data.

13.5.1.2 Unlocking National Energy Efficiency Potential (UNNATEE)

Bureau of Energy Efficiency (BEE) has developed a national strategy document titled UNNATEE towards developing an energy efficient nation **(2017-2031).** UNNATEE Implementation Strategy involves:

- **Favorable Regulations -** through an overarching energy efficiency policy, which includes targets, incentives and penalties.
- **Institutional Framework -** through strong enforcement mechanism at state levels, which would lend further strength to the national and local level program.
- **Availability of Finance -** in the form of a revolving fund, risk guarantee, On-bill financing, Energy Savings Insurance, Energy Conservation Bonds. Highlights of Charging Infrastructure
- **Use of technology** - including Internet of Things and Block chain have the ability to bring an energy revolution across sectors. E.g. in agriculture (smart control panels), municipal (Centralized Control Monitoring System-CCMS), commercial (building management systems), domestic (electric cook stoves).
- **Stakeholder Engagement** would result in faster adoption and smoother implementation. E.g. for adoption of electric vehicles, it is important to first have policies for promotion and adoption of EVs, institutional framework to train new breed of engineers to make the transition to EVs, ecosystem players to provide services like EV charging and consumers to buy the vehicles.
- **Data Collection-** Setting up of a Nodal Agency that advocates data collection and dissemination, covering the entire energy value chain of the country.
- **Setting State wise targets**- Mandatory reporting of sector wise energy consumption, status of all EE programs and the target of the same and energy efficiency roadmap.
- **Center of Excellence for industries** to increase R&D in specific sectors.

13.5.2. Energy Conservation Act, 2001

The Act provides for the legal framework, institutional arrangement and a regulatory mechanism at the Central and State level to embark upon energy efficiency drive in the country. Five major provisions of EC Act relate to Designated Consumers, Standard and Labelling of Appliances, Energy Conservation Building Codes, Creation of Institutional Set up (BEE) and Establishment of

Energy Conservation Fund. The EC Act was amended in 2010 and the main amendments of the Act are given below:

Student Notes:

13.5.2.1. The Energy Conservation (Amendment) Act, 2010- Main Amendments

- The Central Government may issue the energy savings certificate to the designated consumer whose energy consumption is less than the prescribed norms and standards in accordance with the procedure as may be prescribed.
- The designated consumer whose energy consumption is more than the prescribed norms and standards shall be entitled to purchase the energy savings certificate to comply with the prescribed norms and standards.
- The Central Government may, in consultation with the Bureau, prescribe the value of per metric ton of oil equivalent of energy consumed.
- Commercial buildings which are having a connected load of 100 kW or contract demand of 120 kVA and above come under the purview of ECBC under EC Act.

13.5.3. Energy Efficiency and conservation in Buildings

Why needed?

- Projection done by **NITI Aayog** indicates that the **electricity consumption for the residential sector is expected to increase 6-13 times by 2047**.
- Commercial building sector in India is expanding rapidly at over 9% per year spurred largely by the strong growth in the services sector. It has been estimated that more than 50% of building stock that will exist in the year 2030 is yet to come up in the country.

13.5.3.1. Concept of Energy Efficient New Towns

Energy conservation through comprehensive land use planning process.

- The design of the town should be such that developmental densities should be highest towards the centre of the town, which is served by municipal water and sewer.
- Proper design, building orientation, construction, and landscaping provide opportunities for energy conservation measures such as passive solar space, domestic hot water heating mechanism, natural lighting and photovoltaic electricity production.
- Energy Conservation Appliances and office equipment should be replaced with energy star rated units. Greening our infrastructures Light bulb should be replaced with the energy efficient compact fluorescent bulbs as they use 75% less energy and last up to ten times longer than standard incandescent bulbs.
- For right attitude towards energy conservation residents should be encouraged to drive less, walk and bike more by installing bike racks at public buildings.

13.5.3.2. Steps taken by the Government

Energy Conservation and Building Code Residential: ECBC-R

To avoid a long-term futile electricity consumption liability in residential buildings, it is essential to make the houses energy efficient. Therefore, ECBC-R is to be launched in phases. Its first part was launched in 2018 by the name Eco-Niwas Samhita.

Eco-Niwas Samhita (Part-I)

- It was launched in 2018 by Ministry of Power. This code is applicable to all residential use building projects built on plot area ≥ 500 m^2.
- Implementation of this Code will have potential for energy savings to the tune of 125 Billion Units of electricity per year by 2030, which is equivalent to about 100 million ton of CO_2 emission.
- The code aims for promoting design and construction of homes including apartments and townships to give the benefits of energy efficiency to the occupants.

- It has been developed to set minimum building envelope performance standards to limit heat gains (for cooling dominated climates) and to limit heat loss (for heating dominated climate) as well as for ensuring adequate natural ventilation and day lighting.
- The code has been developed with special consideration for its adoption by the Urban Local Bodies (ULBs) into building byelaws.

Energy Efficiency Label for Residential Buildings:

- This program was launched in 2019 by Ministry of Power.
- The objective of the labelling program is to make an energy performance of a home an instrument of comparison while deciding over the home prices in the future.
- It also aims to provide a benchmark to compare one house over the other on the energy efficiency standards to create a consumer-driven market transformation solution for energy efficiency in the housing sector.
- It has been proposed to label all types of residential buildings in India and make it as a mandatory information required in any real estate transaction/leasing.

Energy Conservation and Building Code Commercial: ECBC-C

- The code is given by Bureau of Energy Efficiency (BEE).
- The purpose of the Code is to provide minimum requirements for the energy-efficient design and construction of buildings.
- It is applicable to buildings or building complexes that have a connected load of 100 kW or greater and are intended to be used for commercial purposes.
    - Buildings intended for private residential purposes only are not covered by the Code.
- It also provides two additional sets of incremental requirements for buildings to achieve enhanced levels of energy efficiency that go beyond the minimum requirements.
- These are:
    - ECBC+ Building.
    - SuperECBC Buidling

About Bureau of Energy Efficiency (BEE)

- It is a statutory body under the Ministry of Power, created under the provisions of the Energy Conservation Act 2001.
- It assists in developing policies and strategies with the primary objective of reducing the energy intensity of the Indian economy.
- It co-ordinates with designated consumers and designated agencies to identify and utilize the existing resources and infrastructure, in performing the functions assigned to it under the Energy Conservation Act, 2001.
- Star-labelling program of BEE seeks to provide consumer an informed choice about energy saving and thereby the cost saving potential of the marketed household and other equipment.
    - The scheme targets display of energy performance labels on high energy end use equipment & appliances and lays down minimum energy performance standards.
    - It is mandatory for all RACs along-with LED lamps, Color TV, Electric Geysers etc.

Star Rating Program: Ministry of Power launched the Star rating of commercial buildings scheme in India in 2009 for existing buildings as a voluntary policy measure to reduce the adverse impact of buildings on the environment. This program rates buildings on 1-5 scale, with 5 star labelled buildings being most efficient. Star Labels for day use office buildings, BPOs, Hospitals and Shopping Malls have been developed. In 2019, a Memorandum of Understanding (MoU) has been signed between BEE and CPWD (Central Public Works Department) for "Energy Efficiency in CPWD managed Buildings**.**

13.5.4. Energy Efficiency and Conservation in Industries

The industrial sector in India consumes more than 50% of the total energy consumption. To increase energy efficiency and conservation, following steps have been taken:

13.5.4.1. National Mission for Enhanced Energy Efficiency (NMEEE)

It is one of the eight national missions under the National Action Plan on Climate Change (NAPCC). NMEEE aims to strengthen the market for energy efficiency by creating conducive regulatory and policy regime and has envisaged fostering innovative and sustainable business models to the energy efficiency sector. The Mission is implemented since 2011 with the help of Bureau of Energy Efficiency (BEE) and Energy Efficiency Services Limited (EESL).

National Energy Conservation Awards (NECA): It is celebrated every year on 14th December by Ministry of Power in association with Bureau of Energy Efficiency in order to recognize the efforts of industry and other establishments towards promoting energy efficiency.

NMEEE consists of four initiatives:

- **Perform Achieve and Trade Scheme (PAT)** – It is a market assisted compliance mechanism to accelerate implementation of cost-effective improvements in energy efficiency in large energy-intensive industries such as Iron and Steel, through certification of energy savings (ESCerts) that could be traded. The PAT cycle I extended from 2012-15, the PAT Cycle II from 2016-19, the PAT Cycle III from 2017-2020, PAT Cycle IV from 2018-2021 and PAT Cycle V from 2019-2022. The PAT Scheme is now being implemented as a rolling cycle where new units are notified for a period of 3 years every year.
- **Market Transformation for Energy Efficiency (MTEE)** - Accelerating the shift to energy efficient appliances in specific application through innovative measures to make the products more affordable. There are two schemes within it:
  - **Bachat Lamp Yojana**: The objective of the Bachat Lamp Yojana (BLY) scheme is to provide Energy Efficient Compact Fluorescent Lamps (CFLs) at the same cost i.e. Rs.15, as of Incandescent Bulbs. The cost differential would be made up by project implementer through carbon credits earned which could be traded in the International market under Clean Development Mechanism (CDM) of Kyoto Protocol.
  - **Super-Efficient Equipment Programme (SEEP)**: It is designed to bring accelerated market transformation for super-efficient appliances by providing financial stimulus innovatively at critical point/s of intervention. Under this program, ceiling fan has been identified as the first appliance to be adopted. The goal is to support the introduction and deployment of super-efficient 35W ceiling fans, as against the current average ceiling fan sold in Indian market with about 70W rating.
- **Energy Efficiency Financing Platform (EEFP)** - Facilitating Financial Institutions to invest in Energy Efficiency Projects and Programs.
- **Framework for Energy Efficient Economic Development (FEEED)** - Developing fiscal instruments to leverage financing for Energy Efficiency through risk mitigation:
  - Partial Risk Guarantee Fund for Energy Efficiency (PRGFEE) and
  - Venture Capital Fund for Energy Efficiency (VCFEE) to promote energy efficiency

13.5.5. Energy efficiency and Transport Sector

- The transport sector accounts for 18% of total energy consumption in India. This translates to an estimated 94 million tonnes of oil equivalent (MTOE) energy.
- India were to follow the current trends of energy consumption, it would require an estimated 200 MTOE of energy supply annually, by the year 2030 to meet the demand of this sector.
- At the moment, this demand is being met mostly through imported crude oil, which therefore makes this sector **vulnerable to the volatile International crude oil prices**. Moreover, the sector also contributes an estimated 142 Million Tonnes of **CO_2 emissions** annually, out of which 123 million tonnes is contributed by the road transport segment alone.
- For instance, the OPEC Plus arrangement has recently decided to cut the crude oil production during 2020 and 2022. For India, the ramifications will be particularly significant as OPEC makes up about 83% of the country's total crude oil imports.

13.5.5.1. Electric Vehicles

Electric mobility presents a viable alternative in addresses the issue of energy security and GHG emission, when packaged with innovative pricing solutions, appropriate technology and support infrastructure and thus, has been on the radar of Government of India.

Benefits of Electric Mobility:

- Shift towards EVs will help cut oil imports (India has set targets to cut oil imports by 10% by 2022).
- EVs convert about 59%–62% of the electrical energy to power at the wheels. Conventional gasoline vehicles only convert about 17%–21% of the energy stored in gasoline to power at the wheels.
- Electric mobility comes with zero or ultra-low tailpipe emissions of local air pollutants and much lower noise, and, by being one of the most innovative clusters for the automotive sector, can provide a major boost to the economic and industrial competitiveness, attracting investments, especially in countries.

However, the Electric Vehicle industry in India is far behind, with less than 1% of the total vehicle sales. Currently, Indian roads are dominated by conventional vehicles and have approximately 0.4 million electric two-wheelers and a few thousand electric cars only. Availability of adequate Charging Infrastructure is one of the key requirements for accelerated adoption of electric vehicles in India. The upfront cost of EVs is very high, about 4-5 times of conventional diesel vehicles. Most critical component which decides EVs cost is Lithium-Ion Battery and about 95% of Global Lithium Production comes from China, Chile, Argentina, Australia. India would need to acquire mineral assets/rights in these nations or Make Outside India will have to be explored.

Challenges with the faster adoption of EVs

- **Charging infrastructure:** The market share of EVs increases with increasing availability of charging infrastructure. This is primarily due to the limited driving range of batteries in the EVs. In India, the limited availability of charging infrastructure seems to be a major impediment to increased adoption of EVs.

- **Battery Technology:** Since the battery is the heart of any EV, development of appropriate battery technologies that can function efficiently in the high temperature conditions in India need to be given utmost importance.
- **Charging time:** Compared to conventional vehicles, even fast chargers can take around half an hour to charge an electric car while slow chargers could take even 8 hours.
- **Funding:** Assuming a moderate level of adoption, India needs about $6 billion for charging infrastructure, $4 billion in incentives and a further $7 billion to build battery capacity, according to estimates by Goldman Sachs Group Inc.
- **Cost to Consumer:** Even if the charging issue was adequately addressed, EVs are currently

priced nearly double the cost of comparable range diesel/petrol cars. Currently, Indian market share of electric cars is a meagre 0.06% when compared to 2% in China and 39% in Norway.

- **Multiple Agencies:** Currently, EV makers have to deal with the Ministry of Heavy Industries and Ministry of Road Transport for guidelines, the Ministry of Power on charging infrastructure, as well as the Ministry of Finance and GST Council over taxation issues.

Student Notes:

13.5.5.2. Steps taken by India to promote Electric Vehicles

National Electric Mobility Mission Plan (NEMMP), 2020

It is a National Mission providing the vision and the roadmap for the faster adoption of electric vehicles and their manufacturing in the country. This plan has been designed to enhance national fuel security, to provide affordable and environmentally friendly transportation and to enable the Indian automotive industry to achieve global manufacturing leadership. NEMMP 2020 includes the FAME India scheme launched by Department of Heavy Industry in 2015.

Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME India) Scheme: Launched in 2015 to promote manufacturing of electric and hybrid vehicle technology and to ensure sustainable growth of the same.

- **The Phase-I of the FAME India:** This scheme was initially launched for a period of 2 years, commencing from 2015. However, it was extended till 2019. It included four focus areas viz Demand Creation, Technology Platform, Pilot Project and Charging Infrastructure. All vehicle segments were incentivised in this phase to increase demand.
- **Phase-II of FAME India Scheme: 2019-2022**
  - It will mainly focus on supporting electrification of **public & shared transportation**, and aims to support through subsidies 7000 e-Buses, 5 lakh e-3 Wheelers, 55000 e-4 Wheeler Passenger Cars and 10 lakh e-2 Wheelers.
  - Support will also be available to **commercially registered** e-3 W, e-4W, and e-buses.
  - **Privately owned** registered e-2Wheelers will also be covered under the scheme as a mass segment.
  - Creation of charging infrastructure will also be supported in selected cities and along major highways.

National Mission on Transformative Mobility and Battery Storage, 2019:

The Prime Minister had outlined the vision for the future of mobility in India based on 7C's which are Common, Connected, Convenient, Congestion-free, Charged, Clean and Cutting-edge mobility. This mission has been launched in this backdrop.

- It will have an inter-ministerial steering committee, **chaired by CEO, NITI Aayog** that will coordinate among key stakeholders to integrate various initiatives to transform mobility in India.
- It will support and implement **Phased Manufacturing Programme (PMP)** which will be valid for 5 years till 2024 for large scale, export competitive integrated batteries and cell-manufacturing Giga plants in India. It will localize production across entire Electric vehicle value chain.
- The Mission will have **'Make in India' strategy** for Electric Vehicle components and battery technologies.

Charging Infrastructure for Electric Vehicles – Guidelines and Standards, 2019

It mentions the roles and responsibilities of various stakeholders at Central & State level, for expediting the development of public EV charging infrastructure across the country. **Ministry of Power has designated Bureau of Energy Efficiency (BEE) as the Central Nodal Agency (CNA)** for the National-level rollout of charging infrastructure in the country. Its features are:

- **Objective:** To enable faster adoption of EVs in India, promote an affordable tariff system for EV owners and operators of charging stations, generate employment and income opportunities for small business owners and support the creation of EV charging infrastructure.
- **Ease of Setting**: No license will be required for setting set up a public charging station.
- **Location of Public Charging Station**: Such that the charging station must cater to slow as well as fast charging requirements.
- **Rollout plan:** Phase I (1-3 years) will cover all mega cities with population above forty lakhs, and the associated expressways and highways. Phase II (3-5 years) will cover state and UT capitals.
- **Open access:** Charging station has been allowed to source electricity from any power generation company through open access.
- Promoting **Private Participation** in charging Infrastructure

Budgetary support, 2020

- **Income tax rebates** of up to Rs 1.5 lakh has been allowed to customers on interest paid on loans to buy EV with the total exemption of Rs 2.5 Lakh over the entire loan period.
- Exemption in **customs duty** on Lithium-ion cells to 0%
- Manufacturers of components such as solar electric charging infrastructure and lithium storage batteries and other components will be offered **investment linked income tax exemptions** under Section 35 AD of the Income Tax Act, and other indirect tax benefits.
- The **GST on EVs** will be reduced from 12% to 5%.

13.5.6. Energy Efficiency and Agriculture

While about 70% of Indian electricity is carbon-based, a quarter of the nation's consumption goes into agriculture, to extract groundwater for irrigation. Improving the energy efficiency of Indian agriculture is thus a critical issue from both a climate change and energy security perspective.

13.5.6.1. Issues associated with Power subsidy in India

- The free-power policy does not help the farmers much, particularly the poorest among them, as this free electricity is largely being stolen by non-agricultural consumers or captured by a few large landed farmers.
- Implementation of a free-power policy, even after cross-subsidisation from industrial and commercial consumers, has driven the electric utilities and state governments into financial crisis. In many cases, as in Punjab, the amount of the agricultural electricity subsidy is much higher than the state's spending on health or education.
- It has prompted the unaccounted and uncontrolled use of electricity, resulting in the agricultural sector consuming one-fourth of the country's total electricity supply.

13.5.6.2. Measures to reduce energy consumption in Agriculture

- **Improving Surface Irrigation:** Expansion of surface irrigation requires a lower level of capital investments as compared to sourcing groundwater particularly when subsidies are taken into account.
- **Groundwater Table management:** Innovative schemes to replenish groundwater tables through rain water harvesting is required, along with awareness regarding wastage of groundwater at the local level. Pump efficiency should be improved as well.
- **Improving technologies for Lift Irrigation:** More efficient Micro-irrigation techniques such as drip and spray irrigation must be encouraged by lowering down their costs.
- **Modifying agricultural practices:** The demand for water and electricity can be reduced through inexpensive measures such as land levelling and mulching.
- **Promoting organic agriculture:** Global adoption of organic agriculture has the potential to sequester up to 72% of the current agricultural GHG emissions on an annual basis and up to

32% of all current man-made GHG emissions. Additionally, organic agriculture offers alternatives to energy-intensive agricultural inputs, such as chemical fertilizers and pesticides.

- **Crop and Varietal Diversification**: Less-water-intensive crops or less water-intensive variants of rice and wheat should be promoted by realigning the food procurement policy and providing higher incentives for less water intensive crops.
- **Redesigning subsidy policy:** Unmetered electricity subsidies encourage unrestricted consumptions and are beneficial only to the rich farmers, therefore it must be checked.

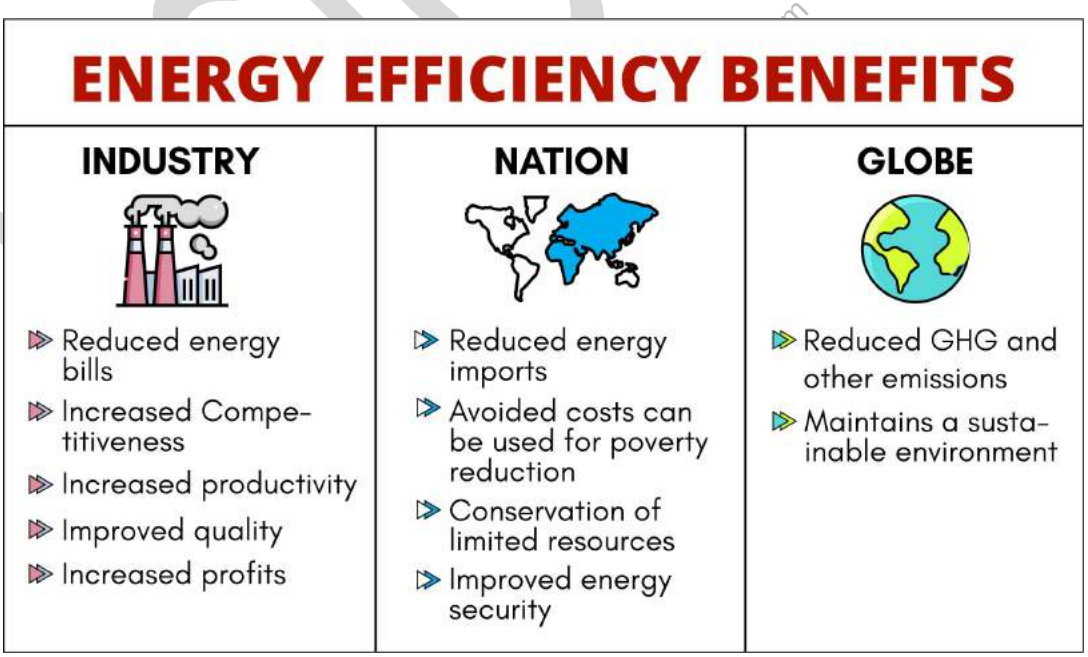
Student Notes:

13.5.6.3. Steps taken by Government

National Mission for Sustainable Agriculture (NMSA)

Operational from the year 2014-15. The mission includes:

- **On Farm Water Management (OFWM):** Its objective is enhancing water use efficiency by promoting technological interventions like drip & sprinkler technologies, efficient water application & distribution system, secondary storage etc. These activities have been subsumed under the **'Per Drop More Crop (PDMC)' component** of Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) during 2015-16.
- **Rainfed Area Development Programme:** The programme focuses on **Integrated Farming System** for enhancing productivity and minimizing risks associated with climatic variability. Under this system, cropping is integrated with activities like horticulture, livestock, fishery, vermi-organic compost, green manuring, apiculture etc. to enable farmers maximising farm returns for sustained livelihood and mitigate the impacts of drought, flood or other extreme weather events with the income opportunity from allied activities.
- **Soil Health Management (SHM)**: It aims at promoting **Integrated Nutrient Management** (INM) through judicious use of chemical fertilizers including secondary and micro nutrients in conjunction with organic manures and bio fertilizers for improving soil health and its productivity, strengthening of soil and fertilizer testing facilities to improve soil test-based recommendations to farmers for improving soil fertility. The activities include trainings and demonstrations on balanced use of fertilizers.



13.6. UPSC Previous Year Questions

Student Notes:

Mains

1. Discuss in detail "Alternative Energy Sources": (2004)
2. What is the energy independence? Discuss how India can be transformed into an 'Energy-independent Nation: (2005)
3. Why is hydrogen being acclaimed as the fuel of the future? (2005)
4. Write a note on 'Bio-refinery versus Fossil fuels. (2006)
5. Bring out the prospects of development of alternative energy sources of India. (2006)
6. Comment on the salient features of the Integrated Energy Policy recently approved by the Government and its implications on the energy security needs of the country. (2009)
7. Evaluate India's approach towards meeting the country's growing energy demands. Compare the success of this approach with that of another Asian giant which has perhaps the fastest growing energy demands. (2010)
8. 'Concentrated' solar energy and 'photovoltaic' solar energy (2011)
9. Given the accelerated pace development and demand for energy, would you consider renewable energy as a viable option for India's future? (2012)
10. With growing scarcity of fossil fuels, the atomic energy is gaining more and more significance in India. Discuss the availability of raw material required for the generation of atomic energy in India and in the world. (2013)
11. Should the pursuit of carbon credits and clean development mechanisms set up under UNFCCC be maintained even though there has been a massive slide in the value of a carbon credit? Discuss with respect to India's energy needs for economic growth. (2014)
12. Give an account of the current status and the targets to be achieved pertaining to renewable energy sources in the country. Discuss in brief the importance of National Programme on Light Emitting Diodes (LEDs). (2016)

Prelims

1. With reference to the usefulness of the by- products of sugar industry, which of the following statements is/are correct? (2013)
1. Bagasse can be used as biomass fuel for the generation of energy.
2. Molasses can be used as one of the feedstock's for the production of synthetic chemical fertilizers. 3. Molasses can be used for the production of ethanol.

Select the correct answer using the codes given below:
(a) 1 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

Answer: C

2. Consider the following organisms: (2013)
1. Agaricus
2. Nostoc
3. Spirogyra

Which of the above is/are used as bio fertilizer/bio fertilizers?
(a) 1 and 2
(b) 2 only
(c) 2 and 3
(d) 3 only

Answer: B

Student Notes:

3. With reference to 'fuel cells' in which hydrogen-rich fuel and oxygen are used to generate electricity. Consider the following statements : (2015)
1. If pure hydrogen is used as a fuel, the fuel cell emits heat and water as by-products.
2. Fuel cells can be used for powering buildings and not for small devices like laptop computers.
3. Fuel cells produce electricity in the form of Alternating Current (AC).

Which of the statements given above is / are correct?
(a) 1 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

Answer: A

4. With reference to the Indian Renewable Energy Development Agency Limited (IREDA), which of the following statements is/are correct? (2015)
1. It is a Public Limited Government Company.
2. It is a Non - Banking Financial Company.

Select the correct answer using the code given below.
(a) 1 only
(b) 2 only
(c) Both 1 and 2
(d) Neither 1 or 2

Answer: C

5. Consider the following statements: (2016)
1. The International Solar Alliance was launched at the United Nations Climate Change Conference in 2015.
2. The Alliance includes all the member countries of the United Nations.

Which of the statements given above is/are correct?
(a) 1 only
(b) 2 only
(c) Both 1 and 2
(d) neither 1 nor 2

Answer: A

6. On which of the following can you find the Bureau of Energy Efficiency Star Label? (2016)
1. Ceiling fans
2. Electric geysers
3. Tubular fluorescent lamps

Select the correct answer using the code given below.
(a) 1 and 2 only
(b) 3 only
(c) 2 and 3 only
(d) 1, 2 and 3

Answer: D

7. In which of the following regions of India are shale gas resources found? (2016)
1. Cambay Basin
2. Cauvery Basin
3. Krishna-Godavari Basin

Select the correct answer using the code given below.
(a) 1 and 2 only (b) 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Answer: D

Student Notes:

8. 'Net metering' is sometimes seen in the news in the context of promoting the (2016)
(a) Production and use of solar energy by the households/consumers
(b) Use of piped natural gas in the kitchens of households
(c) Installation of CNG kits in motor-cars
(d) Installation of water meters in urban households

Answer: A

9. With reference to solar power production in India, consider the following statements: (2018)
1. India is the third largest in the world in the manufacture of silicon wafers used in photovoltaic units.
2. The solar power tariffs are determined by the Solar Energy Corporation of India.

Which of the statements given above is/are correct?
(a) 1 only
(b) 2 only
(c) Both 1 and 2
(d) neither 1 nor 2

Answer: D

10. In the context of which one of the following are the terms 'pyrolysis and plasma gasification' mentioned? (2019)
(a) Extraction of rare earth elements
(b) Natural gas extraction technologies
(c) Hydrogen fuel-based automobiles
(d) Waste-to-energy technologies

Answer: D

11. In the context of proposals to the use of hydrogen-enriched CNG (H-CNG) as fuel for buses in public transport, consider the following statements: (2019)
1. The main advantage of the use of H-CNG is the elimination of carbon monoxide emissions.
2. H-CNG as fuel reduces carbon dioxide and hydrocarbon emissions.
3. Hydrogen up to one-fifth by volume can be blended with CNG as fuel for buses.
4. H-CNG makes the fuel less expensive than CNG.

Which of the statements given above is/are correct?
(a) 1 only
(b) 2 and 3 only
(c) 4 only
(d) 1, 2, 3 and 4

Answer: B

12. Consider the following statements: (2020)
1. Coal ash contains arsenic, lead and mercury.
2. Coal-fired power plants release sulphur dioxide and oxides of nitrogen into the environment.
3. High ash content is observed in Indian coal.

Which of the statements given above is/are correct?
(a) 1 only
(b) 2 and 3 only
(c) 3 only
(d) 1, 2 and 3

Answer: D

13.7. Vision IAS Previous Years Test Series Questions

Student Notes:

1. With growing concerns w.r.t. global climate change and energy security, biofuels have been gaining popularity. What are the advantages of using biofuels? Discuss the implications of biofuel expansion on food security, social welfare and environment in the context of India.

Approach:

- Briefly elaborate the statement on biofuels gaining popularity.
- Bring out the various advantages of using biofuels.
- Write about the implications of biofuel expansion on food security, social welfare and environment in the context of India.

Answer:

Biofuels are fuels produced directly or indirectly from organic material – biomass – including plant materials and animal waste. Biofuels have been in usage from the beginning of 20th century itself. But discoveries of huge petroleum deposits kept petrol and diesel cheap for decades, and biofuels were largely forgotten. However, with the recent rise in oil prices, along with growing concern about global warming caused by carbon dioxide emissions, biofuels have been regaining popularity.

Various advantages of using biofuels are:

- Biofuels produce less greenhouse gases overall than fossil fuels when they are burned.
- Since plants absorb carbon dioxide as they grow, crops grown for biofuels should suck up about as much carbon dioxide as comes out when these fuels are burnt.
- Whereas oil is a limited resource that comes from specific materials, biofuels can be manufactured from a wide range of materials including crop waste, manure, and other by-products. This makes it an efficient step in recycling.
- Biofuels are alternative sources to fossil fuels - allowing for greater fuel security for countries with little or no oil reserves of their own.
- Biofuels may not produce any particulates, such as soot and other fine particles.
- Because biofuels are produced locally, biofuel-manufacturing plants can employ hundreds or thousands of workers, creating new jobs in rural areas.
- Biofuel production will also increase the demand for suitable biofuel crops, providing economic stimulation to the agriculture industry.

Presently, India's position in the global biofuel map is not very prominent. However, the country has ambitious plans to expand the biofuel sector, though cautiously. Implications of biofuel expansion on food security, social welfare and environment are as follows.

Implications on food security:

- There are strong apprehensions that as more and more land is brought under biofuel crops, food prices would increase substantially affecting poor consumers particularly those from low-income countries like India.
- Using valuable cropland to grow fuel crops could have an impact on the cost of food and could possibly lead to food shortages.
- Even though India is food self-sufficient in terms of food production, almost 50% of children and practically the same number of women suffer from protein calorie malnutrition. Therefore, any large-scale biofuel programme has to ensure that it does not compromise with the nation's food and nutritional security.

Student Notes:

Implications on Social welfare:

- Huge sums of outlays for subsidies on biofuels essentially means a shift of money away from the poor and vulnerable who end up spending more on food due to increased food prices, with little left for energy, even though cheaper.
- However, diversion of forest and wasteland for cultivation of energy plantations may cause a conflict with pastoral livelihoods.
- The promotion of biofuel development has potential for creating employment opportunities for the rural poor, promoting local level entrepreneurship and enhancement of women's participation.
- Local institutions like Joint Forest Management (JFM) committees, self-help groups (SHGs) and panchayats can play an important role in involving village communities in bio-fuel programmes.

Implications on environment:

- In some countries large areas of land are being used for biofuel crops. Such practice in India can result in loss of habitat and the extinction of some species of animals and plants.
- Massive quantities of water are required for proper irrigation of biofuel crops as well as to manufacture the fuel, which could strain local and regional water resources.
- While biofuels may be cleaner to burn, there are strong indications that the process to produce the fuel - including the machinery necessary to cultivate the crops and the plants to produce the fuel - has hefty carbon emissions.
- To refine biofuels to more efficient energy outputs, and to build the necessary manufacturing plants to increase biofuel quantities, a high initial investment is often required.

2. The World Bank recently announced limiting the financing of coal-fired power plants in developing countries. In light of the above statement, explain the detrimental effects of coal-fired power plants on environment and human health. Also analyse the constraints in shifting from coal based power generation to renewable energy in India.

Approach:

- Explain the detrimental effects of coal-fired power on the environment and health.
- Discuss the constraints in shifting to renewable energy in India.
- In light of above argument end the answer by commenting on the World Bank decision.

Answer:

The Coal fired power plants have adverse and myriad impact on the environment and human health.

Impacts on Environment:

- Strip mining to produce coal eliminates existing vegetation, destroys the soil profile, displaces or destroys wildlife, alters current land uses, and changes general topography of the area mined and exposes land to erosion generating dust.
- Mine collapses cause devastation in populated areas. Mining also induces small earthquakes.
- Surface mining contaminates groundwater.
- Mining residue and warm water exhaust from power plant cause river pollution. It also impacts fertility of soil.
- Layer of ash on plant leaves reduces their photosynthetic capacity.

- Coal and coal waste products release approximately 20 toxic chemicals like arsenic, lead, mercury, radium etc. polluting air, soil and water.

Impacts on Human Health:

- Toxic chemicals in air are inhaled and in water are consumed directly or assimilated by eatable plants and animals through bioaccumulation or biomagnification. This leads to diseases like lung and skin cancer, minamata, mental retardation, genetic diseases etc.
- Coal particulates pollution causes respiratory diseases and causes approximately one million deaths annually worldwide.
- Generates secondary pollutants like ground level ozone and Peroxyacyl nitrates (PAN). These cause mild to severe respiratory diseases.
- Coal also contains low levels of uranium, thorium, and other naturally occurring radioactive isotopes whose exposure in any form can cause cancer and genetic disorders.

In light of these negative effects, it is imperative to shift to renewable energy resources. However, there are several constraints such as:

- High cost of production for solar energy as compared to cheap coal based.
- Dependency on imports for equipment as in-country manufacturing is inadequate due to high cost, poor technological capacity and lack of investment.
- Disparity in potential of renewable energy availability across regions.
- Poor R&D and innovation in country to bring down cost.
- Lack of standardization resulting in fragmentation of market among suppliers and manufacturers leading to policy confusion and loopholes.
- Latest technologies like micro-grids, smart grids, net metering etc are still in infancy.
- Public indifference towards clean and sustainable energy.

Thus, idea of limiting coal fired plants is novel but it should be supplemented with appropriate international economic and technical support to developing countries so that it does not hamper their economic development and poverty alleviation agenda.

3. Discuss the feasibility of using methane as a source of energy and fuel in India. How can it contribute to socio-economic development and environmental protection?

Approach:

- In the first section, write about the feasibility of methane to be used as energy and fuel as per present research and development in India. Also, write about the limiting factors in brief.
- In the second section, clearly delineate the potential of methane usage in helping socio economic development and environmental protection.

Answer:

The use of methane as a source of energy and fuel is useful to improve landfill safety, generate electricity, reduce greenhouse emissions, and to earn carbon emission reduction credits. The feasibility of Methane as a source of energy depends upon the following factors:

- **Availability**: Methane can be extracted from natural sources as well as anthropogenic activities. With current available technology, it is very difficult to capture Methane from Oceans, termites and wetlands; however, it is possible to extract methane from landfills, agriculture waste and coal bed methane.

Student Notes:

- **Accessibility**: In India, coal bed methane and landfills are considered as potential sources for energy. However, the use of landfills has practical challenges like:
  - Direct exposure to methane gas and seasonal changes in temperature etc.
  - A lack of local service and technology providers for methane identification, quantification, and mitigation activities.
  - There are legal and regulatory in obtaining access to the electricity grid to sell back power.
- **Affordability:** Many coal mines do not have adequate internal investment capital for project funding, and thus a lack of adequate financing is remains an important challenge.

Contribution in Socio and Economic development and environment protection

- Collection and use of methane provides a valuable, clean-burning energy source that promotes local economic development and reduces local environmental pollution and odors.
- Methane capture will witness improvement in local air quality and, ozone related-mortalities will decrease.
- It will benefit water quality, particularly in the agricultural sector, via improved management of animal waste.
- Producing energy from methane recovery avoids the use of conventional energy resources, reducing end-user and power plant emissions of CO_2 and air pollutants.
- Capturing methane from coal mines, landfills, and oil and gas facilities can also improve safety conditions by reducing explosion hazards.
- It will lead to increase in local employment as methane capture plants creates jobs associated with the design, construction, and operation of energy recovery systems.
- By linking communities with innovative ways to deal with the waste it can help in, better waste management and responsible community planning.

4. Despite numerous health hazards associated with traditional cooking energy fuels, access to clean cooking in India still continues to be a luxury. Discuss. Also enumerate the steps taken by the government to make it accessible along with the challenges faced in the process.

Approach:

- Begin with the present status of use of traditional fuels.
- Then explain how it impacts health.
- Enumerate important steps taken by government.
- Also mention the challenges faced and way forward.

Answer:

More than 80% of the rural population in India depends on traditional fuels like firewood, crop residue, cow dung and lignite, according to 2011 Census. The health hazards associated with this dependence are:

Health hazards of traditional fuels

- **During fuel gathering** - In less secure environments, women and children are at risk of injury and violence during fuel gathering.
- **Indoor pollution** - Black carbon and PM 2.5 from 'chullah' may lead to:
  - Inflammation in lungs.
  - Reduction in the oxygen-carrying capacity of blood.

Student Notes:

- According to World Health Organisation (WHO), more than 50% of premature deaths due to pneumonia among children under 5 are caused by the particulate matter inhaled from household air pollution.
- The WHO estimates 500,000 deaths per year in India are due to this pollution.

Hindrances in access to clean cooking fuel

- Mismatch between connection and sustained use: Cleaner alternatives such as LPG connection does not necessarily translate into sustained use for cooking. For instance, **regular refill** is a problem for poor. Moreover, Almost 50% of the country's LPG consumption is imported, thus, increasing burden on public exchequer and also mean energy insecurity in long term.
- **Unreliable supply infrastructure:** In rural areas the supply chain is weak, thereby it is difficult for rural household to access clean fuel. For instance, use of **electricity** as clean fuel through induction cookers depends on reliable connectivity.
- **Lack of awareness and ease of use:** Many studies have found that rural people do not consider traditional fuels hazardous. Moreover, locally available fuels such as biomass is easy to use. Cleaner alternatives such as **biogas**, despite numerous government schemes in the past, could not be sustained as financial and administrative aspects were structured in a way that didn't promote local ownership. Incentives to ensure good quality construction were not in place, which resulted in faulty construction
- **Lack of convergence among various Ministries:** Clean cooking fuel is a multidimensional issue. A lack of convergence between ministries such as Health, Women & Child Development, Petroleum, has impeded creative and effective mechanism to popularise clean alternatives. For instance, a conditional cash transfer programme for compulsory use of LPG cylinder during pregnancy by making it a sub-programme under Janani shishu suraksha program.

Government initiatives

- The **Ministry of Petroleum and Natural Gas** has three schemes to augment LPG connectivity- Rajiv Gandhi Gramin LPG Vitran Yojana, Pradhan Mantri Ujjwala Yojana and PAHAL Scheme.
- **The Ministry of New & Renewable Energy** is implementing a National Biogas and Manure Management Progamme (NBMMP) for setting up biogas plants in the country and National Biomass Cookstoves Initiative to enhance the use of improved biomass cookstoves.
- The Ministry of New & Renewable Energy's programme of intensive distribution of clean fuel cooking devices like Unnat Chulhas, Solar Cookers, Solar Lamps, Solar home lighting Systems etc. using CAMPA fund.

Suggested solutions

- Diversified choices of fuel such as biomass, biogas, electricity etc. as every fuel has certain limitations in certain areas.
- A concerted policy with coordination between various ministries. E.g. Linking clean cooking fuel programmes with poverty reduction/income generation programmes. Synergising efforts by the national governments, private sector, NGOs and international agencies like UN.
- Mass awareness campaign for attitude change and making people stakeholders in any clean fuel initiative.

Student Notes:

5. Ensuring that buildings comply with green norms will require much more than current arrangements. Analyse. Also discuss the relevant features of the new building code issued by the Bureau of Energy Efficiency in this context.

Approach:

- In the introduction, highlight the reasons for non compliance of building activities with green norms
- Give a holistic overview of the issue concerned.
- Give a brief background of the National Building Code, 2016.
- Analyse the features of the Code which highlight environmental norms of buildings.

Answer:

Green building norms ensure less usage of water, optimises energy efficiency, conserves natural resources, generates less waste and provides healthier spaces for occupants, as compared to a conventional building. In the current scenario, the National Building Code regulates the building construction activities across India. Despite being a comprehensive code it does not incorporate green standards i.e. it is not compulsory for the builder to make environment friendly structures. Further, the National Building Code does not include water or material efficiency standards. It does have the standards for energy efficiency but the compliance is voluntary. It is due to these deficiencies that most buildings in India do not comply with the environmental norms.

The leadership in green buildings norms is provided by non-government organisations such as:

- **Indian Green Building Council** (IGBC) by Confederation of Indian Industry (CII).
- **Green Rating for Integrated Habitat Assessment** (GRIHA) by The Energy and Resources Institute (TERI).

Leadership in Energy and Environmental Design (LEED) by The Energy and Resources Institute (TERI) and the US Green Building Council (USGBC).

State governments often provide incentives to the green buildings that adhere to the above-mentioned non-governmental standards. However, most of the times grant of these incentives are not backed by proper monitoring of the resource savings and actual energy use in such buildings. Thus, there is no adequate mechanism in place to ensure compliance.

Therefore, in order to ensure that buildings adhere to the green norms, the **Energy Conservation Building Code, 2017** has been issued by the **Bureau of Energy Efficiency**. The relevant features of this Building Code are:

- ECBC 2017 is developed with technical support from United States under Partnership to Advance Clean Energy-Deployment Technical Assistance (PACE-DTA) Program
- **Standards**: it prescribes the energy performance standards for new commercial buildings to be constructed across India
- **Integrated approach**: ECBC 2017 sets parameters for builders, designers and architects to integrate renewable energy sources in building design with the inclusion of passive design strategies.
- **Three tier**: It has three levels of adoption - basic, ECBC Plus, and Super ECBC. These levels determine the degree of carbon efficiency. For Ex: Super ECBC helps you to move to a net zero or even a net positive scenario.
- **Specific criterion:** For different application of a building like school, hospital, residential etc. Thus, in the form of ready reckoner, different purpose building codes can be adopted easily by developers.

Student Notes:

- ECBC compliant building **would require minimum energy savings f 25%**. Higher grades like 'ECBC Plus' or 'Super ECBC' status will be accorded if energy savings of 35% and 50% respectively are achieved.
- It is estimated to achieve a 50% reduction in energy use by 2030 ad peak demand reduction of over 15GW in a year.

Thus, with rapid urbanisation in India, it is imperative that active steps are taken to ensure that buildings comply with green norms.

6. Explain the significance of solar energy for meeting India's energy demands. What are the challenges that lie in harnessing its potential? What steps have been taken to address them?

Approach:

- Introduce the solar energy targets of government of India.
- Discuss the importance of solar energy.
- Discuss challenges and steps undertaken to address those.

Answer:

Solar energy has been at the focus of India's expanding energy needs. Being a tropical country, the potential and significance of solar energy in India is very high. Under its 2022 energy targets, India has envisaged 227 GW of power from renewable energy, out of which solar constitutes about 113 GW. The target was revised up from 100GW owing to favourable current trend of overachieving the said targets.

Advantages of solar power for meeting India's demands

- **Reduce peak demand**: One of the biggest markets for solar energy is the distributed rooftop segment. Solar rooftop panels aid DISCOMs by reducing the peak demand during daytime.
- **Reduce losses**: Solar rooftop panels leads to decreased T&D losses as the power is consumed at the point of generation.
- **Cheaper**: Roof top panels are less expensive and there is no need for energy grid to get solar energy.
- **Tropical country**: Being tropical country, almost all parts of India receive 4-7 kWh of solar radiation per sq. meters.
- **Environment friendly:** It does not release CO_2 and other gases which pollute the air. Also, use of solar energy can reduce the use of firewood and dung cakes by rural household.
- **Rural development:** As it is a decentralised source of energy, it generates new avenues for rural entrepreneurship.

Strategic independence: It will help reduce pressure on exchequer through reduced oil imports.

Challenges in solar energy

- **Lack of trust and financing**: Consumers are not ready to invest despite subsidies, direct and indirect tax benefits etc. Banks are also reluctant to lend because of high risks and limited information on the track records of rooftop solar investments.
- **Inferior Technology and Quality**: The efficiency and quality of solar panels produced by the Indian players is not able to compete with its global counterparts.
- The distribution of solar energy is not uniform across regions and time, which makes the supply of solar energy unpredictable.
- **Higher capital costs** of the project compared to the savings it generates.

Student Notes:

- **Attitudinal issues:** Most residents do not want to block their rooftops. They use the terraces for various purposes such as drying clothes, installing water tanks and split ACs.
- **Other limitations:** Unlike in Europe and America, houses in India do not have standardized roofs and getting the economically feasible shade-free area is a big challenge.

Steps undertaken to address challenges in solar energy

- India is the founding member of the International Solar Alliance. Some other innovative efforts have also been undertaken such as solar cities and solar charkhas.
- National Solar Energy Federation of India (NSEFI) and MNRE are raising awareness through television and radio media
- It has focused on enhancing manufacturing of high quality solar cells that are inexpensive and highly efficient. For ex- perovskite solar cells.
- Various benefits have been given by the government such as 30% capital subsidy on residential rooftops, encouraging financing under priority sector, lower interest rates, net metering regulations etc.

To address the unpredictable nature of solar energy there is need to push for hybrid power plants. Inspiration may be taken from the success story of Germany's solar power generation.

Unit-4

Environmental Issues

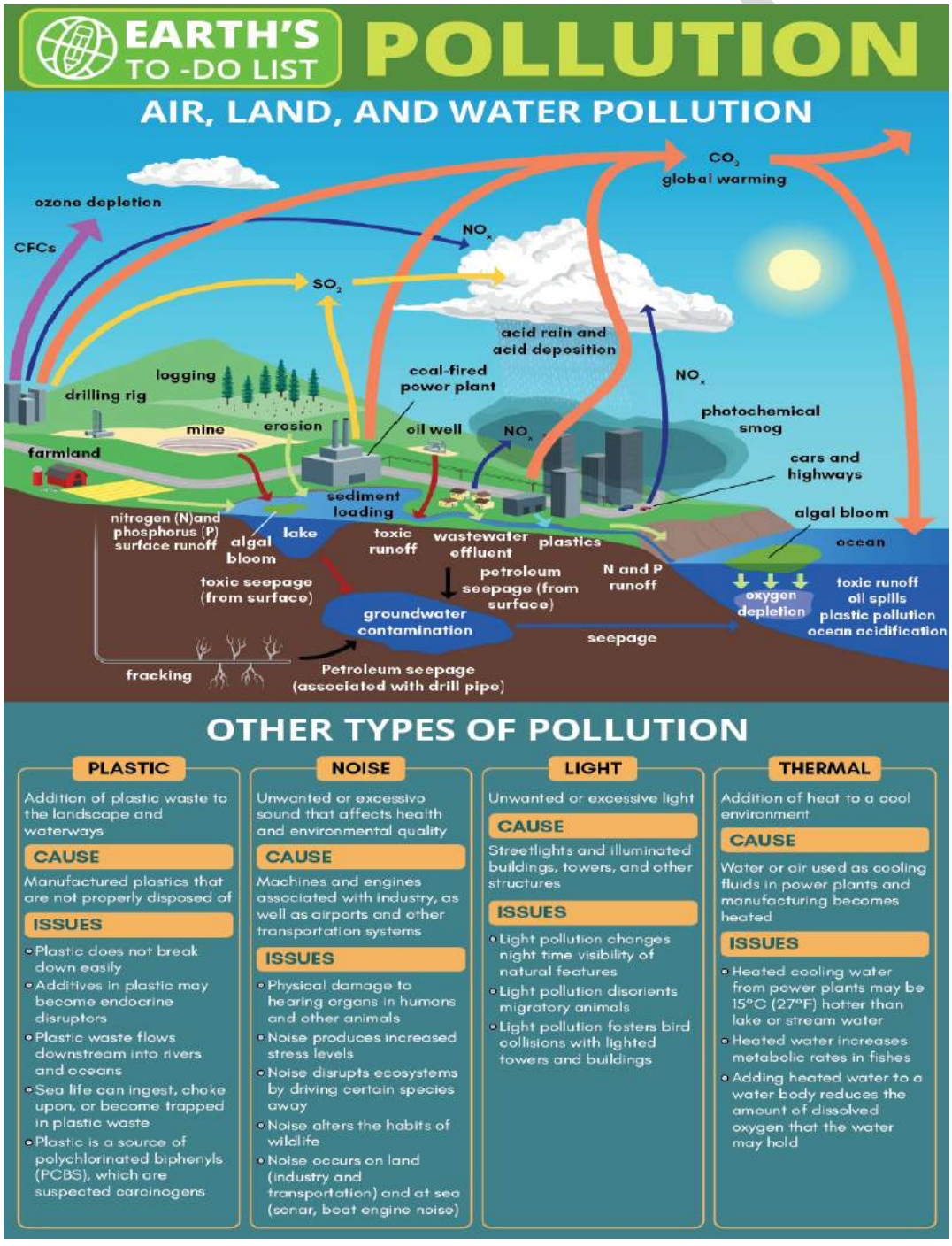
UNIT - 4

CHAPTER - 14 - POLLUTION AND RELATED ISSUES

14. Pollution

Pollution may be defined as addition of undesirable material into the environment as a result of human activities. Agents which cause environmental pollution are called pollutants. A pollutant may be defined as a physical, chemical or biological substance unintentionally released into the environment which is directly or indirectly harmful to humans and other living organisms.

14.1. Types of Pollution



14.2. Air Pollution

Air pollution may be defined as the presence of any solid, liquid or gaseous substance including noise and radioactive radiation in the atmosphere in such concentration that may be directly and indirectly injurious to humans or other living organisms, plants, property or interferes with the normal environmental processes.

Types of Air Pollution

Indoor air pollution (IAP): Poor ventilation due to faulty design of buildings leads to pollution of the confined space.

Air pollution is the cause of 7 million premature deaths worldwide. Out of this 7 million, 2.6 million premature deaths are caused by indoor air pollution.

Most Polluted Regional Cities

Rank	City	2019 AVG
1	Ghaziabad, India	110.2
2	Gujranwala, Pakistan	105.3
3	Faisalabad, Pakistan	104.6
4	Delhi, India	98.6
5	Noida, India	97.7
6	Gurugram, India	93.1
7	Raiwind, Pakistan	92.2
8	Greater Noida, India	91.3
9	Bandhwari, India	90.5
10	Lucknow, India	90.3
11	Lahore, Pakistan	89.5
12	Bulandshahr, India	89.4
13	Muzaffarnagar, India	89.1
14	Bagpat, India	88.6
15	Jind, India	85.4

Cleanest Regional Cities

Rank	City	2019 AVG
1	Sanandaj, Iran	6.5
2	Borazjan, Iran	11.6
3	Kabudrahang, Iran	12.7
4	Tabriz, Iran	13.2
5	Qorveh, Iran	13.7
6	Yazd, Iran	13.7
7	Zanjan, Iran	15.1
8	Nahavand, Iran	15.4
9	Satna, India	15.5
10	Saqqez, Iran	15.7
11	Darreh Shahr, Iran	16.6
12	Pardis, Iran	16.9
13	Pokhara, Nepal	17.1
14	Eslamshahr, Iran	19.7
15	Saveh, Iran	19.8

- **Causes:** Burning of firewood and biomass, release of volatile organic compounds (VOCs) from Paints, carpets, furniture, etc. or use of disinfectants, fumigants, etc.
- **Characteristics of IAP:**
  - IAP impacts are more prominent among low Socio Demographic Index (SDI) countries.
  - Within a country, the IAP is more likely to impact poor & rural households compared to affluent and urban households.
  - Within a household, IAP affects women and children more than men.

Suggestive measures to curb the menace of indoor air pollution:

- **Public awareness:** Spreading awareness among people about the issue and the serious threat IAP poses to their health and wellbeing.
- **Change in pattern of fuel use:** At present, majority of low-income families rely solely on direct combustion of biomass fuels for their cooking needs as this is the cheapest and easiest option available to them. Therefore, promoting use of cleaner energy sources such as gobar gas, LPG, etc. is required.
- **Modification of design of cooking stove:** The stoves should be modified from traditional smoky and leaky cooking stoves to the ones which are fuel efficient, smokeless and have an exit (e.g., chimney) for indoor pollutants.
- **Improvement in ventilation:** During construction of a house, importance should be given to adequate ventilation; for poorly ventilated houses, measures such as a window above the cooking stove and cross ventilation though doors should be instituted.
- **Intersectoral coordination and global initiative:** Indoor air pollution can only be controlled with coordinated and committed efforts between different sectors concerned with health, energy, environment, housing, and rural development.

Controlling Indoor Air Pollution in India:

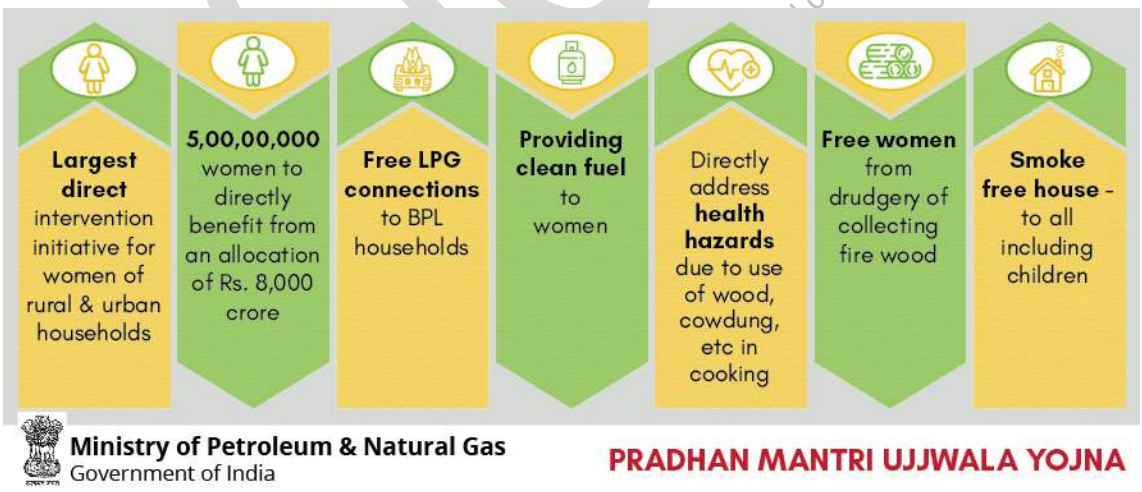
As per Census 2011, about 65.9 per cent of households depend on solid biomass, including firewood, crop residue and cow dung as primary fuel for cooking in India. The use of traditional biomass for cooking through simple traditional cook stove is a cause of indoor air pollution due to incomplete combustion of biomass which produces a range of toxic products.

NEERDHUR:

- It is a multi-fuel improved cookstove developed by CSIR-NEERI (National Environmental Engineering Research Institute).
- Besides wood, it can consume several fuels including coal, cow dung, charcoal, biomass and other agricultural residue.
- It is designed as a hybrid with technology innovations and uses much less fuel with lower emissions.

The Ministry of New and Renewable Energy (MNRE) is implementing following programmes to reduce dependence upon traditional biomass cooking:

- **The Unnat Chulha Abhiyan:** It was launched in 2014 for promotion of improved biomass cook stove in the country for providing a clean cooking energy solution with a view to reduce consumption of fuel wood with higher efficiency and low emissions.
- **National Biogas and Manure Management Programme (NBMMP)** for setting up of family type household biogas plants for meeting cooking energy needs of rural and semi urban areas and to save the use of firewood.
- Promoting solar cookers to reduce the indoor air pollution.
- **Pradhan Mantri Ujjwala Yojana (PMUY):**
    - It was Launched in 2016 with a motto **'Swachha Indhan, behtar Jeevan'** (Clean fuel, better life) by the Ministry of Petroleum and Natural Gas to safeguard the health of women & children by providing them with clean cooking fuel through LPG.
    - Under this scheme, 8 crore new LPG connections will be provided to women's belonging to Below Poverty Line (BPL) families up to 2020.
    - The Scheme provides a financial support of Rs 1600 for each LPG connection to the BPL households and interest free loan to purchase stove and refill by Oil Marketing Companies. The administrative cost of Rs. 1600 per connection, which includes a cylinder, pressure regulator, booklet, safety hose, etc. would be borne by the Government.



14.3. Atmospheric Pollution

Tropospheric Pollution:

The lowest region of atmosphere in which the human beings along with other organisms live is called troposphere. It extends up to the height of ~ 10 km from sea level. Tropospheric pollution occurs due to the presence of undesirable solid or gaseous particles in the air. The following are the major gaseous and particulate pollutants present in the troposphere:

- **Gaseous air pollutants:** These are oxides of sulphur, nitrogen and carbon, hydrogen sulphide, hydrocarbons, ozone and other oxidants.

Pollutant	Source	Harmful effects
Gaseous Pollutants		
Oxides of Carbon (CO and $CO_{2)}$	Burning of wood and coal and other fossil fuels like petroleum	Global warming Respiratory issues
Oxides of Sulphur (SO_2 and H_2S)	Power plants and refineries Volcanic eruptions When Sulphur containing fuel is burnt	Acid rain Respiratory issues Loss of chlorophyll in plants (Chlorosis)
Oxides of Nitrogen (NO and N_2O)	Naturally (Lightning) In Automobile exhaust: (at high temperature) $N_2 (g) + O_2 (g) \rightarrow 2NO(g)$ $2NO (g) + O_2 (g) \rightarrow 2NO_2 (g)$	Irritation in eyes and lungs Low productivity in plants Acid rain
Hydrocarbons (Benzene and Ethylene)	Automobiles and Petroleum industries (Incomplete combustion of fuels)	Respiratory issues Carcinogenic
Particulate Pollutants		
Suspended Particulate matter: • Fly Ash • Lead and other metals • Dust	Thermal power plants Construction activities metallurgical processes Automobiles exhaust	Smog (Smoke + Fog) leads to Poor visibility Breathing problems Lead interferes with the development of red blood cells Carcinogenic
Fibres (Cotton, wool)	Textiles and carpet weaving industries	Lung disorders

- **Particulate pollutants:**
  Their size ranges from 0.001 to 500 µm in diameter. Particles less than 10µm float and move freely with the air current. Particles which are more than 10µm in diameter settle down. Particles less than 0.02 µm form persistent aerosols. The effect of particulate matter (PM) is largely dependent on the particle size. PM bigger than 5 microns are likely to lodge in the nasal passage, whereas particles of about 10 microns enter into lungs easily. Dust, mist, fumes, smoke, smog etc. are particulate pollutants.
  - **Dust** is composed of fine solid particles (over 1µm in diameter), produced during crushing, grinding and attribution of solid materials. Sand from sand blasting, saw dust from wood works, pulverized coal, cement and fly ash from factories, dust storms etc., are some typical examples of this type of particulate emission.
  - **Mists** are produced by particles of spray liquids and by condensation of vapours in air. Examples are sulphuric acid mist and herbicides and insecticides that miss their targets and travel through air and form mists.
  - **Fumes** are generally obtained by the condensation of vapours during sublimation, distillation, boiling and several other chemical reactions. Generally, organic solvents, metals and metallic oxides form fume particles.
  - **Smog,** the word is derived from smoke and fog. This is the most common example of air pollution that occurs in many cities throughout the world. There are two types of smog:
    - ✓ **Classical smog:** It occurs in cool humid climate. It is a mixture of smoke, fog and sulphur dioxide. Chemically it is a reducing mixture and so it is also called as **reducing smog**.
    - ✓ **Photochemical smog:** It occurs in warm, dry and sunny climate. The main components of the photochemical smog result from the action of sunlight on unsaturated hydrocarbons and nitrogen oxides produced by automobiles and factories. Photochemical smog has high concentration of oxidising agents and is, therefore, called as **oxidising smog.**

PHOTOCHEMICAL SMOG

The common components of photochemical smog are ozone, nitric oxide, acrolein, formaldehyde and peroxyacetyl nitrate (PAN). They cause serious health problems. Both ozone and PAN act as powerful eye irritants. Ozone and nitric oxide irritate the nose and throat and their high concentration causes headache, chest pain, dryness of the throat, cough and difficulty in breathing. Photochemical smog leads to cracking of rubber and extensive damage to plant life. It also causes corrosion of metals, stones, building materials, rubber and painted surface

Formation:

When fossil fuels are burnt, a variety of pollutants are emitted. Two of the pollutants are hydrocarbons (unburnt fuels) and nitric oxide (NO). When these pollutants build up to sufficiently high levels, a chain reaction occurs from their interaction with sunlight:

1. In automobile exhausts:

$$N2\ (g) + O_2\ (g) \rightarrow 2NO\ (g)$$

2. In atmosphere:

$$2NO\ (g) + O_2\ (g) \rightarrow 2NO_2\ (g)$$

3. After sometimes, this NO_2 absorbs energy from sunlight and breaks up into nitric oxide and free oxygen atom.

$$NO_2\ (g) \rightarrow NO\ (g) + O$$

4. Free Oxygen atoms are very reactive and combine with the O_2 in air to produce ozone.

$$O + O_2\ (g) \rightarrow O_3\ (g)$$

The Ozone formed in this reaction is **tropospheric Ozone or Bad Ozone** (in contrast with stratospheric Ozone which is good and protects earth from harmful UV rays)

5. The ozone formed in the above reaction reacts rapidly with the NO(g) formed in the reaction 1 to regenerate NO_2.

$$O_3 + NO\ (g) \rightleftharpoons NO_2\ (g) + O_2$$

The NO_2 is a brown gas and at sufficiently high levels can contribute to haze.

6. Ozone is a toxic gas and both NO_2 and O_3 are strong oxidising agents and can react with the unburnt hydrocarbons in the polluted air to produce chemicals such as formaldehyde, acrolein and peroxyacetyl nitrate (PAN).

Control

If the primary precursors of photochemical smog such as NO_2 and hydrocarbons are controlled, the secondary precursors such as ozone and PAN will automatically be reduced. Therefore, catalytic converters are used in the automobiles, which prevent the release of nitrogen oxide and hydrocarbons to the atmosphere. Certain plants e.g., Pinus, Juniperus, Quercus, Pyrus and Vitis can metabolise nitrogen oxide and therefore, their plantation could help in this matter.

Gothenburg Protocol:

It is one of the Eight Protocols under UNECE **Convention on Long Range Transboundary Air Pollution (CLRTAP or Air convention).** It was adopted in 1999 to **abate Acidification, Eutrophication and Ground-level Ozone.** The revised Protocol (2012) sets national emission ceilings (up to 2020) for four pollutants: sulphur (SO2), nitrogen oxides (NOx), volatile organic compounds (VOCs) and ammonia (NH3). It is also the first binding agreement to include emission reduction commitments for fine particulate matter. Also, black carbon (or soot), a short-lived climate pollutant is included within particulate matter for policymaking. Parties whose emissions have a more severe environmental or health impact and whose emissions are relatively cheap to reduce have to make the biggest cuts.

DELHI-NCR AIR POLLUTION:

- According to a study conducted by The Energy and Resources Institute (TERI) in 2018, 36% of the pollution has its source in Delhi itself, 34% in National Capital Region while 30% comes from across international borders.

Student Notes:

- According to study by IIT Kanpur in 2015-16: In summer, maximum contribution of PM 2.5 is from Soil and Road dust followed by Coal and Fly ash. Whereas in winter, maximum contribution of PM 2.5 is from secondary particles followed by Biomass burning.
- **Vehicular Pollution:** TERI's study shows that vehicle pollution is the cause of 28 per cent of PM2.5 emissions.
- **Stubble burning:** Crop residue burning during winter is one of the chief causes for rising air pollution levels in Delhi.
- **Industrial pollution:** Industries contribute 30 per cent of PM2.5 levels, with 14 per cent from small industries. The north-westerly winds that come into Delhi transport Sulphur dioxide (SO2) emitted from large power plants and refineries that are situated upwind of Delhi.

The meteorological and geographical factors responsible for Delhi's pollution:

- **Lack of winds in winter season:** The lack of winds that can carry away pollutants is one of the most important factors impacting air quality. Dust particles and pollutants in the air become unable to move and get locked in the air and affect weather conditions, resulting in smog.
- **Delay in monsoon withdrawal:** Late monsoon withdrawal is not good for air quality in north India as the time progresses towards winter. When monsoon begins to withdraw, an anti-cyclonic circulation gets formed nearly 4-5 kms above the surface of earth. This period is marked by dry weather, clear skies and very low speed of surface winds. So, whatever the particulate matter is in the air, it does not get dispersed and gets arrested in the atmosphere.
- **Geography of Delhi:** Delhi lies to the north-east of the Thar Desert, to the north-west of the central plains and to the south-west of the Himalayas. As winds arrive from the coasts, bringing with them pollutants picked up along the way, they get 'trapped' right before the Himalayas.
- **Dust storms:** Delhi-NCR comes under a thick blanket of dust primarily due to dust storms from Rajasthan which is facing extremely dry weather conditions, with high temperatures and wind speeds. Destruction of the Aravallis that protects north India from dust storms has increased this impact. Also, a study in 2017 by the System of Air Quality and Weather Forecasting and Research (under the Ministry of Earth Sciences) and India Meteorological Department (IMD) "multi-day dust storm" in Iraq, Kuwait and Saudi Arabia was one of the main causes of Delhi's smog.

Stubble burning:

The states surrounding Delhi are known collectively as the "grain bowl" of India after the agricultural sector underwent a green revolution in the 1960s, leading to a dramatic increase in rice and wheat productivity. But as production grew, the sector could not keep up with an increasing demand for labour, with farmers eventually abandoning hand harvesting in favour of less labour-intensive methods such as the combine harvester.

- Unlike manual harvesting techniques however, combine harvesters leave behind rice stubble, which prevents machines from sowing wheat seeds.
- With as little as 10 days between rice harvesting season and the sowing of wheat, farmers often turn to stubble burning to quickly remove the remaining rice crop residue.
- In 2009 **Punjab Preservation of Subsoil Water Act** was passed which has delayed the date for paddy transplantation from June 1 to June 20 in order to arrest rapid decline in the groundwater table. But late transplanting has meant that farmers are now setting fire to their fields mostly clashing with the time just before the onset of winter, when wind movement is very slow and moisture levels in the lower atmosphere are also high.
- The wind carries all the pollutants and dust particles, which gets locked in the air. A study estimates that crop residue burning released 149.24 million tonnes of CO_2, along with CO, oxides of sulphur, particulate matter and black carbon.

Policy Response:

- **National Green Tribunal (NGT)** has banned crop residue burning in the states of Rajasthan, Uttar Pradesh, Haryana and Punjab.
- **Some of the laws that are in operation pertaining to crop residue burning are:** The Section 144 of the Civil Procedure Code (CPC) to ban burning of paddy residue; The Air Prevention and Control of Pollution Act, 1981; The Environment Protection Act, 1986; The National Tribunal Act, 1995; and The National Environment Appellate Authority Act, 1997.
- **National Policy for Management of Crop Residue (NPMCR**): launched by Ministry of Agriculture in 2014 to ensure prevention of burning of crop residues by incentivizing purchase of modern

machineries to minimize left-over crop residue in the field, in situ conservation and mixing of residue in soil to increase soil fertility, multiple uses of crop residue, formulation of fodder pellets and briquettes.

- Central Sector Scheme on **'Promotion of Agricultural Mechanization for In-Situ Management of Crop Residue in the States of Punjab, Haryana, Uttar Pradesh and NCT of Delhi'** for the period from 2018-19 to 2019-20 has been launched to address air pollution and to subsidize machinery required for in-situ management of crop residue.

Student Notes:

Fly ash

It is a fine powder, which is the by-product of burning coal in thermal power plants. It includes substantial amounts of oxides of silica, alumina and calcium. Elements like Arsenic, Boron, Chromium, lead etc. are also found in trace concentrations. Owing to large-scale dependence on thermal power generation and high ash content in Indian coal, large quantity of ash is generated in the country (nearly 200 million tons). It not only requires large area of precious land for its disposal but is also one of the sources of air and water pollution.

Utilisation of Fly Ash:

- **In agriculture:** It improves water holding capacity, works as soil conditioner and contains micronutrients like phosphorus, potassium and calcium thus increasing the crop yield.
- **In Construction works**: Fly ash is a proven resource material for many applications of construction industries and currently is being utilized in manufacturing of Portland cement, bricks/blocks/tiles manufacturing, road embankment construction and low-lying area development, etc.
    - Concrete made with fly ash is stronger and more durable than traditional concrete made with Portland cement.
    - Fly ash is a lightweight material and therefore it undergoes lesser settlement and hence can be used for embankment construction over weak substrate such as alluvial clay or silt where excessive weight could cause failure.
- **In manufacturing of Absorbents** that are suitable for purification of waste gases, drinking water purification, waste water treatment etc.
- **In preventing contamination of Water Resources**- by preventing contamination of surface water through erosion, runoff, airborne particles landing on the water surface etc.

Government Measures to promote Fly Ash Utilization: At present, nearly 63% of the fly ash is being utilised in India

- **Central Electricity Authority (CEA)** has been monitoring the fly ash generation and its utilization in the country at coal/ lignite based thermal power stations since 1996-97.
- **Notifications on Fly Ash utilisation, 2016:** by Ministry of Environment, Forests and Climate Change (MoEFCC):
    - Mandatory uploading of details of fly ash available on Thermal Power Station's (TPS) website
    - Increase in mandatory jurisdiction of area of application from 100 km to 300 km
    - Cost of transportation of fly ash to be borne entirely by TPS up to 100 km.
    - Mandatory use of fly-ash based products in all Government schemes or programmes e.g. Pradhan Mantri Gramin Sadak Yojana, Mahatma Gandhi National Rural Employment Guarantee Act, 2005, Swachh Bharat Abhiyan, etc.
- As per, 2019 government notification the existing red clay brick kilns located within 300 km shall be converted into fly ash-based bricks or blocks or tiles manufacturing unit within one year.
- The GST rate on fly ash and fly ash aggregate with 90% or more of fly ash content was reduced from 18% to 5%.
- A mobile app for ash management- ASH TRACK was created to help establish a link between fly ash users and power plant executives.
- NTPC in collaboration with Institutes like IIT-Delhi and IIT-Kanpur has initiated manufacturing of prestressed railway concrete sleepers.

Way Forward

- **Renovation and modernization** of coal/lignite based Thermal Power Stations need to include - technological advancement required to ensure development of dry fly ash collection, storage and disposal facilities so that fly ash in dry form could be made available to its users

- **Policy support:** To promote the usage of fly ash, state and local governments should issue preferential policies that encourage its recycling, such as the preferential purchase of recycled fly ash products and reduction of the overall effective tax.
- **Identifying prospective users:** Areas having large prospective of fly ash utilization needs to be discovered for increasing the overall utilization of fly ash in India. New emerging areas includes Light Weight Aggregates and Geo-polymers, Coal Beneficiation Blending and Washing, etc.
- **Encouraging Industry-Academia Partnership** and interactions regarding scientific disposal of fly ash for entrepreneur development, creating awareness and organizing training programmes. In view of large quantity of fly ash generation, induction of 'Fly Ash' as a subject in academic curriculum of Engineering and Architecture may be introduced.

Control of vehicular pollution

- Strict implementation of the emission standards for automobiles and catalytic converters as provided by Bharat Stage norms and Pollution Under Control (PUC) certificate. Reduction in Sulphur content of the fuel.
- Introduction of alternate fuels such as CNG and LPG or shifting towards electric vehicles.
- Proper traffic management by use of technology like GPS and creating infrastructure such as flyovers and subways, to cut fuel use.
- Augmentation of public transport systems such as increased frequency of metro trains, electric buses, etc. to discourage use of private vehicles.
- Information dissemination such as display of ambient air quality, pollution control measures, etc.

Control of Industrial Pollution:

- Use of cleaner fuels such as liquefied natural gas (LNG) in power plants, fertilizer plants etc. which is cheaper in addition to being environmentally friendly.
- Employing environment friendly industrial processes so that emission of pollutants and hazardous waste is minimized.
- **Installing devices which reduce release of pollutants, for instance:**
    - **Filters:** They remove particulate matter from the gas stream. The medium of a filter may be made of fibrous materials like cloth, granular material like sand, a rigid material like screen, or any mat like felt pad.
    - **Electrostatic precipitators (ESP):** The emanating dust is charged with ions and the ionized particulate matter is collected on an oppositely charged surface. The particles are removed from the collection surface by occasional shaking or by rapping the surface. They are used in boilers, furnaces, and many other units of thermal power plants, cement factories, steel plants, etc.
    - **Inertial collectors:** It works on the principle that inertia of SPM in a gas is higher than its solvent and as inertia is a function of the mass of the particulate matter this device collects heavier particles more efficiently.
    - **Scrubbers:** They are wet collectors. They remove aerosols from a stream of gas either by collecting wet particles on a surface followed by their removal, or else the particles are wetted by a scrubbing liquid. The particles get trapped as they travel from supporting gaseous medium across the interface to the liquid scrubbing medium.

Pollution from burning of Agricultural or municipal wastes:

Crop residue/stubble burning after the end of harvest season has become a major cause of air pollution, especially in Delhi and large part of Northern India in winters causing smog and serious health issues. Burning of municipal waste for heating purposes also adds to the woe.

According to the Indian Ministry of New and Renewable Energy (MNRE), India generates on an average 500 Million tons of crop residue per year. A majority of this crop residue is in fact used as fodder and fuel for other domestic and industrial purposes. However, there is still a surplus of 140 Mt out of which 92 Mt is burned each year.

Student Notes:

The strategy to control residue burning:

- Promotion of technologies for optimum utilization and in-situ management of crop residue to prevent loss of invaluable soil nutrients, minerals and improvement of general soil health.
- Promotion of diversified uses of crop residue for various purposes viz. power generation, as industrial raw material for production of bioethanol, packing material for fruits & vegetables and glassware, utilization for paper/ board/panel industry, biogas generation/composting and mushroom cultivation in Public Private Partnership (PPP) mode.
- Capacity building of various stakeholders including farmers and extension functionaries under crop development programmes and organization of field level demonstrations on management of crop residues in all programmes/schemes.
- Promotion of adaptive research for management of crop residue and development of machineries for effective utilization of such residues.
- Formulation and implementation of necessary policy measures for control of crop residue burning through suitable laws/ legislation/ executive orders etc.

Legislations to control Air Pollution:

THE AIR (PREVENTION AND CONTROL OF POLLUTION) ACT, 1981: This act defines air pollutants and pollution, and provides regulations for appliances, fuels, and automobiles for preserving the quality of air. It has also conferred power to the Central Pollution Control Board (CPCB)/SPCB to act as a nodal authority to control air pollution in India.	**Environment (Protection) Act, 1986:** It authorizes the central government to protect and improve environmental quality, control and reduce pollution from all sources (air, water, land), and prohibit or restrict the setting and /or operation of any industrial facility on environmental grounds.

Steps taken to curb Air Pollution

National Clean Air Programme (NCAP)	• The Central Government launched NCAP in 2019 under the Central Sector "Control of Pollution" Scheme as a long-term, time-bound, national level strategy to tackle the air pollution problem across the country in a comprehensive manner with targets to achieve 20 % to 30 % reduction in PM_{10} and $PM_{2.5}$ concentrations by 2024 keeping 2017 as the base year for the comparison of concentration. • 122 non-attainment cities mostly in Indo-Gangetic Plains have been identified based on ambient air quality data for the period 2014-2018. • A non-attainment city is considered to have air quality worse than the National Ambient Air Quality Standards.
Bharat Stage Emission Standards (BSES)	• These are the legal limits on the amount of air pollutants like carbon monoxide and particulate matter that a vehicle in India can emit. • These standards are targeted at making improvements in three areas i.e., emission control, fuel efficiency and engine design. • India has planned to shift to BS-VI norms from BS-IV from 2020.
Carbon Emission by Thermal Power Plants (TPPs)	Ministry of Environment, Forest and Climate Change had notified environmental norms to reduce emission of PM 10, SO2 and oxide of nitrogen.
Graded Response Action Plan (GRAP) enforced by EPCA	For Delhi and the NCR region, which comprises the graded measures for each source framed according to the Air Quality Index categories. For example: • During 'very poor' air quality, it recommends banning diesel generators and parking fee increased by three to four times. • Similar to EPCA's GRAP the NGT divided air pollution into four categories, for graded measures, which include odd-even scheme among others
Focus on short-lived climate pollutants (SLCP)	Like methane, HFCs, black carbon (soot), tropospheric ozone etc. SLCP mitigation has the potential to avoid up to 0.6°C of warming by mid-century while aggressive CO2 mitigation in a comparable scenario leads to less than half as much near-term reduction in warming.

Other Measures:	**Ban on pet coke and furnace oil:** Supreme Court banned the use of furnace oil and pet-coke in Haryana, Rajasthan and Uttar Pradesh. Many other steps like Clean Air- India Initiative, Dust Mitigation Plan, India's Paris pledges etc.
Faster Adoption and Manufacturing of Electric vehicles	Launched in 2015, the scheme provides subsidies for electric 2- and 3-wheelers, hybrid and e-cars and buses. Its first phase ended in 2019 and second phase will run for 3 years from 2019 to 2022.
SAMEER app	It is an app wherein air quality information is available to public along with provision for registering complaints against air polluting activities.

National Ambient Air Quality Monitoring Program (NAMP):

This program is executed by CPCB. Under NAMP four air pollutants viz., **Sulphur Dioxide (SO2), Oxides of Nitrogen as NO2, Respirable Suspended Particulate Matter (RSPM / PM10) and Fine Particulate Matter (PM2.5)** have been identified for regular monitoring at all the locations.

Its objectives are:

- To determine the status and trends of ambient air quality
- To ascertain whether the prescribed ambient air quality standards are violated
- To Identify Non-Attainment Cities
- To obtain the knowledge and understanding necessary for developing preventive and corrective measures and
- To understand the natural cleansing process undergoing in the environment through pollution dilution, dispersion, wind-based movement, dry deposition, precipitation and chemical transformation of pollutants generated.

The monitoring of meteorological parameters such as wind speed and wind direction, relative humidity (RH) and temperature are also integrated with the monitoring of air quality.

National Air Quality Index (AQI):

- It was launched by MoEFCC in 2014 under Swachha Bharat Abhiyan as '**One Number- One Colour- One Description**' for the common man to judge the air quality within his vicinity.
- There are six AQI categories, namely Good, Satisfactory, Moderately polluted, Poor, Very Poor, and Severe.
- The proposed AQI will consider eight pollutants **(PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, O_3, NH_3, and Pb)** for which short-term (up to 24-hourly averaging period) National Ambient Air Quality Standards are prescribed.
- Based on the measured ambient concentrations, corresponding standards and likely health impact, a sub-index is calculated for each of these pollutants. The worst sub-index reflects overall AQI.

AQI	Associated Health Impacts
Good (0-50)	Minimal Impact
Satisfactory (51-100)	May cause minor breathing discomfort to sensitive people.
Moderately polluted (101-200)	May cause breathing discomfort to people with lung diseases such as asthma, and discomfort to people with heart disease, children and older adults.
Poor (201-300)	May cause breathing discomfort to people on prolonged exposure, and discomfort to people with heart disease
Very Poor (301-400)	May cause respiratory illness to people on prolonged exposure. Effect may be more pronounced in people with lung and heart disease.
Severe (401-500)	May cause respiratory impact even on healthy people, and serious health impacts on people with lung/heart disease. The health impacts may be experienced even during light physical activity.

AQI Category, Pollutants and Health Breakpoints

AQI Category (Range)	PM_{10} 24-hr	$PM_{2.5}$ 24-hr	NO_2 24-hr	O_3 8-hr	CO 8-hr (mg/m³)	SO_2 24-hr	NH_3 24-hr	Pb 24-hr
Good (0-50)	0-50	0-30	0-40	0-50	0-1.0	0-40	0-200	0-0.5
Satisfactory (51-100)	51-100	31-60	41-80	51-100	1.1-2.0	41-80	201-400	0.5-1.0
Moderately polluted (101-200)	101-250	61-90	81-180	101-168	2.1-10	81-380	401-800	1.1-2.0
Poor (201-300)	251-350	91-120	181-280	169-208	10-17	381-800	800-1200	2.1-3.0
Very Poor (301-400)	351-430	121-250	281-400	209-748	17-34	801-1600	1200-1800	3.1-3.5
Severe (401-500)	430 +	250 +	400 +	748 +	34 +	1600 +	1800 +	3.5 +

Student Notes:

Student Notes:

CLEAN COAL TECHNOLOGIES

Clean coal technology seeks to reduce harsh environmental effects by using multiple technologies to purify the coal before it burns and contain its emissions. Some of the common clean coal technologies include:

- **Coal washing**, removes unwanted minerals by mixing crushed coal with a liquid and allowing the impurities to separate and settle.
- **Wet scrubbers**, or flue gas desulfurisation systems, minimises sulfur dioxide emissions from burning of coal which is a major cause of acid rain.
- **Low-NOx (nitrogen oxide) burners** reduce the creation of nitrogen oxides, a cause of ground-level ozone.
- **Electrostatic precipitators** remove particulates that aggravate asthma and cause respiratory ailments.
- **Carbon capture and storage** capturing carbon dioxide usually from large point sources, such as a cement factory or biomass power plant, transporting it to a storage site, and depositing it where it will not enter the atmosphere, normally an underground geological formation.

Recently, National Centre for Clean Coal Research and Development has been inaugurated at Indian Institute of Science (IISc) in Bengaluru by Ministry of Science and Technology. The Centre would address several critical R&D challenges towards the development of clean coal technologies in tandem with developing supercritical power plant technologies.

EMISSION NORMS FOR THERMAL POWER PLANTS

In 2015, Ministry of Environment, Forests and Climate Change (MoEFCC) notified specific standards for the thermal power plants (TPPs) to control the emissions under "Environment (Protection) Amendment Rules, 2015'. **The deadline for the same has been extended to 2022 for over 300 such units**.

The emission norms provide different mechanisms to reduce the emissions and usage of water such as:

- Flue Gas Desulphurization (FGD) process for controlling SOx emissions.
- Selective Non-Catalytic Reduction (SNCR) and Selective Catalytic Reduction (SCR) system for controlling NOx emissions.
- Electro-Static Precipitators (ESPs) are to be deployed for control of particulate matter (PM) in thermal power stations.
- Installation of cooling towers in order to change over to closed cooling water system for controlling water consumption.

COAL GASIFICATION:

It is one of the clean coal technologies and involves the process of converting coal into **synthesis gas (also called syngas)**.

Syngas is a mixture of hydrogen (H_2), carbon monoxide (CO) and carbon dioxide (CO_2).

The by-products of coal gasification include coke, coal tar, sulfur, ammonia and fly ash.

CO_2 and ammonia can be further reacted to produce urea.

Syngas can also be used in a variety of other applications such as in the production of electricity, fuel for IC engines, making plastics, cement etc.

CARBON CAPTURE, UTILISATION & STORAGE (CCUS)

CCUS is group of technologies designed to reduce the amount of CO_2 released into the atmosphere from coal and gas power stations as well as heavy industry including cement and steel production. Once captured, the CO_2 can be either re-used in various products, such as cement or plastics (utilisation), or stored in geological formations deep underground (storage).

- **Capture technologies** separate CO_2 from other gases which may be done in three different ways:
  - **Pre-combustion capture**: It refers to capturing CO_2 generated as an undesired co-product of an intermediate reaction of a conversion process. A pre-combustion system involves first converting solid, liquid or gaseous fuel into a mixture of hydrogen and carbon dioxide using one of a number of processes such as 'gasification' or 'reforming'.
    - ✓ **Gasification** is a process that converts biomass- or fossil fuel-based carbonaceous materials into carbon monoxide, hydrogen and carbon dioxide.

- ✓ **Reforming,** in chemistry, processing technique by which the molecular structure of a hydrocarbon is rearranged to alter its properties.

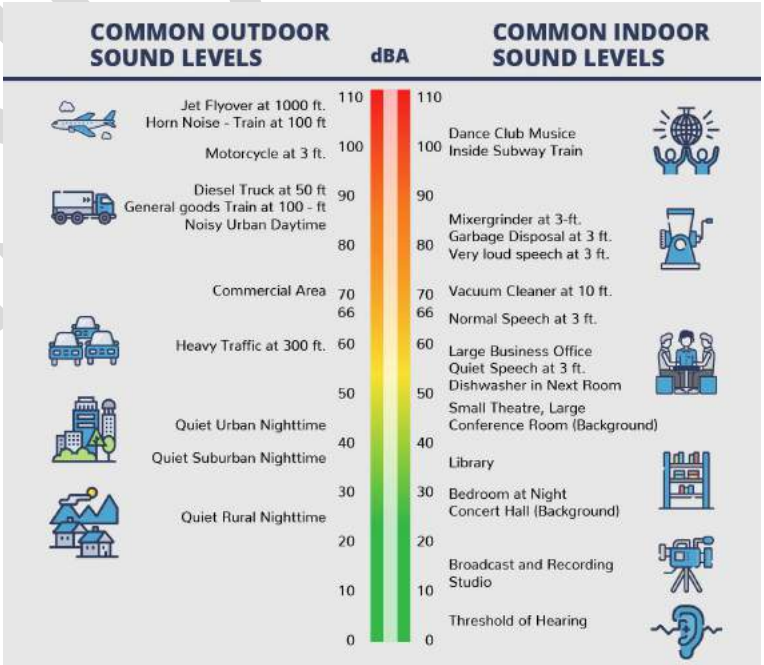
- **Post-combustion capture**: It involves separation of CO_2 from waste gas streams after the conversion of the carbon source to CO_2 – for example, via combustion of fossil fuels or digestion of wastewater sludge. It includes methods like absorption in solvents, high pressure membrane filtration, adsorption by solid sorbents, including porous organic frameworks, and cryogenic separation etc.
- **Oxy-fuel combustion**: It can only be applied to processes involving combustion, such as power generation in fossil-fuelled plants, cement production and the iron and steel industry. Here, fuel is burned with pure oxygen to produce flue gas with high CO_2 concentrations and free from nitrogen and its compounds.
  - ✓ **Flue gas** refers to the combustion exhaust gas produced at power plants and other industries.

- **Storage:** Suitable storage sites for captured carbon include former gas and oil fields, deep saline formations (porous rocks filled with very salty water), coal bed formations, ocean bed etc.
- **Utilization:** As an alternative to storage, captured CO_2 can be used as a commercial product, either directly or after conversion. Examples of utilisation include:
  - **In the food and drink industry**: CO_2 is commonly used as a carbonating agent, preservative, packaging gas and as a solvent for the extraction of flavours and in the decaffeination process.
  - **In the pharmaceutical industry**: where CO_2 can be used as a respiratory stimulant or as an intermediate in the synthesis of drugs
  - **Concrete building materials**: CO_2 can be used to cure cement, or in the manufacture of aggregates**.**
  - **Enhanced oil and coal-bed methane recovery:** where the carbon dioxide is injected into depleting oil or gas reserves to increases the amount of recovery.
  - **Mineral carbonation**: It is a chemical process in which CO_2 reacts with a metal oxide such as magnesium or calcium to form carbonates.
  - **Biofuels production**: CO_2 can be used to cultivate microalgae used for the production of biofuels.

However, at present CCUS technologies are expensive and not scalable. It is also associated with environmental concerns such as possible leakage of CO_2 and acidification of Oceans.

14.4. Noise Pollution

Noise by definition is "sound without value" or "any noise that is unwanted by the recipient". W.H.O. (World Health Organization) has prescribed optimum noise level as 45 dB by day and 35 dB by night. Anything above 80 dB is hazardous. Noise pollution leads to irritation and an increased blood pressure, loss of temper, decrease in work efficiency, loss of hearing which may be first temporary but can become permanent in the noise stress continues.



14.4.1. Regulations for Noise Pollution

The CPCB has laid down the permissible noise levels in India for different areas. Noise pollution rules have defined the acceptable level of noise in different zones for both daytime and night time.

- In industrial areas, the permissible limit is 75 dB for daytime and 70 dB at night.
- In commercial areas, it is 65 dB and 55 dB, while in residential areas it is 55 dB and 45 dB during daytime and night respectively.
- Additionally, state governments have declared 'silent zones' which includes areas that lie within 100 meters of the premises of schools, colleges, hospitals and courts. The permissible noise limit in this zone is 50 dB during the day and 40 dB during the night.

14.4.2. Laws Governing Noise Pollution

- **Air (Prevention and Control of Pollution) Act, 1981**: It includes 'Noise' as an air pollutant.
- **Noise Pollution (Regulation and Control) Rules, 2000**: It defines and regulates noise pollution and its sources.
- **Environment (Protection) Rules, 1986**: It prescribes noise standards for motor vehicles, air-conditioners, refrigerators, diesel generators and certain types of construction equipment.
- **Noise emanating from industry** is regulated by State Pollution Control Boards / Pollution Control Committees (SPCBs / PCCs) for states / Union territories under the Air (Prevention and Control of Pollution) Act, 1981.

14.5. Water Pollution

Addition or presence of undesirable substances in water is called water pollution. It is one of the most serious environmental problems. Water pollution is caused naturally (erosion, leaching of minerals and decaying of organic matters) as well as by a variety of human activities such as industrial, agricultural and domestic.

14.5.1. Sources of Water Pollution

- **Pesticides:** Pesticides like DDT and others used in agriculture may contaminate water bodies. Aquatic organisms take up pesticides from water get into the food chain (aquatic in this case) and move up the food chain. At higher trophic level they get concentrated and may reach the upper end of the food chain.
- **Industrial effluents**: Metals like lead, zinc, arsenic, copper, mercury and cadmium in industrial waste waters adversely affect humans and other animals.
  - **Mercury** causes Minamata disease in humans and dropsy in fishes.
  - **Lead** causes displexia, while **Cadmium** poisoning causes Itai – Itai disease etc.
- **Domestic sewage:** Sewage, especially from towns and cities cause organic pollution of water bodies leading to Eutrophication and spread of diseases.
- **Oil Spills**: Oil pollution of sea occurs from leakage from ships, oil tankers, rigs and pipelines. For example, the Mumbai Oil Spill in 2010.

14.5.2. Types of Water Pollution in India

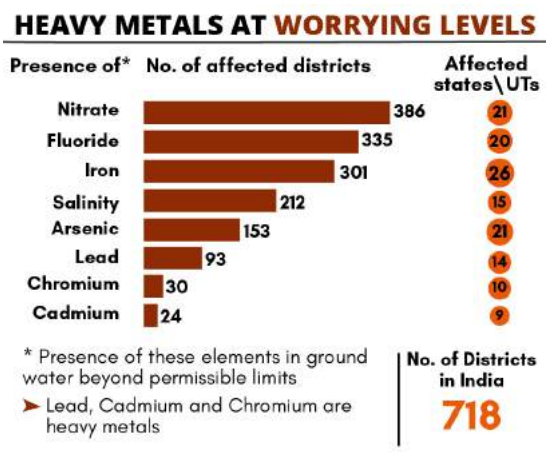
14.5.2.1 Ground Water Pollution

Discharge of toxic elements from industries and landfills and diffused sources of pollution like fertilisers and pesticides over the years has resulted in high level of contamination of ground water with the level of nitrates exceeding the permissible limits in more than 50% districts of India.

Ground water pollutants:

- **Fluoride:** High concentration of fluoride in ground water is beyond the permissible limit of 1.5 mg/L. Excess fluoride causes neuro-muscular disorders, gastro- intestinal problems, teeth deformity, hardening of bones, and skeletal fluorosis.
- **Arsenic:** In West Bengal, 79 blocks in 8 districts have Arsenic beyond the permissible limit of 0.01 mg/L. Chronic exposure to Arsenic causes Black foot disease. It may also cause diarrhoea, lung and skin cancer.

- **Nitrates:** High Nitrate concentration in ground water in India has been found in almost all hydrogeological formations. Excess Nitrate in drinking water causes methemoglobinemia or Blue baby Syndrome.
- **Iron:** High concentration of Iron (>1.0 mg/l) in ground water has been observed in more than 1.1 lakh habitations in the country, such as from Assam, West Bengal etc.
- **Uranium:** Aquifers in as many as 16 states of India are contaminated by uranium, whose presence in drinking water has been linked to chronic kidney disease.



14.5.2.2. Regulation of Groundwater Pollution in India

There is currently no Central law on groundwater regulation. The Groundwater (Sustainable Management) Bill, 2017 is still pending. Water as a subject belongs to the states which makes it their responsibility to regulate and manage it. However, under the Environment Protection Act 1986, the Central Ground Water Authority (CGWA) has been conferred power to issue guidelines for development and management of ground water resources in the country. The chemical quality of ground water is monitored once a year by the Central Ground Water Board through a network of about 15,000 observation wells located all over the country.

India and Stockholm Convention:

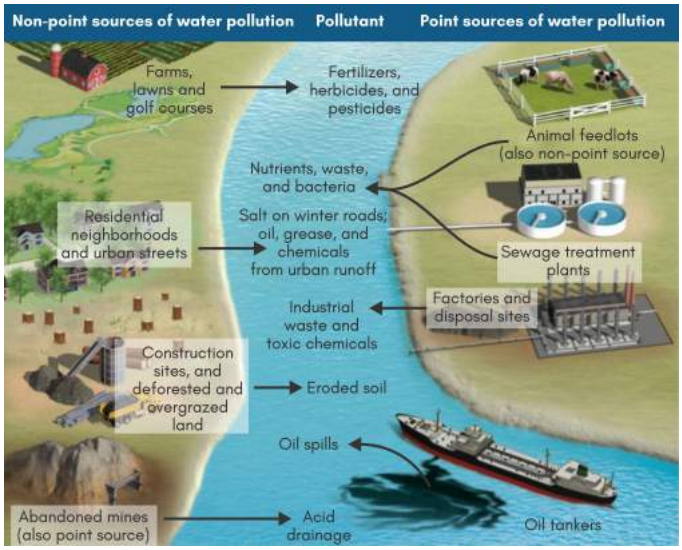
India ratified the Convention in 2006 and in 2018, the MoEFCC notified the **'Regulation of Persistent Organic Pollutants Rules'** under the provisions of Environment (Protection) Act, 1986.

The regulation inter alia prohibited the manufacture, trade, use, import and export **seven chemicals** namely (i) Chlordecone, (ii) Hexabromobiphenyl, (iii) Hexabromodiphenyl ether and Heptabromodiphenylether (Commercial octa-BDE), (iv) Tetrabromodiphenyl ether and Pentabromodiphenyl ether (Commercial penta-BDE), (v) Pentachlorobenzene, (vi) Hexabromocyclododecane, and (vii) Hexachlorobutadiene, which were already listed as POPs under Stockholm Convention.

After updating its National Implementation program, India would be able to access the financial resources of **the Global Environmental Facility (GEF),** the designated financial mechanism under Stockholm convention.

14.5.3. Surface Water Pollution

The CPCB considers a BOD less than 3 mg/l as an indicator of a healthy river. As per CPCB report, 80% of India's surface water is polluted. The report holds domestic sewerage, inadequate sanitation facilities, poor septage management and the near absence of sanitation and wastewater policy frameworks responsible for this. Also, alarmingly high levels of water pollution are leading to poor nutritional standards along with increasing the burden of vector borne diseases such as cholera, dysentery, jaundice and diarrhoea.



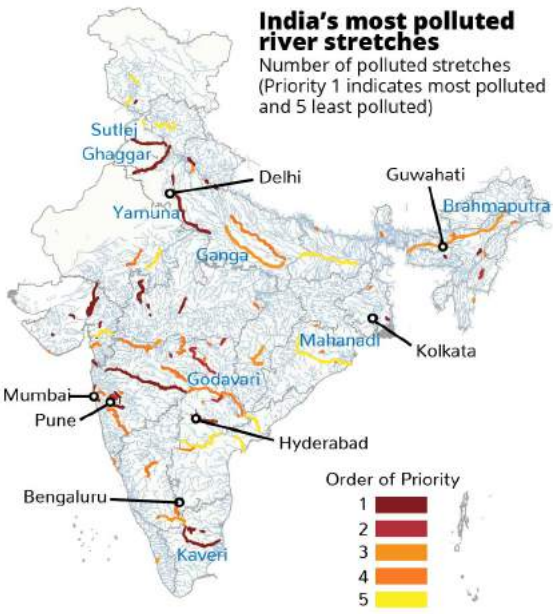
- According to an assessment by the CPCB in 2018, there were 351 polluted river stretches (302 in 2015) in the country, with 45 of them being critically polluted.

Student Notes:

- Maharashtra, Assam and Gujarat account for 117 of the 351 polluted rivers stretches.

Sources of River Water Pollution:

- **Point source pollution:** It refers to the pollution entering the water way through a discrete conveyance like pipes, channels etc., from source such as industry.
- **Non- point source pollution**: It refers to the pollution that does not enter the water way through a discrete source but is accumulative in nature. These pollutants are:
  - Natural contaminants such as dry leaves, dead insects and animals, bird droppings etc.
  - Agricultural contaminants such as agricultural runoff containing fertilizers, pesticides etc.
  - Industrial contaminants such as industrial runoff containing industrial wastes.
  - Microbial contaminants such as Faecal & Total Coliform, especially during Cultural Congregation like Kumbh in India.
  - Human added contaminants such as organic matter through domestic discharges.



India's most polluted stretches of rivers in 2018, identified by the Central Pollution Control Board. Level of pollution decreases with priority level, with priority 1 the most polluted. Priority 1,2 and 3 stretches are highlighted, while only selected priority 4 and 5 stretces in major rivers are highlighted.

Central Pollution Control Board (CPCB)

It is a statutory body constituted under the **Water (Prevention and Control of Pollution) Act, 1974**. Further, it was also entrusted with the powers and functions under the **Air (Prevention and Control of Pollution) Act, 1981**. It also serves as a field formation and also provides technical services to the Ministry of Environment and Forests under the provisions of **the Environment (Protection) Act, 1986.**

Functions:

- **Water Quality Monitoring**: To promote cleanliness of streams and wells in different areas of the States by prevention, control and abatement of water pollution, and
- **Air Quality Monitoring**: To improve the quality of air and to prevent, control or abate air pollution in the country.

GANGA RIVER POLLUTION

Current Status:

- As per Central Pollution Control Board (CPCB), Ganga river water is NOT FIT for "direct drinking" and only seven spots from where it passes can be consumed after disinfection.
- The report on 'Biological Water Quality Assessment of the River Ganga (2017-18)' shows that the water quality of the river was either clean or slightly polluted (bathing standard or having a standard which could support aquatic life) at only four out of 41 locations during the pre-monsoon phase and at only one out of 39 locations in post-monsoon period.
- The report also analysed the comparative water quality data from 2014 to 2018, showing hardly any improvement at most of the locations in the past four years. Water quality at some locations (Jagjeetpur in Uttarakhand and Kanpur, Allahabad and Varanasi in Uttar Pradesh) had even deteriorated in 2017-18 as compared to 2014-15.

Existing structure to check pollution of River Ganga:

Under the **Environment (Protection) Act, 1986**, a five-tier structure has been envisaged at national, state and district level to take measures for prevention, control and abatement of environmental

pollution in river Ganga and to ensure continuous adequate flow of water so as to rejuvenate the river Ganga as below:

- National Ganga Council under chairmanship of Prime Minister of India (replaced **National Ganga River Basin Authority**).
- **Empowered Task Force** (ETF) on river Ganga under chairmanship of Union Minister of Water Resources, River Development and Ganga Rejuvenation.
- **National Mission for Clean Ganga (NMCG)**.
- **State Ganga Committees** and
- **District Ganga Committees** in every specified district abutting river Ganga and its tributaries in the states.

Namami Gange Programme: It is an Integrated Conservation Mission, approved as 'Flagship Programme' by the Union Government in June 2014 with budget outlay of Rs.20,000 Crore to accomplish the twin objectives of effective abatement of pollution, conservation and rejuvenation of National River Ganga. NMCG is its nodal body.

Progress within Namami Gange:

- **Rural Sanitation:** 4,465 villages on the Ganga stem have been declared ODF and support is being provided to 1,662 Gram Panchayats along Ganga for solid and liquid waste management.
- **Urban River Management:** NMCG, in partnership with National Institute of Urban Affairs (NIUA), is preparing an Urban River Management Plan to protect and enhance the status of river health within the city, to prevent their deterioration and to ensure sustainable use of water resources. High-resolution Light Detection and Ranging (LIDAR) maps of the entire Ganga stretch would be generated.
- **Industrial Pollution:** 1,109 Grossly Polluting Industries (GPIs) were identified and surveyed. The compliance of the operational GPIs in 2017 as against 2018 improved from 39% to 76%. Zero black liquor discharge has been achieved in Paper and Pulp industry and in distillery.
- **Water Quality:** Both dissolved oxygen levels and organic pollution load has improved at multiple locations. Multiple Real Time Water Quality Monitoring Stations (RTWQMS) are operational under Namami Gange Programme.
- **Ecosystem Conservation**: Massive afforestation drive undertaken in the five Ganga States with total plantation of 96,46,607 leading to increase in forested area of 8,631 hectares.
- **River as Public Space**: 143 ghats have been taken up under the Mission out of which 100 have been completed.
- **Sewerage Project Management**: through Hybrid Annuity Mode (HAM) and improved governance through 'One City One Operator' approach ensuring competitive and positive market participation.

14.5.4. Eutrophication

The enrichment of water bodies with nutrients causes eutrophication of the water body. This is a natural process by which natural ageing of a lake takes place. However, discharge of domestic waste, agricultural surface runoff, land drainage and industrial effluents in a water body leads to rapid nutrients enrichment **called Cultural or Accelerated Eutrophication**.

- This encourages the growth of algae duckweed, water hyacinth, phytoplankton and other aquatic plants, which increases the biological demand for oxygen (BOD).
- As more plants grow and die, the dead and decaying plants and organic matter acted upon by heterotrophic protozoans and bacteria, deplete the water of dissolved oxygen (DO). Decrease in DO result in sudden death of large population of fish and other aquatic organisms including plants, releasing offensive smell and makes the water unfit for human use.

Eutrophication sets off a chain reaction in the ecosystem such as Harmful Algal Blooms, Dead Zones and Fish Kills.

Harmful Algal Blooms

Harmful algal blooms are the rapid growth of algae or cyanobacteria in a water body. Aggregations of these organisms discolour the water and impart a distinct colour to it such as red, mahogany, brown, or green. Such blooms can be both toxic and non-toxic and have devastating consequences over coastal environment.

Student Notes:

The growth of HABs is attributed to following factors:

- **Increased nutrients:** An algal bloom is mostly caused by the presence of large amounts of nutrients especially nitrogen and phosphorus present in water. It may occur naturally such as upwelling, formation of mud-banks, nutrient discharges from estuaries, washing off of leachable nutrients from soil through rain as well as through agricultural and urban run-off and industrial waste discharge.
- **Thermal Pollution**: Water is used as a coolant in powerplants and factories. When such water is released, it changes the ambient temperature of the water body, and hence supports algal growth.
- **Climate change**: Global warming has led to warmer seas that supports the growth of HAB. Also, due to change in precipitation patterns, water levels in lakes and inland waterways have reduced. This has increased the risk of HAB as warm, shallow, nutrient-rich water supports their growth.

Consequences of HAB over aquatic environment:

- **Impact over water quality:** The colour of the water changes and it also gives a foul, obnoxious smell making the water unfit for drinking purposes.
- **Impact over biodiversity:** HABs limit the penetration of light causing die-offs of plants in littoral zones and their dependent population. To decompose these dead organisms, a large quantity of Oxygen is consumed. This increases the Biological Oxygen Demand (BOD) of water. Dissolved oxygen decreases and results into fish-kills. In worst cases, it leads to Hypoxia of water-bodies, further leading to formation of dead-zones where water can no more support life.
    - Furthermore, high rates of photosynthesis associated with eutrophication can deplete dissolved inorganic carbon and raise pH to extreme levels during the day. Elevated pH can in turn 'blind' organisms that rely on perception of dissolved chemical cues for their survival by impairing their chemosensory abilities.

Biomagnification

Biomagnification, also known as bioamplification, is the process by which **substances become more concentrated** in the bodies of consumers **as one moves up the food chain** (trophic levels).

When chemicals or pesticides are let into rivers or lakes they are consumed by aquatic organisms like fish, which in turn are consumed by large birds, animals or humans. These harmful substances become concentrated in tissues, internal organs as it moves up the food chain.

Following substances have the potential to biomagnify:

1. **Polychlorinated Biphenyls** used as insulators in transformers and fire retardants.
2. **Polynuclear aromatic hydrocarbons** which are present in petroleum products.
3. **Heavy metals** like Mercury, copper, cadmium, chromium, lead, nickel, zinc, tin (TBT or tributyltin).
4. **Cyanides** used in fishing and gold leaching

Effects of biomagnification:

1. High concentrations of DDT in some bird species caused **failure of eggs by thinning the shells.**
2. PCBs can **affect the immune system**, fertility, child development and possibly increase the risk of certain cancers.
3. **Mercury poisoning** interferes with the nervous system development in fetuses and young children.

Bioaccumulation v/s Biomagnification

- Although sometimes used interchangeably with bioaccumulation, an important distinction between the bioaccumulation and biomagnifications is that bioaccumulation occurs within a trophic level, and is the increase in concentration of a substance in certain tissues (usually in fatty tissue.) of organisms' bodies due to absorption from food and the environment.
- The longer the half-life of the substance the greater is the risk of poisoning though levels of toxins are not very high in the environment. Bioaccumulation varies between individual organisms as well as between species.
- Large, fat, long-lived individuals or species with low rates of metabolism or excretion of a chemical will bioaccumulate more than small, thin, short-lived organisms. Thus, an old lake trout may bioaccumulate much more than a young bluegill in the same lake.

Student Notes:

- **Impact over humans:**
  - The human illnesses caused by HABs are rare but it can be debilitating or fatal. For example, eating seafood contaminated by toxins from algae called Alexandrium can lead to paralytic shellfish poisoning, which can cause paralysis and even death. The algae Pseudo nitzschia produces a toxin called domoic acid that can cause vomiting, diarrhoea, confusion, seizures, permanent short term memory loss, or death, when consumed at high levels.
  - Fish and Tourism industries are also affected by the HABs.
  - Consumption of aquatic resources from the regions of HAB may result into accumulation of toxic wastes in the human body through biological processes such as Bio-accumulation and Bio-Magnification.

In India, four regions have been identified as Algal bloom hotspots viz North Eastern Arabian Sea, Coastal waters off Kerala, Gulf of Mannar, and coastal waters of Gopalpur. Indian scientists have found that the HABs in Indian seas have increased by more than 15% in the last 12 years. To manage the HABs, there is a dire need to reduce the use of pesticides and fertilisers in farming and bring strict laws for treatment of industrial discharge and urban wastes.

Dead Zones: When these dense algal blooms eventually die, microbial decomposition severely depletes dissolved oxygen, creating a hypoxic or **anoxic** 'dead zone' lacking sufficient oxygen to support most organisms. Dead zones are found both in freshwater lakes and Oceans.

Fish Kills: It is the sudden and unexpected death of a number of fish or other aquatic animals such as crabs or prawns over a short period of time and often within a particular area in the wild. Most fish kills occur as a result of fluctuations in the natural environment with the most common cause being algal blooms and resulting water quality issues such as low oxygen or production of toxins.

Ways to Abate River Pollution

- The enforcement towards recycling and reuse of wastewater after treatment should be strictly implemented. The drains should discharge sufficiently treated effluent in proportion to self-cleaning capacity of rivers.
- Solid waste management should also be clearly supported through policy initiatives and state of art technology for converting solid waste into useful resources.
- Suitable bioremediation measures may be taken on drains of small towns and STPs may be installed at all big cities so that they shall not discharge untreated water directly to the river.
- Widespread and intense awareness programme for the common public should be undertaken to inform them about the serious implications of river pollution.
- Provide sufficient water in the river for ecological flow and dilution. This can be made possible by:
  - Constructing storage structures at the upstream, which can continuously release discharge for meeting dilution requirements.
  - Improving water use efficiency so that less diversion of water is needed for consumptive usage

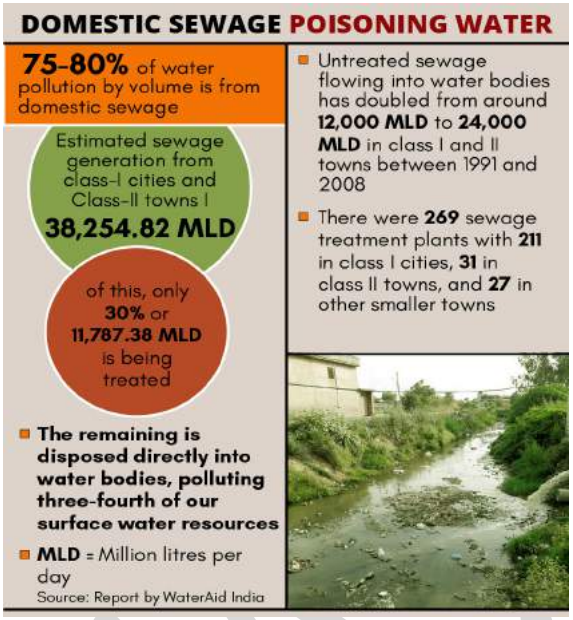
Treatment of sewage:

Waste water from domestic or industrial sources or from garbage dumps is generally known as sewage. It may also contain rain water and surface runoff. The sewage water can be treated to make it safe for disposal into water bodies like rivers, lakes etc. The treatment involves three stages i.e., primary, secondary and tertiary. This includes:

- Sedimentation
- Coagulation/flocculation
- Filtration
- Disinfection

- Softening and
- Aeration.

Suspended particulate matters are removed in primary treatment. The residue obtained from primary treatment are known as sludge. Secondary treatment removes organic solids, left out after primary treatment, through their microbial decomposition. Effluents after secondary treatment may be clean but contain large amounts of nutrients which can cause problem of eutrophication. During tertiary treatment these nutrients are removed and water is disinfected to remove pathogenic bacteria. Lastly aeration is done to remove hydrogen sulphide and reduce the amount of carbon dioxide and make water healthy and fit for aquatic organisms.



14.5.5. Laws and Policies for Controlling Water Pollution in India

- **Water (Prevention and Control of Pollution) Act (1974):** It established Pollution Control Boards at the Central and State levels and bestowed them with powers to prevent and control water pollution and to advise governments on matters pertaining to such pollution.
- **National River Conservation Plan**: Launched in 1985 with Ganga Action Plan, its main objective is to reduce the pollution load in rivers through implementation of various pollution abatement works, thereby improving their water quality.
- **National Water Monitoring Programme (NWMP):** Under it, CPCB monitors the water quality of both surface and ground water through a network of monitoring stations in the country.
- **Namami Gange programme** for effective abatement of pollution, conservation and rejuvenation of National River Ganga.
- **National Water Policy, 2012:** One of its important provision includes conservation of river corridors and water bodies and ensuring that the industrial effluents, local cesspools, residues of fertilisers and chemicals etc. do not reach the water source.
- In **budget 2019-2020**, Government unveiled vision for 2030 which includes clean rivers, with safe drinking water to all Indians, sustaining and nourishing life and efficient use of water in irrigation using micro-irrigation techniques.
- To assess the efficacy of river cleaning programmes, the CPCB has been ordered by NGT to launch a nationwide programme on biodiversity monitoring and indexing of the rivers. NGT has also directed MoEFCCC to consider giving environmental awards to institutions and states that comply with orders and ensure a reduction in pollution.

14.5.6. Marine Pollution

As per UNEP Report 2015, India dumped 0.6 tonnes of plastic waste into oceans annually and ranked 12th among the top 20 countries responsible for marine pollution. Marine Pollution leads to reduction of planktons, which form the major component in marine food chain, and hence leads to loss of marine biodiversity. It also contributes to global warming.

14.5.6.1. Regulation of Marine pollution in India

- India is a signatory to MARPOL (International Convention on Prevention of Marine Pollution). However, does not have a distinct policy for Marine pollution and for tackling marine litter, Indian policy is restricted only to the banning of single use plastic. Prevention of Marine Pollution is dealt with by Merchant Shipping Rules, 2009 (under the Merchant Shipping Act, 1958), Environment (Protection) Act 1986, Air (Prevention and control of pollution) Act 1981 and rules made under CPCB.

Student Notes:

- **Automated Ocean Pollution Observation System:** Indian National Centre for Ocean Information Services (INCOIS) has established the system in 2018 to keep a tab on ocean pollution levels and offer insights on how the marine system is changing.
- **Algal Bloom Information Service (ABIS):** INCOIS has developed a service for "Detection and Monitoring of Bloom in the Indian Seas". INCOIS-ABIS will provide near-real time information on spatio-temporal occurrence and spread of phytoplankton blooms over the North Indian Ocean.

14.6. Thermal pollution

Power plants (both thermal and nuclear), chemical and other industries use lot of water for cooling purposes and the used hot water is discharged into rivers, streams or oceans. The discharge of hot water may increase the temperature of the receiving water by 10 to 15 °C above the ambient water temperature. This is thermal pollution.

14.6.1. Effects of Thermal Pollution

- Increase in water temperature decreases dissolved oxygen in water which adversely affects aquatic life.
- Aquatic organisms are adopted to a uniform steady temperature of environment and any fluctuation in water temperature severely affects aquatic plants and animals. Hence discharge of hot water from power plants adversely affects aquatic organisms. Aquatic plants and animals in the warm tropical water live dangerously close to their upper limit of temperature, particularly during the warm summer months. It requires only a slight deviation from this limit to cause a thermal stress to these organisms.
- Discharge of hot water in water body affects feeding in fishes, increases their metabolism and affects their growth. Their swimming efficiency declines. Running away from predators or chasing prey becomes difficult. Their resistance to diseases and parasites decreases. Due to thermal pollution biological diversity is reduced.

One of the best methods of reducing thermal pollution is to store the hot water in cooling ponds, allow the water to cool before releasing into any receiving water body

14.7. Soil Pollution

Addition of substances which adversely affect the quality of soil or its fertility is known as soil pollution.

14.7.1. Status of Soil-Pollution in India

CPCB identified critically polluted industrial areas and clusters or potential impact zone based on its Comprehensive Environmental Pollution Index (CEPI) rating. Forty-three critically polluted zones were reported in the 16 states which have CEPI rating more than 70. Among the 43 sites, 21 sites exist in only four states namely Gujarat, Uttar Pradesh, Maharashtra and Tamil Nadu.

14.7.1.1. Status of Major Soil Pollutants in India

- **Municipal Solid Waste:** The urban India generates 62 million tonnes of municipal solid waste per annum. Only 43 million tonnes (MT) of the waste are collected, 11.9 MT is treated and 31 MT is dumped in landfill sites.
  - Plastic bags made **from low density polyethylene (LDPE)** are virtually indestructible and create colossal environmental hazard. The discarded bags block drains and sewage systems. Leftover food, vegetable waste etc. on which cows and dogs feed may die due to the choking by plastic bags.
  - Burning of solid waste release highly toxic and poisonous gases like carbon monoxide, carbon dioxide, phosgene, dioxins and other poisonous chlorinated compounds.
- **Agricultural Waste:** India is estimated to produce around 620 Million tonne per annum of agricultural wastes, 43 per cent of which is animal dung and slaughter wastes.

- Agricultural chemicals especially fertilizers and pesticides pollute the soil. Fertilizers in the run-off water from these fields can cause eutrophication in water bodies. Pesticides are highly toxic chemicals which affect humans and other animals adversely causing respiratory problems, cancer and death.

- **Industrial hazardous waste:** India produces approximately 51.1 MMT (million metric tonnes) of waste annually, with around 7.46 MMT of hazardous waste. Approximately 3.41 MMT (46%) is landfilled, 0.69 MMT (9%) is incinerated, and 3.35 MMT (45%) is recycled. Gujarat is the highest producer of hazardous wastes in India.
  - Industrial wastes include fly ash, chemical residues, metallic and nuclear wastes. Large number of industrial chemicals, dyes, acids, etc. find their way into the soil and are known to be carcinogenic.
- **Bio-Medical waste:** As per Assocham, the total quantity of medical waste generated in India is 550 tonnes per day (TPD) and by 2022, it is likely to increase to 775.5 TPD.
- **Electronic Waste:** India generates about 1.85 million tonnes per annum of e-waste and ranks fifth in the world among top e-waste producing countries. It is projected that by 2020 the e-waste generation in India will be 5.2 million tonnes per annum.

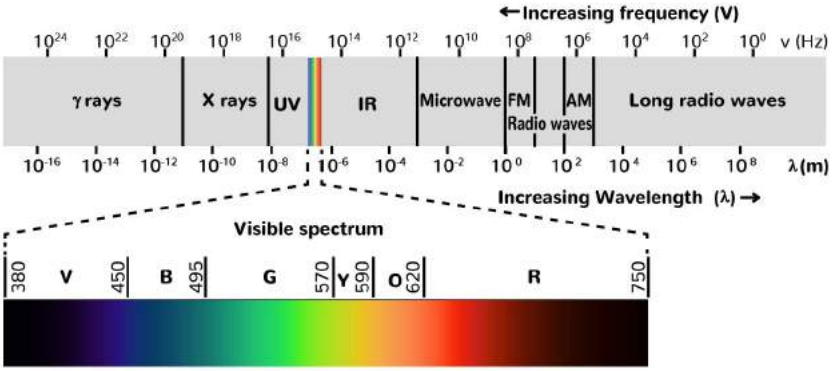
14.7.2. Control of Soil Pollution in India

Unlike water and air pollution, there is no specific legislation in India that regulates land pollution. In general, land pollution is dealt under Environmental Protection Act, which defines hazardous substances and confers the powers of making rules related to them upon the Central government. **Acting on such powers, the Central government has brought Solid Waste Management Rules 2016, Hazardous and Other Wastes (Management& Transboundary Movement) Rules 2016, Plastic Waste Management Rules 2016, E-Waste (Management) Rule 2016 and Bio-Medical Waste Management Rules, 2018.**

14.8. Radiation Pollution

Radiation is a form of energy travelling through space. Radiations can be categorized into two groups namely the non-ionizing radiations and the ionizing radiations.

- **Non-ionizing radiations:** They are constituted by the electromagnetic waves at the **longer wavelength** of the spectrum ranging from **near infra-red rays to radio waves**. These waves have energies enough to excite the atoms and molecules of the medium through which they pass, causing them to vibrate faster but **not strong enough to ionize them**. In a microwave oven the radiation causes water molecules in the cooking medium to vibrate faster and thus raising its temperature.
- **Ionizing radiations:** Electromagnetic radiations such as **short wavelength** ultra violet radiations (UV), X-rays and gamma rays and energetic particles produced in nuclear processes, electrically charged particles like alpha and beta particles produced in radioactive decay and neutrons produced in nuclear fission, are highly damaging to living organisms. Electrically charged particles produced in the nuclear processes **can have sufficient energy to knock electrons out of the atoms or molecules of the medium, thereby producing ions**. **The ionizing radiations cause damage to biological systems and are, therefore are pollutants.** A gamma ray passing through a cell, can ionise the water molecules near the DNA. These ions might react with the DNA causing it to break. They can also cause chemical changes by breaking the chemical bonds, which can damage living tissues.



14.8.1. Radiation Damage and its Types

The biological damage resulting from ionizing radiations is generally termed as radiation damage. Large amounts of radiation can kill cells that can dramatically affect the exposed organism as well as possibly its offspring. Affected cells can mutate and result in cancer. A large enough dose of radiation can even kill the organism.

Radiation damage can be divided into two types:

- **Somatic damage (also called radiation sickness):** It refers to damage to cells that are not associated with reproduction. Effects of somatic radiation damage include reddening of the skin, loss of hair, ulceration, fibrosis of the lungs, the formation of holes in tissue, a reduction of white blood cells, and the induction of cataract in the eyes. It can also cause cancer and death.
- **Genetic damage:** It refers to damage to cells associated with reproduction. This damage can subsequently cause genetic damage from gene mutation resulting in abnormalities. Genetic damages are passed on to next generation.

Radiation dose

- The biological damage caused by the radiation is determined by the intensity of radiation and duration of the exposure.
- A traditional unit of human-equivalent dose is the rem, which stands for radiation equivalent in man.
- At low doses, such as what we receive every day from background radiation (< 1 rem), the cells repair the damage rapidly. At higher doses (up to 100 rem), the cells might not be able to repair the damage, and the cells may either be changed permanently or die.
- Radiation Sickness: This is a condition that results after high doses is given to the whole body (>100 rem). The regeneration of cells becomes slow and therefore tissues fail to function.

14.8.2. Electromagnetic Radiation Pollution

- Wireless and radio communication, power transmission, or devices in daily use such as smartphones, tablets, and portable computers every day expose people to electromagnetic pollution.
- Electronic devices such as smartphones, tablets, microwave ovens, radio, and television sets emit low intensity electromagnetic radiation at frequencies from 300 MHz to 300 GHz that can be associated with microwaves.
- The Radio Frequency Radiation (RFR) exposure from both mobile phones and mobile towers may have possible thermal/non-thermal effects.

14.8.2.1. EMF Radiation norms in India

- India adopted the International Commission for Non-Ionizing Radiation Protection (ICNIRP) Guidelines in 2008.

- Based on the Recommendations of an Inter-Ministerial Committee constituted by DoT in the year 2010, the permissible limit of Electromagnetic Radiation from Mobile towers is reduced to 1/10th of the limit prescribed by the ICNIRP.
- India has adopted the most stringent SAR value of 1.6 Watt/Kg for mobile handsets. It has been made mandatory for all the mobile phones sold in India to display its SAR value.
- Indian Telegraph Act 1885 has been enacted for strict compliance.

Though the extremely low frequency electromagnetic fields were classified as potentially carcinogenic, **there is no convincing scientific evidence that the weak Radio Frequency (RF) Signals from base stations and wireless networks causes adverse health effects.**

14.8.3. Radioactive Pollution

Radioactive wastes are generated during various operations of the nuclear fuel cycle. Mining, nuclear power generation, and various processes in industry, defence, medicine and scientific research produce by-products that include radioactive wastes. They cause Radioactive Pollution and expose people living nearby to radiation hazards.

Radioactive waste can be in gas, liquid or solid form, and its level of radioactivity can vary. The waste can remain radioactive for a few hours or several months or even hundreds of thousands of years. Depending on the level and nature of radioactivity, radioactive wastes can be classified as exempt waste, Low & Intermediate level waste and High-Level Waste

14.8.3.1. Management of High-Level Radioactive Wastes

High level radioactive waste is generally material from the core of the nuclear reactor or nuclear weapon. The waste includes uranium, plutonium, and other highly radioactive elements made during fission. Most of the radioactive isotopes in high level waste emit large amounts of radiation and have extremely long half-lives (some longer than 100,000 years) creating long time periods before the waste will settle to safe levels of radioactivity.

High level radioactive wastes are managed in 3 stages:

- Immobilisation of high-level liquid waste into vitrified borosilicate glasses
- Storage of the vitrified waste for passive cooling & surveillance over a period of time, qualifying it for ultimate disposal.
- Ultimate storage/disposal of the vitrified waste in a deep geological repository.

The basic requirement for geological formation or the repository to be suitable for the location of the radioactive waste disposal facility is **remoteness from environment**, **absence of circulating ground water** and ability **to contain radionuclides** for geologically long periods of time.

14.8.3.2. Principles and Philosophy of Radioactive Waste Management followed in India

The Atomic Energy Regulatory Board (AERB) of India calls for reprocessing of the spent fuel and then disposing the waste to a repository. In managing the radio-active wastes, given principles are followed:

- **Principle 1: Protection of Human Health and Environment-** Radioactive waste shall be managed in such a way as to provide an acceptable level of protection for human health and the environment.
- **Principle 2: Concern for Future Generations-** Radioactive waste shall be managed in such a way that it will not impose undue burden on future generations and its predicted impact on the health of future generations will not be greater than relevant levels of impact that are acceptable today.
- **Principle 3: Establishing Legal Framework-** Radioactive waste shall be managed within an appropriate legal framework including clear allocation of responsibilities and provision for independent regulatory functions.

- **Principle 4: Waste Minimisation, Management Interdependency and Safety of Facilities-** Generation of radioactive waste shall be kept to the minimum practicable. Interdependency among all steps in radioactive waste generation and management shall be taken into account. The safety of facilities for radioactive waste management shall be assured during their lifetime.

Student Notes:

14.9. Previous Years UPSC Questions

Mains

1. Justify with necessary logic "Biological clean-up methods can be cheaper than the conventional physical and chemical pollution treatments".(2006)
2. Comment on the spatial components in urban solid waste management in the country. (2010)
3. Enumerate the National Water Policy of India. Taking river Ganges as an example, discuss the strategies which may be adopted for river water pollution control and management. What are the legal provisions of management and handling of hazardous wastes in India? (2013)
4. Mumbai, Delhi and Kolkata are the three Mega cities of the country but the air pollution is much more serious problem in Delhi as compared to the other two. Why is this so? (2015)
5. What are the impediments in disposing the huge quantities of discarded solid wastes which are continuously being generated? How do we remove safely the toxic wastes that have been accumulating in our habitable environment? (2018)

Prelims

1. Consider the following: (2019)
1. Carbon monoxide
2. Methane
3. Ozone
4. Sulphur dioxide

Which of the above are released into atmosphere due to the burning of crop/biomass residue?
(a) 1 and 2 only (b) 2, 3 and 4 only (c) 1 and 4 only (d) 1, 2, 3 and 4

Solution: D

2. In India, the use of carbofuran, methyl parathion, phorate and triazophos is viewed with apprehension. These chemicals are used as (2019)
(a) pesticides in agriculture
(b) preservatives in processed foods
(c) fruit-ripening agents
(d) moisturizing agents in cosmetics

Solution: A

3. Which of the following is/are the possible consequence/s of heavy sand mining in riverbeds? (2018)
1. Decreased salinity in the river
2. Pollution of groundwater
3. Lowering of the water-table

Select the correct answer using the code given below.
(a) 1 only (b) 2 and 3 only (c) 1 and 3 only (d) 1, 2 and 3

Solution: B

4. How is the National Green Tribunal (NGT) different from the Central Pollution Control Board (CPCB)? (2018)
1. The NGT has been established by an Act whereas the CPCB has been created by an executive order of the Government.

Student Notes:

2. The NGT provides environmental justice and helps reduce the burden of litigation in the higher courts whereas the CPCB promotes cleanliness of streams and wells, and aims to improve the quality of air in the country.

Which of the statements given above is/are correct?

(a) 1 only (b) 2 only (c) Both 1 and 2 (d) Neither 1 nor 2

Solution: B

5. With reference to 'fly ash' produced by the power plants using coal as fuel, which of the following statements is/are correct? (2015)

1. Fly ash can be used in the production of bricks for building construction.
2. Fly ash can be used as a replacement for some of the Portland cement concrete.
3. Fly ash is made up of silicon dioxide and calcium oxide only, and does not contain any toxic elements.

Select the correct answer using the code given below.

(a) 1 and 2 (b) 2 only (c) 1 and 3 (d) 3 only

Solution: A

6. Which of the following can be found as pollutants in the drinking water in some parts of India? (2013)

1. Arsenic
2. Sorbitol
3. Fluoride
4. Formaldehyde
5. Uranium

Select the correct answer using the codes given below.

(a) 1 and 3 only (b) 2, 4 and 5 only (c) 1, 3 and 5 only (d) 1, 2, 3, 4 and 5

Solution: C

7. Due to improper/indiscriminate disposal of hold and used computers or their parts, which of the following are released into the environment as e-waste?(2013)

1. Beryllium
2. Cadmium
3. Chromium
4. Heptachlor
5. Mercury
6. Lead
7. Plutonium

Select the correct answer using the codes given below:

(a) 1, 3, 4, 6 and 7 only (b) 1, 2, 3, 5 and 6 only
(c) 2, 4, 5 and 7 only (d) 1, 2, 3, 4, 5, 6 and 7

Solution: B

8. Which of the following are some important pollutants released by steel industry in India? (2014)

1. Oxides of sulphur
2. Oxide of nitrogen
3. Carbon monoxide
4. Carbon dioxide

Select the correct answer using the code given below.

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

Solution: D

9. There is some concern regarding the nanoparticles of some chemical elements that are used by the industry in the manufacture of various products. Why? (2014)

1. They can accumulate in the environment and contaminate water and soil.

2. They can enter the food chains.
3. They can trigger the production of free radicals.

Select the correct answer using the code given below.

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

Solution: D

10. Brominated flame retardants are used in many household products like mattresses and upholstery. Why is there some concern about their use? (2014)

1. They are highly resistant to degradation in the environment.
2. They are able to accumulate in humans and animals.

Select the correct answer using the code given below.

(a) 1 only (b) 2 only (c) Both 1 and 2 (d) Neither 1 nor 2

Solution: C

11. There is a concern over the increase in harmful algal blooms in the seawaters of India. What could be the causative factors for this phenomenon? (2011)

1. Discharge of nutrients from the estuaries.
2. Run-off from the land during the monsoon.
3. Upwelling in the seas.

Select the correct answer from the codes given below:

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

Solution: D

14.10. Previous Years Vision IAS Mains Test Series Questions

1. Noise pollution is one of the emerging environmental concerns in India. Bring out the underlying factors and list the legislative measures adopted to tackle the issue.

Approach:

The answer can begin by bringing out the emergence of noise pollution as a problem. The answer needs to be structured in two core parts. First, elucidating the underlying causes of noise pollution in India and second, listing the legislative measures. Conclude briefly dwelling on challenges along with succinct suggestion.

Answer:

Noise pollution refers to the increasing ambient noise levels in public places, which poses a hazard to human health and the psychological wellbeing. Experts believe that continuous noise levels in excess of 90 decibels pose several threats to health. Metropolitan areas in India usually register an average more than 90 decibels, which can be attributed to:

- Industrial activities, which are an important source of noise. With increasing industrialization noise from industrial sources has become important concern.
- Increasing urbanization has made construction activities an important source of noise emission.
- Use of public address systems and loudspeakers
- Ambient noise emanating from transport sector- Road Traffic, Air Craft, and rail roads.
- Use of fire cracker during festivals such as Diwali and wedding celebrations.
- Noise from household equipment- vacuum cleaners and some kitchen appliances.

In India noise is recognised as a part of air pollution in Section 2 (a) of the Air (Prevention and Control of Pollution) Act, 1981.

- Wider interpretation of Article 21 provides the legislative basis for the recognition of regulating noise pollution as crucial to decent quality of life.

Student Notes:

- The Environment (Protection) Act of 1986 (EPA) has recognized noise as an environmental pollutant and empowers the Central Government to frame rules prescribing the maximum permissible limits for noise in different areas.
- Motor Vehicles Act 1988 makes Central and State Governments competent to make rules for the upkeep of the motor vehicles and control of noise produced by them.
- Central Motor Vehicles Rules 1989 (Rules of the Road Regulations) prohibit the use of certain types of horns and also provide that at certain places like hospitals and schools etc., horns cannot be used
- Under Section 5 of the Aircrafts Act, 1934, regulates construction of airports away from human habitations to.
- The Noise Regulation Rules, 2000 regulate noise levels in industrial, Commercial and residential zones, and also establish zones of Silence near schools, courts, hospitals, etc. It also prescribes time based restrictions.

Despite legislative measures being in place the social recognition of noise as health hazard is low and similarly the awareness regarding measures to curb it also requires improvement. Integration of key concerns in planning and execution is important in this context. The need is to adopt practices such as Noise-mapping to integrate noise standards into urban planning.

2. According to the Indian Fertiliser Scenario 2014, the use of urea in India has increased by more than 50 per cent since 2000. How does human intervention turn nitrogen from a nutrient to a pollutant? Discuss the impacts of nitrogen pollution on environment and human health. Also, explain how nitrogen pollution can be managed.

Approach:

- Introduce the answer by briefly elaborating on the statement.
- Bring out various methods by which humans have increased concentration of nitrogen in atmosphere.
- Discuss the negative impacts of nitrogen pollution on environment such as degradation of soil, smog etc. and on human health such as blue baby syndrome.
- Conclude the answer by suggesting various measures to contain nitrogen pollution, such as precision farming.

Answer:

Urea, being most common nitrogen fertilizer, is indiscriminately used in India irrespective of scientific prescriptions, primarily because it is a cheap fertiliser owing to the subsidy provided to it. Per hectare consumption of nitrogen of at least 100 kg has been reported in eight Indian states, including Bihar, Punjab, Haryana, Uttarakhand, Uttar Pradesh, Andhra Pradesh, Tamil Nadu and Puducherry. The increasing rate of nitrogen use by humans has led to an imbalance in the nitrogen content in the environment.

According to "Our Nutrient World", a 2013 report of the United Nations Environment Programme (UNEP), human-induced nitrogen inputs or fertilisers and associated emissions from agriculture, fossil fuel burning, sewage and industrial waste have directly or indirectly far surpassed natural emissions, causing nitrogen pollution that has reached alarming levels.

Nitrogen as a pollutant is detrimental to the environment and health.

- Nitrate-contaminated drinking water can cause reduced blood function, cancer and endemic goiters, blue baby syndrome etc.
- Surplus inputs of nitrogen compounds have been found to cause soil acidification. The lowering pH, as a result of the acidification, can lead to nutrient disorders and increased toxicity in plants.

- Nitrous oxide along with ozone and hydrocarbons in sunlight form (peroxyacetyl nitrate) PAN responsible for photochemical smog.
- Higher concentrations of N02 (10-50 ppm) checks the metabolic activities and retard the photosynthesis in plants.

The challenge for the current century is to optimise the use of nitrogen while minimising the negative impacts.

- The nitrogen pollution due to indiscriminate use in agriculture can be curtailed by adopting methods like precision farming, application through tablets and coated forms of nitrogen, adopting soil test-based fertilizer prescriptions and rationalising urea subsidy.
- The nitrogen pollution from vehicular emissions can be controlled by use of efficient engines, clean fuel and providing catalytic filters in the vehicles.

3. Degradation of natural resources can occur, not just by the action of pollutants but also by improper resource utilization practices. Explain along with appropriate examples and suggest possible solutions for the same.

Approach:

- Briefly discuss how degradation of natural resources occurs - by pollution and improper resource management practices.
- Suggest solutions to ensure optimal use of natural resources in a sustainable way.
- Conclude by emphasizing the need to prevent degradation of natural resources.

Answer:

Degradation of natural resources may occur due to:

- Pollution – for example water pollution in rivers, land pollution by human activities like coal mining, deforestation etc.
- Improper utilization of non-renewable resources (which include earth minerals and metal ores, soil, fossil fuels and groundwater in certain aquifers). In contrast renewable resources are inexhaustible (for example: Solar energy, Wind energy etc.)

The improper utilization of non-renewable resources degrades them and make them unavailable for future generations thus threatens sustainability.

Examples of Improper resource utilization

- **Soil Erosion and Desertification-**Though Soil formation takes centuries, various practices like over-cultivation, unrestricted grazing, deforestation and poor irrigation practices, results in accelerated rates of soil erosion and destroys the fertile top layer. This leads to arid patches of land which coalesce over time to form deserts.
- **Waterlogging and soil salinity-**Irrigation without proper drainage leads to waterlogging in agricultural fields. Besides affecting the crops, waterlogging draws salt to the surface of the soil. This degrades soil quality for growing crops.
- **Destruction of Habitat for harvesting natural resources or for Urbanization-** Examples of destruction of habitat include encroachment of wetlands, deforestation, practicing agriculture , diversion of rivers, mining etc. Biodiversity loss follows habitat destruction.
- **Excessive pumping of ground water-** in most areas it takes too long for groundwater aquifers to recharge once all the water has been pumped out. The negative effects include -drying up of wells, deterioration of water quality and land subsidence among others.

Student Notes:

Possible Solutions to reduce degradation of natural resources

- **Reducing the usage.** For example reducing the use of fossil fuels by finding alternate fuels like solar energy or making more efficient use of such fuels like making smaller and more efficient car engines and with aerodynamic body, reducing dependence on groundwater by conserving rainwater. Similarly enforcement of green building codes helps in reducing power consumption at home and office spaces.
- **Replacing** the use of minerals by alternatives-for example instead of packaging products in metal cans many products are packaged today in paper (a renewable resource).
- **Recycling** minerals not only reduce the need to mine more mineral, it also helps to reduce the use of fossil fuel. For example recycling Aluminium requires up to 95% less energy than processing aluminium from ore. Metals like gold, silver, lead, copper and iron are also recycled. Similarly rare earths are recycled from e-waste.
- Increasing the use of **non-renewable resources** like Solar Energy, Wind Energy, Tidal energy, blending of ethanol in petroleum etc.
- **Preserving and reclaiming the available resources-** It includes Soil conservation, groundwater recharge, afforestation, restoring habitats, reclamation of waste land, biodiversity conservation, revitalizing the wetlands etc.
- **creating awareness and bringing in behavioural changes-** It includes measures like environmental education, influencing consumer behaviour to promote energy efficient appliances like LED bulbs and 5 star electrical devices , developing efficient mining techniques, promoting water efficient irrigation techniques like drip and sprinkler irrigation etc.

Improper utilization practices pose a grave threat to sustainable development agenda, and hence must be replaced by efficient and sustainable ways of utilizing the available resources.

4. Describe the factors responsible for increase in marine pollution in the past few decades. What impact does marine pollution have on the ocean ecosystem? Discuss the measures taken by the international community to deal with it.

Approach:

- Discuss the factors responsible for marine pollution and the effects they cause to the marine ecosystem**.**
- Discuss the international measures to tackle the issue.

Answer:

Marine pollution includes a range of threats which include those from land-based sources, oil spills, untreated sewage, heavy siltation, eutrophication (nutrient enrichment), invasive species, persistent organic pollutants (POP's), heavy metals from mine tailings and other sources, acidification, radioactive substances, marine litter, overfishing and destruction of coastal and marine habitats.

Over 80% of marine pollution comes from land-based activities either through deliberate dumping or from run-off through drains and rivers. The various factors and their impact on the marine system include:

- **Oil Spills**-responsible for around 12% of the oil entering the seas each year while 36% comes from runoff from industries and cities (US National Research Council)
- **Fertilizer runoff** from farms is a huge problem for coastal areas. The extra nutrients cause **eutrophication** - flourishing of algal blooms that deplete the water's dissolved oxygen and suffocate other marine life. Eutrophication has created enormous dead zones in several parts of the world, including the Gulf of Mexico and the Baltic Sea.

Student Notes:

- **Solid garbage**-High concentrations of plastic material, particularly plastic bags, have been found blocking the breathing passages and stomachs of many marine species, including whales, dolphins, seals, puffins, and turtles. This garbage can also come back to shore, where it pollutes beaches and other coastal habitats.
- **Sewage disposal**-In many parts of the world, sewage flows untreated, or under-treated, into the ocean. For example, 80% of urban sewage discharged into the Mediterranean Sea is untreated. This sewage can also lead to eutrophication. In addition, it leads to beach closures.
- **Toxic chemicals**-such as pesticides, chemical weapons, and radioactive waste; Electronic waste and mine tailings are included amongst the sources of heavy metal pollution in Southeast Asia. Some toxic man-made chemicals become more concentrated after entering the food chain.
- **spread of invasive organisms-**Invasive species thrive due to absence of natural predators and may damage the original ecosystem by consuming native species, competing with them for food or space, or introducing diseases. For example, zebra mussel was accidentally introduced by a cargo ship into the North American Great Lakes from the Black Sea in 1988. The tiny mollusk multiplied uncontrollably, starving out many of the Great Lakes' native mussel populations and interfering with human structures from factory intake pipes to ship rudders.
- **Altering of sedimentation rate**-the rate has decreased in some areas due to reduced river flows as a result of terrestrial overuse for agricultural irrigation, while it has increased in other regions due to coastal development and deforestation along rivers, water sheds and coastal areas, and clearing of mangroves.
- **overexploitation of fisheries** and physical destruction of marine coastal habitats by dredging
- **Coastal development** in terms of settlements, resort or industrial development reduces the diversity of the coastal vegetation and destroys significant areas, such as mangroves. These ecosystems play an essential role in limiting silt and nutrient outflows to the nearshore marine environment, including run-off of sewage animal waste and top soil during the heavy tropical rains or from rivers.
- **Increasing levels of atmospheric carbon dioxide** is making the oceans more acidic. This is affecting corals and the ability of shellfish to form shells. It will also weaken the capacity of the ocean to act as a carbon sink.
- Marine life can be susceptible to **noise or the sound pollution** from sources such as passing ships, oil exploration seismic surveys, and naval low-frequency active sonar.

These factors will severely exacerbate the effects of extreme weather and the productivity of coastal ecosystems to supply livelihoods and basic food to impoverished.

Measures taken by the international community

Broadly two juridical systems may be identified:

1) United Nations Convention on the Law of the Sea, 1982

It lays down a comprehensive regime of law and order in the world's oceans and seas establishing rules governing all uses of the oceans and their resources. The UNCLOS governs all aspects of ocean space, such as delimitation, environmental control, marine scientific research, economic and commercial activities etc. Part XI has established the **International Seabed Authority** which regulates the regime of exploration and minerals on the seabed outside any state's territorial waters or EEZ. The convention dedicates Part XII to the protection and preservation of the marine environment.

Student Notes:

2) International Maritime Organisation Conventions

The International Maritime Organization (a UN specialized agency) has developed a number of global legal frameworks related to shipping safety and marine environment in order to accomplish with its mandate of improving the safety and security of international shipping and preventing marine pollution from ships.

The marine environment related instruments can be classed considering the object of their regulation:

1. **Pollution Prevention:**
   - Convention for the Prevention of Pollution from ships 1978 (MARPOL CONVENTION) Annexes I, II, III, IV, V, VI
   - Protocol to the Convention for the Prevention of Pollution from ships (MARPOL PROTOCOL);
   - Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter1972 (LONDON)
   - Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and other matter 1996
2. **Pollution Response:**
   - Convention on oil pollution preparedness, response, and Co-operation, 1990 (OPRC Convention)
   - Convention on Preparedness, response and cooperation to pollution incidents by Hazardous and Noxious Substances, (OPRC-HNS) 2000, etc.
3. **Ballast Water Management and Control Convention 2004**
4. **Anti-Fouling Systems Convention 2001;**
5. **Safe and Environmentally Sound Recycling of Ships, Honk Kong Convention 2009**
6. **Wreck Removal Nairobi Convention 2007.**

5. The perennial problem of smog across large parts of North India has worsened despite government and judicial interventions. Examine. What feasible steps can be taken to effectively address this problem?

Approach:

- Begin with a brief description of the issue & list its causes.
- Mention steps taken by the government & the judiciary over the years to combat this issue.
- Suggest a few reasons for their failure.
- Conclude by listing a few pertinent solutions to address this problem effectively.

Answer:

Large areas in Punjab, Haryana, Delhi, UP and other regions of North India, which gets covered with thick layer of smog usually in winters, have been facing the problem of worsening air quality year on year. The reasons behind this include cold weather and stagnant winds trapping smoke, mainly from burning of crop stubbles, lit garbage, industrial pollution and road dust, in lower layers of the atmosphere.

Steps taken by the Centre and state governments:

- The 'odd-even' rule aimed at decongestion of roads.
- Setting up of monitoring network for assessment of ambient air quality.
- Implementation of Bharat Stage norms.
- Imposition of green cess on commercial vehicles etc.

Student Notes:

Steps taken by the judiciary:

The judiciary has also taken cognizance of the issue & issued directives to the Centre & state governments, such as:

- Appointing Environment Pollution Control Authority
- Banning the sale of fire crackers in the national capital
- Enforcing Graded Response Action Plan (GRAP)
- Ordering a shift to CNG for commercial vehicles etc.

Additionally, the National Green Tribunal prohibited burning of crop residue in Delhi, Punjab, Haryana, Rajasthan & UP. It also ordered phasing out of diesel vehicles for Central & State government personnel.

However, despite these measures, the problem of smog has become a persistent annual phenomenon. This can be attributed to the passive & reactionary attitude of the state governments, pressure on urban areas, geographic causes like northern India witnessing no daily change/reversal in direction of wind movement due to continentality, lack of a proper coordination mechanism among concerned authorities, poor implementation of judicial directives, and negligence on part of civic agencies to ensure greening of road margins to check dust levels.

Steps required to effectively address the problem:

Despite these, a comprehensive action plan needs to be implemented that should include the following:

- **Effective policy and financial support**: for utilization of crop residue, paddy straw and other agro-waste into biomass briquette making, livestock feed, compost etc.
- **Greening of cities on a mission mode**: via landscaping of open spaces and paving of all public areas to reduce dust.
- **Strict implementation of Waste Management Rules**: specifically, to ensure re-utilization of construction and demolition waste and strict enforcement of ban on burning of municipal waste.
- **Stress on use of public transport,** along with adequate parking reforms and infrastructure creation to ease mobility across cities.
- **Adoption of international best practices**, such as the steps taken during the Great London Smog, the air pollution action plan in Beijing and Mexico.

To ensure the success of above steps, inter-State and inter-Departmental coordination becomes imperative.

CHAPTER - 15 - WASTE MANAGEMENT

Student Notes:

15. Waste Management

"Wastes" are materials which are discarded after use at the end of their intended life-span. Waste management is a collective activity involving segregation, collection, transportation, re-processing, recycling and disposal of various types of wastes. Waste management differs for different types of wastes and for wastes in different geographical locations such as urban, rural and hilly areas.

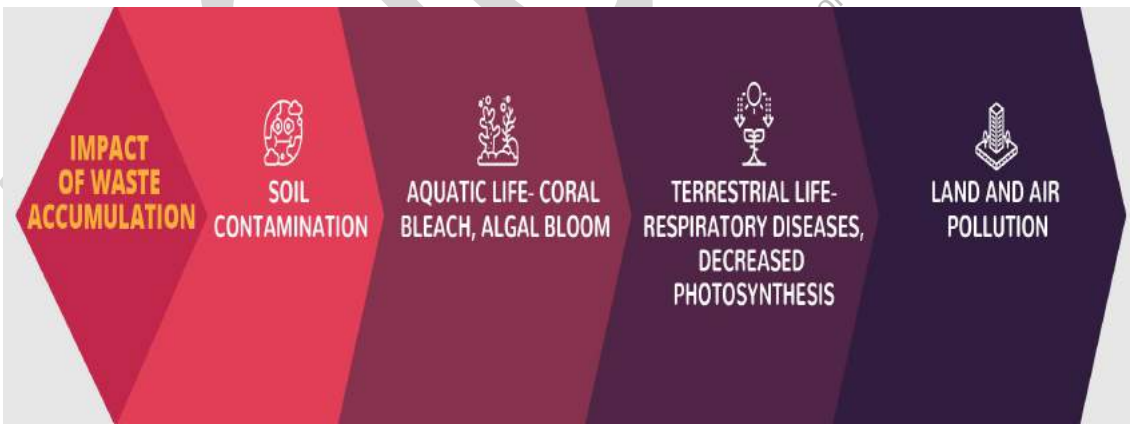
15.1. Classification of Waste

It is important to classify waste so that based on their nature and properties we may opt for the most suitable method for their management and disposal.

BASED ON PROPERTIES	BASED ON ORIGIN AND TYPE	BASED ON IMPACT ON HUMAN HEALTH AND ENVIRONMENT
○ BIODEGRADABLE ○ NON BIODEGRADABLE	○ INDUSTRIAL ○ MUNICIPAL ○ BIO-MEDICAL ○ AGRICULTURE	○ HAZARDOUS ○ NON HAZARDOUS

15.2. Impact of Waste Accumulation

According to World Health Organization 22 types of diseases can be prevented or controlled by improving solid waste management in India. Hence, people in India as well as local municipal bodies should change their casual attitude towards waste management. A more collective, structured and institutional approach from all stakeholders will be required to address this menace. It can lead to:



15.3. Solid Waste Management

Solid waste management (SWM) is a major problem for many urban local bodies (ULBs) in India, where urbanization, industrialization and economic growth have resulted in increased municipal solid waste (MSW) generation per person **due to inadequate waste collection**, transport, and treatment and disposal facility.

India generates over **150,000 tonnes of municipal solid waste (MSW) per day**, with Mumbai being the world's fifth most wasteful city. Yet, only 83% of waste is collected and less than 30% is treated.

Student Notes:

Municipal solid waste management (MSWM) is a critical element towards sustainable metropolitan development. It comprises segregation, storage, collection, relocation, carry-age, processing, and disposal of solid waste to minimize its adverse impact on environment. Unmanaged MSW becomes a factor for propagation of innumerable ailments.

Challenges to effective SWM

- **Segregation:** There is no organized and scientifically planned segregation of MSW either at household level or at community bin. Sorting of waste, is mostly accomplished by unorganized sector and seldom practiced by waste producers. Segregation and sorting takes places under very unsafe and hazardous conditions and the effectiveness of segregation is reasonably low as unorganized sector segregates only valuable discarded constituents.
- **Disposal:** In India, almost every city, town, or village adopted unscientific disposal of MSW.
- **Issues with Landfill management:**
  - Violations of rules with respect to the scientific requirements for the location of a landfill and the mandatory security-set up like compound walls, CCTV cameras, firefighting equipment and water tanks, and regularization of rag pickers.
  - Occasional fires drawing on air quality and health. (due to methane production)
  - Many Landfills have been functioning beyond the stipulated timeline.
  - With the expansion of cities old land fill need to be reclaimed and new sites should be identified.
  - The demand for alternate sites gets entangled in the tussle between the Municipal Corporations and the State governments as the matter rests with the latter.
- **Processing Facility**
  - The composting and waste to energy plants run at under-capacity.
  - Many of the new projects for garbage processing facility are stuck
  - The facilities of composting of wet waste is not present everywhere
  - Indifference of citizens/ Lack of community participation towards waste management due to lack of awareness
- **Characterization of municipal solid waste:** limited source of information available about waste hinder an appropriate solutions for the kind of waste produced for a particular region.
- **Characterization of municipal solid waste:** limited source of information available about waste hinder an appropriate solutions for the kind of waste produced for a particular region.
- **Failure of waste-to-energy projects**: India is still struggling to make waste-to-energy project a success story. There is a need to import economically feasible and proven technologies. Apart from this, suitably characterized and segregated waste needs to be provided to waste-to-energy plants as per its requirement.
- **Lack of coordination among Centre and State:** Such lack of coordination for specific action plan and poor strategy at implementation level by ULBs are main hindrance.
- **Urbanization and lack of appropriate level funding**: Most of the landfill sites are running beyond their capacity in metropolitan cities. Inadequate financial support to cater to waste management problem aggravates it. Due to financial crunch ULBs do not have adequate infrastructure.

Steps taken by government

Solid Waste Management Rules, 2016

- Rules have mandated the source segregation of waste in order to channelise the waste to wealth by recovery, reuse and recycle.
- Waste generator will have the responsibility of segregating the waste into wet, dry and Hazardous. They will have to pay user fine to the waste collector and spot fine for littering around; the amount will be decided by the local body.
- Waste processing facilities will have to be set up by all local bodies having 1 million or more population within two years.

- Rules have mentioned about the integration of rag pickers, waste pickers and kabadiwalas from the informal sector to the formal sector by the state government.
- Developers of Special Economic Zone, industrial estate, industrial park to earmark at least 5 % of the total area of the plot for recovery and recycling facility.

Star Rating Protocol for Garbage Free Cities

- It aims to enthuse the cities with a spirit of healthy competition to improve their overall cleanliness and allow multiple cities to be awarded the same star rating.
  The major focus in the ratings will be on waste storage and litter bin.
- An online database was also launched in order to capture the progress of states and cities on their SBM components, thereby enhancing the robustness and transparency of Mission monitoring.

15.3.1. Methods of Disposal of Solid Waste

Waste management is a collective activity involving segregation, collection, transportation, re-processing, recycling and disposal of various types of wastes.

Different methods are:

- **Landfill:** This method involves burying off the waste in the vacant locations around the cities. The dumping site should be covered with soil to prevent contamination. Suitable trees should be planted to hold the soil (of shallow roots).
  - **Advantage of Landfills:** If designed carefully they can serve as economical and quite sanitized method for waste dumping.
  - **Disadvantage:** Mostly unplanned dumping occur in suburbs and slums which causes serious environmental and health hazards. E.g: release of poisonous gases, secretion of toxic liquid, destruction of vegetation.
- **Incineration: It is controlled high temperature oxidation** (burning/thermal treatment) of primarily organic compounds that produce thermal energy, CO2 and water.
  - **Advantages:** Useful to deal with large quantities of organic hazardous waste and produces electricity.
  - **Disadvantages:** The installation is expensive (high cost of equipment and skilled operators) and Generates ash and toxic gases (HCL, CO, SO2).
- **Other Thermal Methods**
  - **Pyrolysis:** In this process the solid is converted in to liquid state and liquid is converted in to gas. These products of treatment can then be used for the production of energy.
  - **Gasification:** The material to be treated is directly converted in to SynGas (synthetic gas) which has hydrogen and carbon dioxide as its components.
- **Bioremediation:** Bioremediation is the use of living organisms, primarily microorganisms, to degrade environ-mental contaminants into less toxic forms. e.g.: Pseudonymous bacterium can decompose synthetic pesticide.
  - Bioremediation techniques are more economical than traditional methods and pollutants can be treated on site, thus reducing exposure risks for personnel.

Sludge Management in India

- Nearly 80 % of the sludge — a human excreta and water mixture that bears disease-carrying bacteria and pathogens — remains **untreated** and is dumped into drains, lakes or rivers, posing a serious **threat to safe and healthy living.**
- As per the **2011 Socio Economic and Caste Census,** 1,82,505 households in rural areas are reported as **manual scavengers.** They face serious health hazards due to absence of proper disposal system or safety regulations in place.
- More than 70 % households with safe sanitation facilities are based on such onsite systems, and in a majority of cities there are no sewered networks or sewage treatment plants

National Policy on Faecal Sludge and Septage Management (FSSM)

- **To set the context, priorities, and direction** for, and to facilitate, nationwide implementation of FSSM services in all ULBs such that safe and sustainable sanitation becomes a reality for all in each and every household, street, town and city.
- **Enable and support synergies** among relevant Central Government programs such as SBM, AMRUT and the Smart Cities Mission to realise safe and sustainable sanitation for all at the

earliest, possibly by the year 2019.

- **Mitigate gender-based sanitation** insecurity directly related to FSSM, reducing the experience of health burdens, structural violence, and promote involvement of both genders in the planning for and design of sanitation infrastructure.
- **Define the roles and responsibilities** of various government entities and agencies, and of other key stakeholders such as the private sector, civil society organisations and citizens for effective implementation of FSSM services throughout the country.

15.4. Waste to Energy

According to Ministry of New and Renewable Energy estimates, the solid waste generated from cities/towns in India has a potential to generate power of approximately 500 MW, which can be enhanced to 1,075 MW by 2031 and further to 2,780 MW by 2050.

- **Current Capacity:** There are five municipal Waste to Energy plants operational in India, with a total capacity to produce 66.4 MW electricity per day, of which 52 MW per day is generated in Delhi. Currently, there are 40-odd WTE plants at various stages of construction.

Need of Waste to Energy Plants

- **Problems of unscientific Municipal Solid Waste (MSW) disposal:** Only about 75- 80% of the municipal waste gets collected and out of this only 22-28 % is processed and treated and remaining is disposed of indiscriminately at dump yards. It is projected that by the year 2031 the MSW generation shall increase to 165 million tonnes and to 436 million tons by 2050.
- **Harmful emission from Landfills**: Organic decomposition of food waste mixed with municipal solid waste at landfill sites leads to high amounts of emissions which is also a public health issue.

Advantages of Waste to Energy (WtE) Plants

- **Net Greenhouse Gas Reducer**: Methane is a greenhouse gas which is mostly emitted from decomposing waste in landfills. WtE facilities avoid the production of methane while producing almost ten times more electricity from each ton of waste compared to landfills.
- **Resource savings and recovery greatly expanded:** Metals left in the municipal solid waste stream can be extracted from the ash resulting from incineration and the metals can be recycled.
- **24*7 Electricity**: WTE facilities, unlike wind and solar, are capable of providing 24*7 renewable electrical power.
- **Landfill usage and expansion greatly reduced**: Waste to energy facilities typically reduce waste volumes by 90%. Fewer and smaller landfills are needed to process.
- **Transportation of waste long distances** can be greatly reduced with a waste to energy facility in a community, resulting in less air pollution.

Challenges

- **Low Calorific Waste:** Municipal waste in India is often **not segregated properly**. It has a very high biodegradable (wet) waste content ranging anywhere between 60 and 70 per cent of the total, compared with 30 per cent in the West. This gives our waste a **high moisture content and low calorific value**. In Delhi, for example, only 12 per cent of the waste can be thermally treated through incineration technologies.
- **High Toxic Waste:** Incinerators develop toxic ash or slag, containing heavy metals and gas pollutants which are toxic (corrosive impact) and pollute underground water.
- **Expensive power:** Compared to Rs 3-4 per kWh from coal and solar plants, WTE plants sell electricity at about Rs 7/kWh.
- **Lack of Finance for Urban Local Bodies (ULBs)** affects institutional capacity necessary for integrated management of municipal solid waste, which requires investments for WtE projects.

- **Other Challenges include** irregular and inadequate quantity of supply; non-payment of agreed fee and non-marketability of waste processed projects, including power.

Way Forward

- **Improved MSW collection system**: Separate collection and transportation of domestic waste (including trade & institutional waste), inert wastes such as street sweepings, silt from surface drains and Construction & Demolition wastes should be ensured by the municipal authorities.
- **Encourage Private Partnership** in building WtE plants as recommended by Task force on WtE (2014) headed by K Kasturirangan.
- **Amendment to Electricity Act-2003** to include a provision for State Electricity Discoms to mandatorily purchase all power generated from municipal solid waste at a tariff decided through competitive bidding.
- **Strict enforcement** to ensure the waste is not mixed at the source of generation and then that the handling of waste is in unmixed streams.
- **Alternative to WtE Plants**: Since WtE technologies are being phased out in the West, they should not be allowed unless the waste offered meets the criterion specified by the Solid Waste Management Rules 2016. Other option could be explored like composting and bio-methanation.
- **Role of urban local bodies (ULBs): Standing Committee on Energy report on Power Generation** from Municipal Solid Waste suggested for increased grants to states and ULBs to maximise waste collection efficiency and also recommended to **integrate ragpickers and kabadiwalas** within the formal system.
    - **Setting up of Monitoring Committee**, consisting of representatives from all the central ministries along with the representatives of the state governments and ULBs, to coordinate efforts at each level, and suggest methods and technologies to be adopted to make the waste-to-energy plants successful.
- **Participation of civil society:** Municipal Authorities should make concerted efforts to involve civil society in managing their waste and motivate Resident Welfare Associations (RWA), Community-Based

15.5. Plastic Pollution

- A 2017 report by the **Central Pollution Control Board (CPCB)** pegs the amount of plastic waste generated in India at 25,940 tonnes per day.
- India notified the **Plastic Waste Management Rules in 2016,** which replaced the earlier Plastic Waste (Management and Handling) Rules, 2011.
- As per the **Rule '17(3)'** of the rules, each State Pollution Control Board or Pollution Control Committee shall prepare and submit the Annual Report to the CPCB on the implementation of these rules by the **31st July of each year.** However, inaction on the states' part made the CPCB approach the **National Green Tribunal (NGT)** to enforce the implementation of plastic waste management rules by non-compliant states.
- The NGT in March 2019, ordered all states and UTs **(except for Andhra Pradesh, Sikkim, West Bengal, and Puducherry)** to submit action plans for implementing Plastic Waste Management Rules, 2016 by **April 30, 2019.** The court had also said that failure to do so would invite a **penalty of Rs 1 crore per month.**
- However, 25 states failed to send their action plans to the Central Pollution Control Board (CPCB) by the designated date.

- **Single-use plastics**: Also referred as disposable plastics, are commonly used for plastic packaging and include items intended to be used only once before they are thrown away or recycled. They have a higher carbon footprint and are more resource and water intensive to produce.
- **Single use plastics are the most challenging to tackle**. Single-use plastics or disposable plastics are commonly used for plastic packaging, **accounting for 36% of 400 million tonnes of plastic produced annually**, and other items, grocery bags, food packaging, bottles, straws, containers, cups and cutlery.

Student Notes:

Why single use plastic is a challenge?

- **Difficultly in collection:** Many times, the packaging is not effectively collected, ending up in landfills and drains in the cities and these single-use plastic items clog rivers, other water bodies and finally ending up in the ocean.
- **Higher cost of collection:** The design of plastics and plastic-containing products is often a barrier to higher rates of plastic collection and recycling.

Recent efforts to tackle the Single use Plastics

India has pledged to phase-out all single use plastics by 2022. However, India's efforts at piloting a resolution at the fourth United Nations Environment Assembly for a global phase-out of single use plastics by 2025 failed in the face of strong opposition from the United States.

Impact of plastic Pollution

- Environmental Pollution: According to a 2014 toxics link study on plastic waste, it contributed directly to ground, air and water pollution.
- Soil Pollution: Toxic chemicals leach out of plastic through landfill site, is linked to decreasing crop productivity, impacting food security, birth defects, impaired immunity, endocrine disruption and other ailments
    - Poisoning Ocean: Every year, up to 13 million tons of plastic leak into our oceans, where it smothers coral reefs and threatens vulnerable marine wildlife. The plastic that ends up in the oceans can circle the Earth four times in a single year, and it can persist for up to 1,000 years before it fully disintegrates.
    - Air Pollution: Disposing of plastic waste by burning it in open-air pits releases harmful gases like furan and dioxin.
- Health Impact: Plastic bags often provide breeding grounds for mosquitoes and pests thus increase the transmission of vector-borne diseases like malaria.
- Bioaccumulation: Plastic bags are often ingested by animals who mistakenly taken them for food due to which toxic chemicals entered the human food chain.
- Financial Loss: The total economic damage to the world's marine ecosystem caused by plastic amounts to at least $13 billion every year.
- **Exuberating Natural Disaster:** Encroachment and clogging of city drainage with plastic and solid waste often leads to suburban flooding e.g. Mumbai's experience of annual flooding like situation during monsoon season due to water clogging etc.
- **Social Cost:** The social damage continuously being inflicted is inestimable as every sphere of life get affected by it like tourism, recreation, business, the health of humans, animals, fish and birds.

Challenges in addressing Plastic Pollution

- **Not prioritized by the state authorities-** Waste management is the last in the list of priorities of municipal corporations. Many States/UTs have not constituted **State Level Monitoring Committee (SLMC) Body** to monitor implementation of PWM Rules.
- **Lack of expertise-** among the state pollution control boards and the dearth of understanding of the scale of the plastic waste challenge.
- **Presence of a communication gap** between the state and central government officials.
- **Poor response of companies/ producers-** which are mandated to set up systems either individually or collectively in cities to ensure the collection of non-recyclable waste. They are supposed to submit their plans to states, which has been founding lacking till now.
- **Lack of accurate data-** Only 14 of India's 35 state pollution control boards filed information on plastic waste generation in 2017-18, as per CPCB. The states have been unable to gather real-time data on its generation.
- **Large-scale presence of informal sector-** Over 90 percent of the plastic industry is informal, thus trying to reach and work with these manufacturers becomes a challenge. It is further compounded due to presence of illegal units.

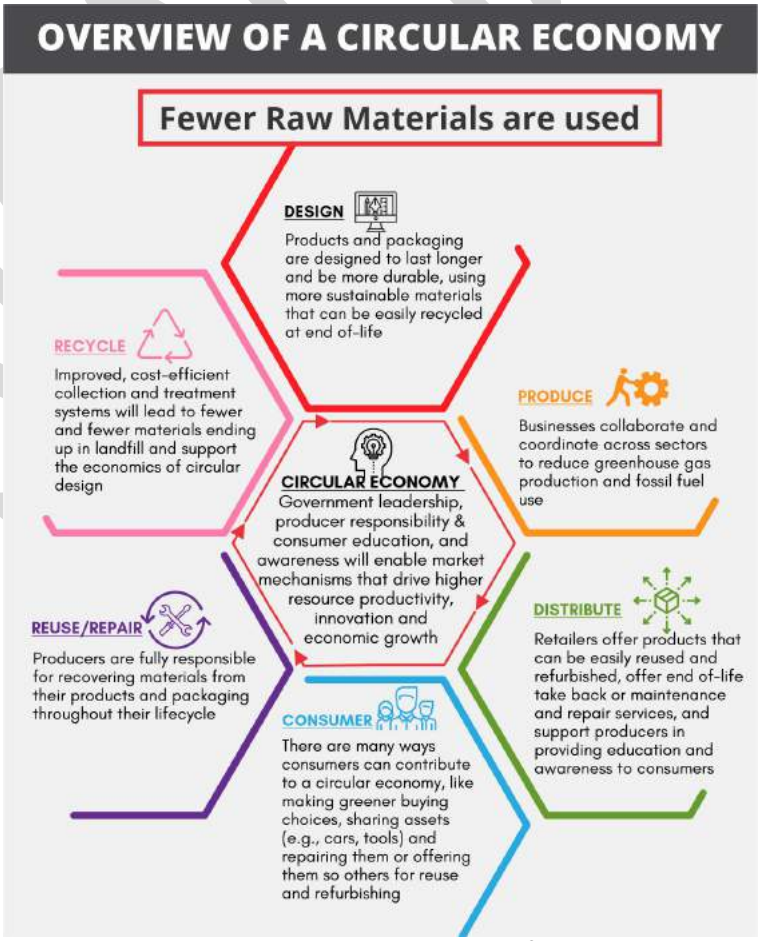
Student Notes:

Way Forward

- The Centre and state should conduct **awareness programmes** and **capacity building exercises** to educate **state-level officials** to carry out necessary measures to segregate plastic and dispose it.
  - To manage plastic waste, it is imperative for states to **devise plans based on real-time targets** and have companies and plastic manufacturers on in the loop. The **informal sector** needs to be given proper recognition, including adequate space, access to waste, storage and recognised plastic collection centres. States should plan to incentivise the informal sector to collect single-use plastic and other plastics which have low or no value, so that they get properly disposed of.
  - For **use of alternatives to plastics,** consumer awareness campaigns need to be devised. Further, the alternatives should be made available at lower prices for consumers to move away from plastics. For this, alternative industries should be promoted so as to reduce their prices.
  - A **multi-stakeholder action plan** should be put in place by the states to consider reduction, focus on low value or no value of plastics and include the informal sector, enabling them to become entrepreneurs. The State Urban Development Authorities should incorporate PWM Rules, 2016 in Municipal Byelaws for its effective implementation.

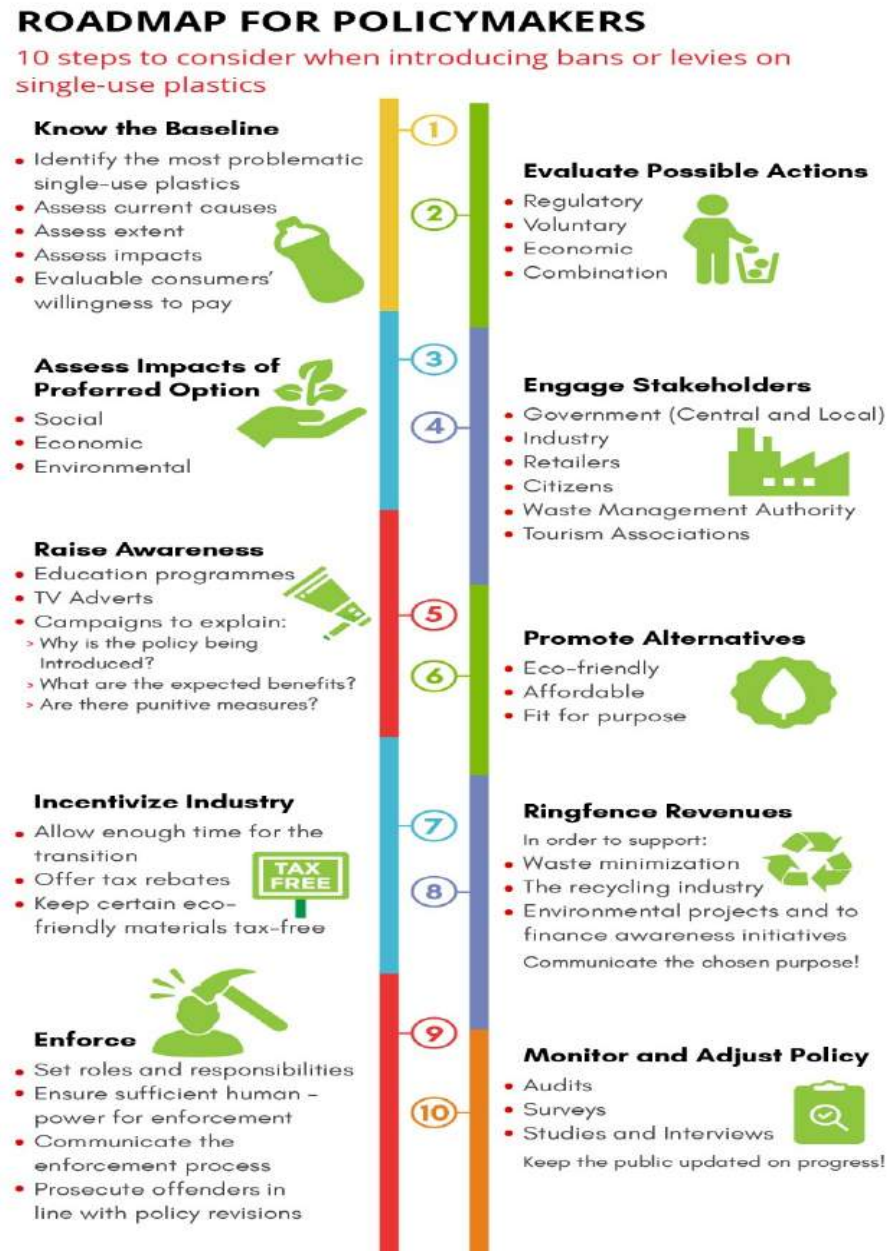
Plastic Waste Management Rules, 2016 (as amended in 2018)

- **Defines minimum thickness of plastic carry bags** i.e. 50 microns. This would increase the cost and the tendency to provide free carry bags would come down.
- **Responsibility of different stakeholders-**
  - **Local Bodies-** Gram sabha will implement in rural areas.
  - **Producers and Brand owners-** have extended producer responsibility
  - **Waste Generator-** shall segregate and store their waste as per Solid Waste Management Rules, and handover segregated wastes to authorized waste disposal facilities
  - **Street Vendor-** Not to provide such carry bags or fine would be imposed. Only the registered shopkeepers on payment of a registration fee to local bodies would be allowed to give out plastic carry bags on charge.
  - **Producers-** are to keep a record of their vendors to whom they have supplied raw materials for manufacturing.
- **Promote the use of plastic for road construction or energy** recovery.
- A **Central Registration System** for the registration of the producer/ importer/ owner.
- **Phasing out of Multi-layered Plastic (MLP)** that are "non-recyclable or non-energy recoverable or have no alternate use".



Student Notes:

- Enacting strong policies that push for a more circular model of design and production of plastics, for achieving India's commitment to eliminate all single-use plastic in the country by 2022.
- Encouraging Public-private partnerships and voluntary agreements as an alternatives to bans as it would allow citizens time to change their consumption patterns and provide an opportunity for affordable and eco-friendly alternatives.
- Exploring Alternative like biodegradable materials such as reused cotton or paper, jute bags, casein (main protein in milk) which can be used to make a biodegradable material for use in insulation, packaging and other products.



15.6. E-Waste

E-Waste **refers to** all items of electrical and electronic equipment (EEE) and its parts that have been discarded by its owner as waste without the intent of re-use.

- The **biggest contributors** to the level of e-waste at present are household appliances such as irons, vacuum cleaners, washing machines and fridges. But the rapidly-growing "**Internet of things" - internet-connected gadgets - is expected to generate e-waste at a faster rate**, as connectivity becomes embedded into everyday items.

Student Notes:

- According to a UN report, the **50 million tonnes of e-waste generated every year** will more than double to 110 million tonnes by 2050, making it the fastest growing waste stream in the world.
- **India is the third largest electronic waste generator in the world after China and the USA** as per the Global E-waste Monitor 2020.
- The issue of electronic waste is overlooked, as **electronic items that could be fixed easily go to waste instead**, contributing to pollution and increasing the demand for components like rare earth elements, which can have a damaging impact on the environment when sourced.

E-Waste management in India

- The government passed the **first law on e-waste management in 2011**, **based on Extended Producer Responsibility**. However, it did not set collection targets
- Thereafter, **the E-Waste (Management) Rules, 2016 were enacted in supersession of the 2011 Rules**.
  - A manufacturer, dealer, refurbisher and Producer Responsibility Organization (PRO) were also brought under the ambit of these Rules.
  - PRO is a professional organization authorized or financed collectively or individually by producers, which can take the responsibility for collection and channelization of e-waste generated from their products to ensure environmentally sound management.
- The **E-Waste Management Rules, 2016 have been amended by the Centre in 2018.**
  - **E-Waste (Management) Amendment Rules, 2018** objective is to channelize the e-waste generated in the country towards authorized dismantlers and recyclers in order to further formalize the e-waste recycling sector.
- **India's first E-waste clinic** is going to be set up **in Bhopal** that would enable segregation, processing and disposal of waste from both household and commercial units.
- **International Best practice:** In October 2019, the EU adopted **new Right to Repair standards**, which means that from 2021 firms will have to make appliances longer-lasting, and will have to supply spare parts for machines for up to 10 years.

Producer Responsibility Organisation: It is an organisation that helps producers meet their EPR targets through various recyclers and dismantlers.

Extended Producer Responsibility (EPR): It is a strategy designed to promote the **integration of environmental costs associated with goods** throughout their life cycles into the market price of the products. Three basic objectives of EPR:

- Manufacturers shall be incentivised to improve the environmental design of their products and the environmental performance of supplying those products.
- Products should achieve a high utilisation rate.
- Materials should be preserved through effective and environmentally-sound collection, treatment.

Issues with E waste

- **Hazardous to human health: E-waste consists of** toxic substances such as liquid crystal, lithium, mercury, nickel, polychlorinated biphenyls (PCBs), selenium, arsenic, cadmium, cobalt, copper, lead etc. These pollutants are not taken care of properly, or they are taken care of by an informal sector and recycled without properly protecting the workers.
- **Environmental effects of e-waste:** The toxic materials from electronic devices are released into bodies of water, groundwater, soil and air, affecting both land and sea animals.
  - Improper management of e-waste also contributes to **global warming**. A total of 98 Mt of CO2-equivalents were released into the atmosphere from discarded fridges and air-conditioners that were not managed in an environmentally sound manner.
- **Low recycling capacity:** Almost all e-wastes contain some form of recyclable material, including plastic, glass, and metals; however, due to improper disposal methods and techniques these materials cannot be retrieved for other purposes.
  - **Only 17.4%** of the total e-waste was collected and recycled globally.
- **Dumping in Developing countries:** A large amount of E-waste from developed countries is dumped into developing countries impacting the environment the health of the people there.

Student Notes:

- Even with International treaties such as **Basel Convention on the Control of Transboundary Movements of Hazardous Wastes,** illegal shipment and dumping of e-wastes continue to take place.

Measures to Manage E waste

- **Formal collection of e waste** by designated organizations, producers, and/or the government via retailers, municipal collection points, and/or pick-up services.
- **Recycling e-waste:** Recycling e-waste enables us to recover various valuable metals and other materials from electronics, saving natural resources (energy), reducing pollution, conserving landfill space, and creating jobs.
  - The value of raw materials in the global e-waste generated in 2019 is equal to approximately $57 billion USD.
- **E-waste Legislation:** Governments around the world are developing national e-waste policies and legislation that lay out plans or courses of action and indicate, in a non-binding manner, what can be achieved by a society, institution, or company.
  - **India** passed the first law on e-waste management in 2011
- **E-waste data:** Understanding the quantities and flows of e-waste provides a basis for monitoring, controlling, and ultimately preventing illegal transportation, dumping, and improper treatment of e-waste.
- **Create awareness:** on the environmental benefits of recycling among consumers.
  - Ministry of Electronics and Information Technology (MeitY) has initiated an **e-waste awareness programme under Digital India**, to create awareness among the public about the hazards of e-waste recycling by the unorganised sector, and to educate them about alternate methods of disposing their e-waste.

"Hazardous waste" means any waste which by reason of any of its physical, chemical, reactive, toxic, flammable, explosive or corrosive characteristics causes danger or is likely to cause danger to health or environment, whether alone or when in contact with other wastes or substances.

Hazardous and Other Wastes (Management & Transboundary Movement) Rules, 2016. deals with management of Hazardous Waste in the country.

An amendment has been done keeping into consideration the **"Ease of Doing Business"** and boosting **"Make in India"** initiative by simplifying the procedures under the Rules, while at the same time upholding the principles of sustainable development and ensuring minimal impact on the environment.

Some of the salient features of the Hazardous and Other Wastes (Management& Transboundary Movement) Amendment Rules, 2019 are as follows:

- **Solid plastic waste has been prohibited from import into the country including in Special Economic Zones (SEZ) and by Export Oriented Units (EOU).**
- Exporters of silk waste have now been given exemption from requiring permission from the Ministry of Environment, Forest and Climate Change.
- **Electrical and electronic assemblies and components manufactured in and exported from India, if found defective can now be imported back into the country, within a year of export,** without obtaining permission from the Ministry of Environment, Forest and Climate Change.
- **Industries which do not require consent under Water (Prevention and Control of Pollution) Act 1974 and Air (Prevention and Control of Pollution) Act 1981, are now exempted from requiring authorization** also under the Hazardous and Other Wastes (Management & Transboundary Movement) Rules, 2016, provided that hazardous and other wastes generated by such industries are handed over to the authorized actual users, waste collectors or disposal facilities.

15.7. Bio Medical Waste

Student Notes:

- Bio-medical waste consists of any waste which is generated during diagnosis, treatment or immunisation of human beings or animals or in research activities.
- It includes syringes, needles, cotton swabs, vials that may contain bodily liquids and spread infections.
- **COVID-19 has brought the need for extremely careful handling of biomedical waste into renewed focus.**
- According to a report filed by the Central Pollution Control Board (CPCB), **India generates about 101 Metric Tonnes per day (MT/day) of COVID-19 related bio-medical waste** in addition to the regular bio-medical waste generation of about 609 MT per day.
- It has been found that only 15% of the bio-medical waste that is generated is hazardous. However, all the waste needs to be treated.

Challenges with COVID-19 biomedical waste

- **Health risk:** This waste has created new biomedical waste crisis and **posing a health risk to sanitation workers and garbage collectors. E.g.** Over 40 sanitation workers have tested positive for COVID-19 and 15 have lost their lives in Delhi.
- **Lack of segregation:** Municipalities pick up biomedical waste from houses, but it **often has other household waste mixed in it**. This decreases the efficiency of the incinerators at waste treatment plants as it results in greater emissions and unburnt ash.
- **Guidelines not being followed properly:** For e.g. Some states are not following the CPCB guidelines on Covid-19 related waste and the existing bio medical waste management rules further increasing the risk.
- **Overburdened disposal Capacity:** PPE are being used everywhere, from hotels to hospitals, railway stations to airports, crematoriums to burial grounds so, the **disposal mechanisms available in the cities are not equipped to deal with this huge volume.**

Biomedical Waste Management in India

- Government had notified Bio- medical Waste Management Rules in 1998 under the **Environment Protection Act 1986** which were later amended twice in 2000 and2003.
- In 2016 government notified revamped **Bio-medical Waste (BMW) Management Rules 2016** to enhance, widen and bring a comprehensive regime for **bio- waste management**.

Key features of Bio-medical Waste Management Rules 2016 (amended in 2018)

- **Widened jurisdiction** – The ambit of the rules was widened to include vaccination camps, blood donation camps, surgical camps etc.
- **Pre-treatment of waste**: Waste generated in laboratories, microbiological waste, blood samples and blood bags to be pre-treated through disinfection or sterilisation on-site in the manner as prescribed by WHO.
- **Phasing out** of use of chlorinated plastic bags, gloves and blood bags by **March 2019**..
- **Better segregation**: Bio-medical waste has been classified into **4 categories:** Untreated human anatomical waste, Animal anatomical waste, Soiled waste and Biotechnology waste.
- **Storage of waste**: Provision within the premises for a safe, ventilated and secured location for storage of segregated biomedical waste.
- **Regular Training and Immunisation** of all health care workers.
- **Ensure proper Transportation and handling of waste** without any adverse effect to the human health and the environment.
- **Record maintenance and monitoring** of the activities related to bio-medical waste management**.**
- **Establish GPS and Bar-coding facility at** Common biomedical waste treatment facility**.**

Student Notes:

15.8. International Initiatives for Waste Management

15.8.1. Basel Convention on the Control of Transboundary Movements of Hazardous Waste and their Disposal

- It was adopted in 1989 and entered into force in 1992.
- The overarching objective of the Basel Convention is to protect human health and the environment against the adverse effects of hazardous wastes.
- Its scope of application **covers a wide range of wastes defined as "hazardous wastes"** based on their origin and/or composition and their characteristics, as well as **two types of wastes defined as "other wastes"** - household waste and incinerator ash.
- The **guiding principles of the Convention** are that transboundary movements of hazardous wastes should be: reduced to a minimum; minimized at the source; managed in an environmentally sound manner; and treated and disposed of as close as possible to their source of generation.
- The **regulatory system is the cornerstone** of the Basel Convention. Based on the **concept of prior informed consent**, it requires that, before an export may take place, the authorities of the State of export notify the authorities of the prospective States of import and transit, providing them with detailed information on the intended movement. The movement may only proceed if and when all States concerned have given their written consent.

Basel Ban Amendment

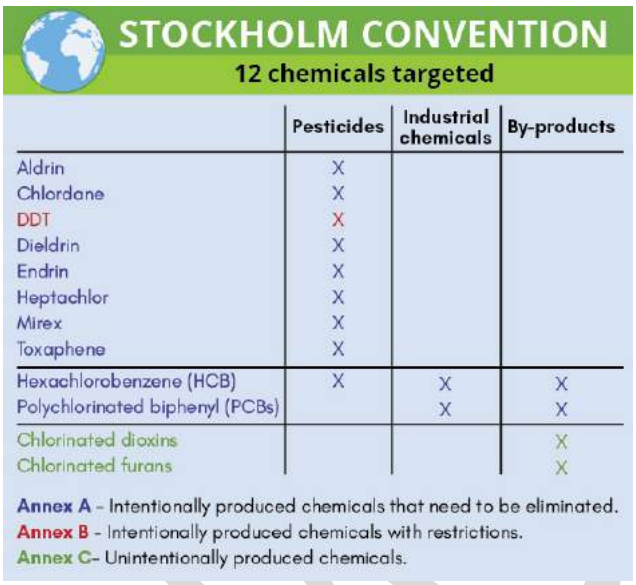
- Croatia became the 97th country to ratify the ban, which was adopted by the parties to the Basel Convention in 1995, to protect human health and the environment against the adverse effects of hazardous wastes.
- The **Ban Amendment prohibits all export of hazardous wastes,** including electronic wastes and obsolete ships from 29 wealthiest countries of the Organization of Economic Cooperation and Development (OECD) to non-OECD countries.
- It will become a new Article in the Convention and will enter into force in the 97 countries.
- However, countries like the **US, Canada, Japan, Australia, New Zealand, South Korea, Russia, India, Brazil, and Mexico are yet to ratify** the ban.

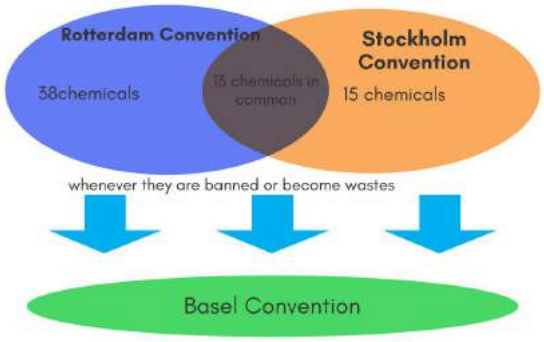
15.8.2. Rotterdam Convention on the Prior Informed Consent Procedure (PIC) for Certain Hazardous Chemicals and Pesticides in International Trade

- It was adopted in September 1998 and entered into force in 2004.
- It's jointly administered by the United Nations Food and Agriculture Organization **(FAO) and UN Environment (UNEP).**
- It creates **legally binding obligations** for the implementation of the **Prior Informed Consent** (PIC) procedure. It built on the voluntary PIC procedure, initiated by UNEP and FAO in 1989.
- **Objectives:**
  - To promote shared responsibility and cooperative efforts among parties in the international trade of certain hazardous chemicals in order to protect human health and the environment from potential harm.
  - To contribute to the environmentally sound use of those hazardous chemicals by: **facilitating information exchange** about their characteristics; providing for a **national decision-making process on their import and export**; and **disseminating** these decisions to parties.
- The Convention **covers pesticides and industrial chemicals** that have been banned or severely restricted for health or environmental reasons by Parties and which have been notified by Parties for inclusion in **Annex III for the purpose of PIC procedure.**

15.8.3. Stockholm Convention on Persistent Organic Pollutants (POP)

- It was adopted in May 2001 and entered into force in 2004.
- It's a global treaty to **protect human health and the environment from chemicals (POP)** that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and have harmful impacts on human health or on the environment.
- It calls for international action on three categories of POPs: pesticides, industrial chemicals, and unintentionally produced POPs.
- **Key provisions:** Elimination (POPs in annex A); Restriction (POPs in annex B) & Reduction or elimination (unintentionally produced POPs in annex C).
- It requires parties to prevent the development of new POPs and promote best available techniques (BAT) and best environmental practices (BEP) for replacing existing POPs.
- It initially addressed 12 substances (**known as "the dirty dozen")** but now 30 chemicals of global concern are listed under it.
- The **Global Environmental Facility (GEF)** is the designated interim financial mechanism for the Stockholm Convention.
- The **United Nations Industrial Development Organization (UNIDO** takes the responsibility for developing nations and transitioning economies to help them implement Stockholm Convention measures.





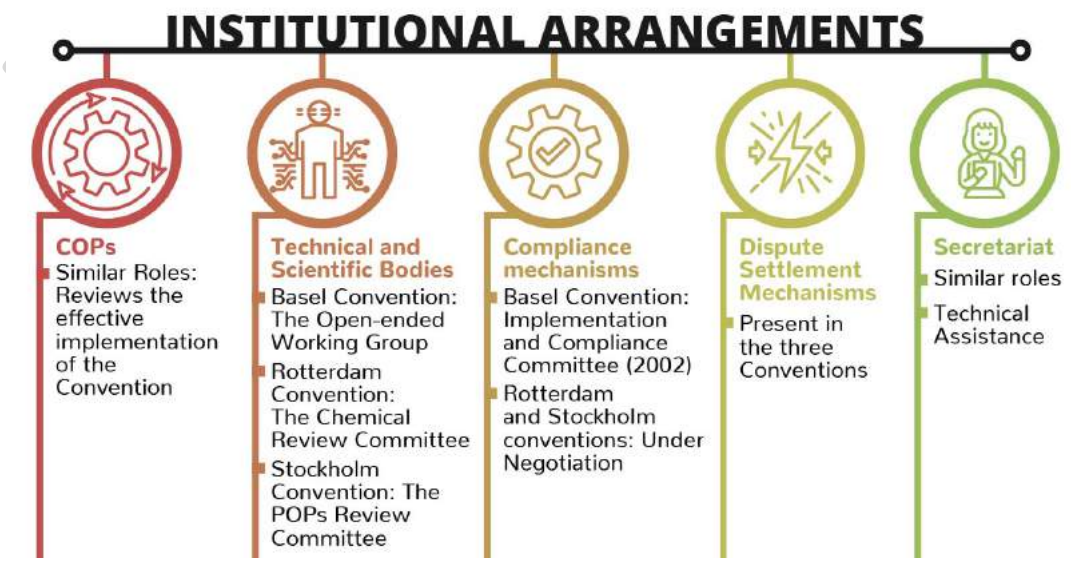
Major decisions at 2019 joint Conferences of the Parties to the Basel (COP-14), Rotterdam (COP-09) and Stockholm (COP-09) convention.

- **Under Basel Convention:** Adoption of an amendment to include unsorted, mixed and contaminated **plastic waste** under **PIC (Prior Informed Consent) procedure** and improve the regulation of its transboundary movement.
  - **Establishment of a Partnership on Plastic Wastes** to encourage member countries to manage plastic wastes in an environmentally sound manner. The partnership will aim to collect information on the progress in member countries efforts for reducing plastic wastes, raise public awareness of this issue and advance other activities. The partnership will embark on its activities after 2020.
  - Provisional adoption of **Technical Guidelines on Transboundary Movements of E-Waste and Used Electrical and Electronic Equipment**: The guidelines provide a list of criteria for member countries in objectively **distinguishing between waste and non-waste** under the Basel Convention when companies intend to import or export used electrical and electronic equipment for reuse.
- **Under the Rotterdam Convention: Establishment of a compliance mechanism** to assist Parties to identify and address gaps in complying with the Convention, with the aim of ensuring that

governments have the information they need about hazardous chemicals to assess the risks and take informed decisions when importing chemicals.
    - Two chemicals, **the pesticide phorate** and the industrial chemical **hexabromocyclododecane (HBCD)** were added to Annex III of the convention, making them subject to the PIC Procedure, through which countries can decide on future imports of these chemicals.
- **Under Stockholm Convention**: **Listing for elimination of dicofol and perfluorooctanoic acid (PFOA),** its salts, and PFOA-related compounds under **Annex A of the Convention**, which obliges Parties to eliminate these chemicals from use.
    - **Dicofol** is used as **a miticide on a variety of field crops**, fruits, vegetables, ornamentals and tea and coffee and is known to cause skin irritation and hyperstimulation of nerve transmissions in humans as well as being highly toxic to fish, aquatic invertebrates, algae and birds.
    - **PFOA** is a widely-used **industrial chemical** used in the production of non-stick cookware and food processing equipment, as well as a surfactant in textiles, carpets, paper, paints and fire-fighting foams. It is known to be linked to **major health problems** including kidney cancer, testicular cancer, thyroid disease and hypertension in pregnancy.

Student Notes:

	BASEL CONVENTION	ROTTERDAM CONVENTION	STOCKHOLM CONVENTION
Evaluating/regulating new and existing chemicals		⊗	⊗
Import/expert controls	⊗	⊗	⊗
Risk assessment	⊗	⊗	⊗
Waste management	⊗		⊗
Risks/hazard communication	⊗	⊗	⊗
Alternatives		⊗	⊗
Environmental releases	⊗		⊗
Technical assistance	⊗	⊗	⊗
External Financial mechanism	⊗	⊗	⊗
Reporting	⊗		⊗



Student Notes:

15.9. UPSC Previous Year Questions

Mains

1. Comment on the spatial components in urban solid waste management in the country. (2010)

Prelims

1. In India, 'extended producer responsibility' was introduced as an important feature in which of the following? (2019)
(a) The Bio-medical Waste (Management and Handling) Rules, 1998
(b) The Recycled plastic (Manufacturing and Usage) Rules, 1999
(c) The e-Waste (Management and Handling) Rules, 2011
(d) The Food Safety and Standard Regulations, 2011

Solution: **C**

2. In the context of solving pollution problems, what is/are the advantage/advantages of bioremediation technique? (2017)
1. It is a technique for cleaning up pollution by enhancing the same biodegradation process that occurs in nature.
2. Any contaminant with heavy metals such as cadmium and lead can be readily and completely treated by bioremediation using microorganisms.
3. Genetic engineering can be used to create microorganisms specifically designed for bioremediation.

Select the correct answer using the code given below:
(a) 1 only (b) 2 and 3 only (c) 1 and 3 only (d) 1, 2 and 3

Solution: C

15.10. Vision IAS Previous Years Test Series Questions

1. Highlight the need to integrate informal and formal sectors for improved waste management.

Approach:

- Briefly discuss waste generation in India.
- Enlist the weaknesses faced by the formal and informal sectors with regard to waste management in India.
- Discuss the need for formal-informal sector integration by highlighting the advantages offered by it in waste management.
- Give a brief conclusion with a way forward.

Answer:

According to the MoEF&CC, about **62 million tonnes of waste is generated annually** in India by more than 350 million people living in urban India, out of which 5.6 million tonnes is plastic waste, 0.17 million tonnes is biomedical waste, hazardous waste generation is 7.90 million tonnes and 15 lakh tonnes is e-waste. With changing consumption patterns and rapid economic growth, it is estimated that it will **increase to 165 million tonnes in 2030.**

Currently, both the formal and informal sectors are engaged in waste management. However, both sectors face certain **weaknesses,** including:

- **Formal sector:** Municipalities and private (formal) service providers do not have the required financial and organizational capacities for carrying out overall collection of waste, recycling and environmentally sound disposal at landfills through mechanization and highly capital-intensive equipment.

- **Informal sector:**
  - **Security:** Issues of harassment by the police while transporting recyclables, lack of secure access to buyers of recyclables etc. are common in the informal sector.
  - **Work related issues:** These include problems like lack of capital, price fluctuations, difficulty in getting high quality recyclables due to non-segregation by waste generators etc.
  - **Health issues:** Workers in the informal sector face health problems due to unsanitary work conditions, exposure to hazardous, allergic and infectious components of waste etc.
  - **Social disadvantage:** Informal workers have limited general business knowledge, and are often faced with issues such as low social status, lack of support from the local governments etc.

In this context, there is a dire need to **integrate formal and informal sectors** of waste management in India. Integration would help in the following ways:

- **Ensure security to workers in the informal sector:** Integration could make working in the sector secure with considerations towards workers' health and occupational safety. It may also prevent them from the vagaries of price fluctuations and would positively impact their standard of living and their mental and physical well-being.
- **Expansion of knowledge base of the informal sector:** Integration would help expand informal workers' knowledge via training about general business, policy changes, relevant government health insurance schemes etc.
- **Ensure social recognition for the informal sector:** It would ensure that the contribution of the informal sector to the society is recognized and the workers are legally permitted by state municipalities to collect, segregate and sell waste from garbage dumps across the country. This reduces the scope of targeting and harassment under Indian laws and otherwise.
- **Lower management cost for municipalities:** The informal sector plays a key role in recovery of recyclables in both urban and rural areas, thus, integration would reduce the overall waste management costs for municipalities. It would also reduce the cost of transportation of goods to recyclers or consolidators.

The role of municipalities is critical in mobilising the informal sector and integrating it with the formal sector. For this reason, policy changes need to be brought in. For instance, municipalities could provide waste pickers with identity cards and health insurance schemes, support can be given through establishment of cooperatives or SMEs, and provision of training for workers in the informal sector can be introduced.

2. E-waste is the byproduct of our increasingly electronic existence. In this context explain the problem of e-waste in India and measures taken to control.

Approach:

In the introduction explain how the consumption of electronic goods has increased leading to huge e-waste generation. Then explain how e-waste is a major problem for India due to its increasing amount, lack of proper disposal, low level of awareness, etc. For the next part of the question, explain the measures taken to control it. Conclude by discussing what more can be done.

Answer:

E-waste is one of the fastest growing components of the municipal solid waste. According to a CAG report, India generated around 4 lakh tonnes of electronic waste in 2010, up from 1.47 lakh tonnes in 2005. This is because people are relying more and more on

Student Notes:

electronic goods. Mobile phones, computers and televisions are being upgraded more frequently than ever before.

The problem of e-waste in India is multi-faceted.

- E-waste contains metals such as lead, mercury, cadmium and arsenic. Thus they are a threat to environment as well as human health.
- Only about 6 percent of the e-waste is recycled, of which 95 percent is recycled through the informal sector in an improper manner. Here the workers are most likely to be affected by the toxic substances. They have little or no protection while working.
- Moreover, many of these recycling sectors are located close to residential areas and thus they are a threat to the local population as well.
- India also faces the problems of e-waste from the developed countries. In the West, treating or processing e-waste is expensive, and smaller countries are running out of landfill space. Therefore, they prefer to ship it out to developing countries like India.
- Most of the rules and guidelines issued by government are often not implemented in an appropriate way.

Measures:

- The government has made Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008, for proper management and handling of hazardous wastes including e-waste.
- Central Pollution Control Board (CPCB) has published guidelines which provide approach and methodology for environmentally sound management of e-waste.
- Separate E-Waste (Management and Handling) Rules, 2011 have been notified. It includes provision of Extended Producer Responsibility (EPR) which makes the producer responsible for the entire life cycle of the product, especially for take back, recycling and final disposal of the product.
- E-waste recycling can be undertaken only in facilities authorized and registered with State Pollution Control Boards/Pollution Control Committees.
- Ministry of Environment and Forests is implementing a Scheme to provide financial assistance for setting up of treatment, disposal and storage facility for hazardous and integrated recycling facilities for E-waste on public private partnership mode.

While government has taken some legislative measures, it should also ensure its proper implementation. Only then India will be able to tackle the challenge of e-waste.

3. Processing and safe disposal of garbage must replace the current model of landfills in order to transform our cities to being 'smart'. Elucidate. In this context, analyse the reasons for failure of waste management policies in India.

Approach:

- Briefly give your understanding of a ‘smart’ city – in context of garbage management with description of current model of waste disposal i.e. landfills.
- Mention the advantages of garbage processing over landfills.
- For the second part, briefly mention the waste management policies in India.
- Then, enlist reasons for failure of waste management policies.
- Give a forward-looking conclusion.

Answer:

When it comes to garbage management, ‘smart’ is synonymous with ‘sustainable’. As a UN Report projects that by 2050, 60% of India’s population will come to live in urban

areas, India has started on a mission to turn its cities 'smart'. Municipal Solid Waste (MSW) Management forms one of the crucial infrastructure services in this context.

Currently, MSW is not managed scientifically. Out of the 62 million tonnes (MT) of MSW generated per annum, only 43 MT is collected, 11.9 MT is treated while 31 MT is dumped in landfill sites. This unscientific and unsanitary dumping leads to various problems:

- Contamination of ground water due to leachate generation in landfills posing health risks. Leachate is the liquid formed when waste breaks down in landfill and water filters through waste. This liquid is highly toxic and can pollute land, groundwater and streams.
- Landfills also generate greenhouse gases lie methane. These gases are inflammable and cn lead to fire as well.
- Huge quantum of untreated waste creates challenge of land availability
- Disasters such as collapse of Ghazipur landfill in east Delhi, recurring fires at Deonar landfill in Mumbai etc. leading to casualties

Thus, going by sustainability principle, garbage processing offers the following advantages:

- Proper segregation of waste at source making subsequent steps such as recycling & resource recovery easier
- Reduced final residue can be then discarded scientifically in sanitary landfills
- Energy-from-waste element converts waste into renewable energy and organic manure and also, reduces the volume of waste
- Various stages such as collection, transportation, treatment etc. offers employment opportunities.

Concerning the waste management, the government came out with various policy measures such as Environment Protection Act, 1986, Solid Waste Management Rules 2016 etc. But these have not delivered the desired results, owing to following reasons:

- Rapid urbanization with low ecological awareness and lack of citizen participation in waste management
- Lack of India-specific studies on characterization of MSW to design adequate processing methods
- Inadequate implementation of rules by the ULBs due to various reasons including absence of auditing and other accountability mechanisms
- Majority of the solid waste management budget is allotted for collection and transportation leaving very little for processing and disposal.
- Resistance for notification of new landfill sites by local residents, leading the existing landfill sites to run beyond their capacity
- Non-involvement of informal sector such as rag pickers etc. into the waste management plan
- Financial non-viability of waste-to-energy projects

Thus, India needs to involve and integrate its organized sector and unorganized sector and empower its ULBs. This only can ensure the success of Swachh Bharat Mission and the actualization of the dream of 'smart' urban India.

Student Notes:

Student Notes:

4. 'Swachh Bharat' cannot succeed unless there is adequate management of solid waste in India. In this context, enumerate the salient features of the new Solid Waste Management Rules (SWM) 2016. Also discuss to what extent they can help in achieving the aims of 'Swachh Bharat'.

Approach:

- Write about the salient features of the new Solid Waste Management Rules (SWM) 2016.
- Evaluate how the new rules can help in achieving the aims of 'Swachh Bharat'.

Answer:

The management of solid waste is the biggest challenge faced by municipal authorities throughout India. The solid waste management rules are revised after 16 years with an aim to overhaul the waste collection and disposal system to achieve the objectives of Swachh Bharat.

Salient features

- Rules are now applicable beyond Municipal areas.
- Source segregation of waste is mandatory in order to channelize the waste to wealth by recovery, reuse and recycle.
- Local bodies have been given power to decide the user fees. Municipal authorities will levy user fees from bulk generators.
- Sanitary napkin companies are responsible for awareness for proper disposal of such waste by generator.
- Brand owners who sale or market their products in packaging material which are non-biodegradable, should put in place a system to collect back the packaging waste.
- Integration of waste pickers and waste dealers in the formal system should be done by State Governments, and Self Help Group, or any other group to be formed.
- The rules also have provisions for spot fines for littering public spaces.
- The concept of partnership in Swachh Bharat has been introduced.

Furthering aims of Swachh Bharat

- Swachh Bharat Mission seeks to create a Clean India by 2019 and management of solid waste and maintenance of cleanliness in public places are its important components.
- The new rules make it mandatory to segregate waste at source and have provisions for collection of user fees and waste processing and treatment. This will have a positive impact on waste collection and treatment.
- Currently, much of the solid waste is simply dumped outside the municipal limits. By extension of jurisdiction of rules will ensure effective implementation of the Rules and achieve objectives of the Swachh Bharat.
- The concept of partnership in Swachh Bharat has been introduced. Bulk and institu tional
  wastegenerators have been directly made responsible for Segregation and Sort ing the waste and manage in partnership with Local Bodies.
- Provisions for maintaining cleanliness in public places and spot fines for littering will help in maintaining cleanliness in public places.

An awareness campaign needs to be planned to push for better implementation of these rules. The Rules need to focus on making solid waste management a people's movement, on the lines of Swachh Bharat.

CHAPTER - 16 - CLIMATE CHANGE AND GLOBAL WARMING

16. Climate Change and Global Warming

16.1. Introduction

Climate refers to characteristic atmosphere conditions of a place over long periods of time. Climate can be classified according to latitude as **tropical, subtropical, continental** and **arctic**. It is also referred to as **Mediterranean, monsoon, desert** type etc. The **temperature** and **precipitation** are two important factors among others which influence the climate.

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

16.2. Theories of Climate Change

Change is the law of nature. Climate is not an exception to this. The experts of climate have put forward a number of theories and concepts about the climate change. Some of them have been presented briefly in the following paragraphs-

Radiative/Climate Forcings

The Earth's surface temperature depends on the balance between incoming and outgoing energy. A shift in the energy balance causes the Earth's average temperature to become warmer or cooler, leading to a variety of other changes in the lower atmosphere, on land, and in the oceans.

A variety of physical and chemical changes can affect the global energy balance and force changes in the Earth's climate. Some of these changes are natural, while others are influenced by humans. These changes are measured by the amount of warming or cooling they can produce, which is called **"Radiative Forcing."**

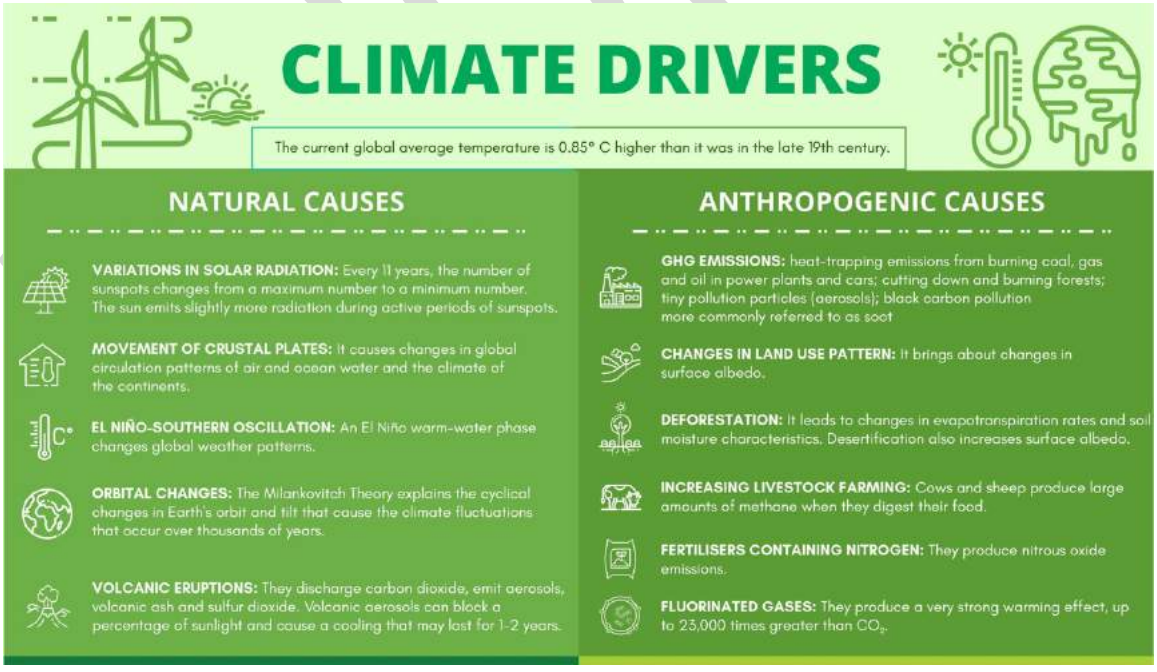
Changes that have a warming effect are called **"positive" forcing**, while **changes that have a cooling effect** are called **"negative" forcing**. When positive and negative forces are out of balance, the result is a change in the Earth's average surface temperature.

Forcings can be natural (changes in Earth's orbital cycle, volcanic eruptions etc.) or human induced (emission of greenhouse gases)

Since 1750, human-caused climate drivers have been increasing, and their effect dominates all natural climate drivers.

- **Astronomical or Orbital Theory:** Sun is the primary source of heat and light to the earth. The eccentricity of the earth's orbit around the sun changes. The earth's orbit undergoes a change of shape during a cycle of 90,000 to 100,000 years.
    - Sometimes the orbit forms a longer ellipse and then it returns to more circular shape. At the time of greater eccentricity of the earth's orbit, the amount of heat received at the earth's surface at perihelion may be 20 to 30 % greater than that of aphelion. Variation of magnitude in the solar radiation would lead to change in the solar constant, thereby affecting the temperature and climate of the earth.
    - The inclination of the earth varies from 22 degree to 24.5 degree during the cycle of 41,000 years. These changes in the axis of the earth may lead to gradual and warmer phases on the earth's surface.
- **Theories of continental drift:** The continental drift theory of Wegner, the sea floor spreading by H.H. Hess, and the plate tectonics by Morgan reveal that the continents and ocean basins have drifted apart. The drift was started about 300 million years back.
    - Consequently, the positions of equator and poles have undergone significant changes and that affected the horizontal distribution of continents of continents and oceans. The geologists and geo-physicists opine that during the geological past the continental drift

must have brought many climatic changes which are reflected in the different evidences such as coal distribution, etc.
    - The changes in the position of continents and oceans might have affected the place flow and direction of the ocean currents. Resultantly, the distributional patterns of temperature and precipitation through the ocean currents might have been affected.
- **Theories about the changes in the Atmospheric Composition:** The contents of carbon dioxide, nitrous oxide, methane, water vapour, etc. are not constant in the atmosphere. The proportion of carbon dioxide changed in the past because of the volcanic eruptions. It is changing faster because of the heavy consumption of fossil fuel by man.
    - The carbon dioxide theory about the climatic change was put forward by T.C. Chamberlin. According to this theory variations in the carbon dioxide content of the atmosphere play an important role in causing the worldwide climatic change.
    - Due to greenhouse effect, any change in carbon content in the atmosphere would bring about changes in the temperature of the atmosphere. The high rate of industrialization and urbanization has been directly adding more carbon dioxide to the atmosphere, which has been attributed as the main cause of climate change
    - The CO2, CH4, CFCs (Chlorofluorocarbons) and NO2 (nitrous oxide) are continuously increasing in the atmosphere, which results into increased temperature and consequently adverse impacts such as sea level rise, ocean acidification, etc.
- **The Volcanic Dust Theory:** The volcanic dust deflects light of short wave lengths coming from the sun. Contrary to this, long wave terrestrial radiation can easily pass through volcanic dust without any loss. Thus, volcanic dust may lower down the earth's temperature to a certain extent. The volcanic dust is considered as responsible for 'Little Ice Age'. In the geological past the frequent volcanic eruptions initiated the process of Ice Age.
- **Sunspots Theory:** There is a close relationship between the sunspots and the heat and energy received at the earth surface. The number of sunspots increases and decreases in a cyclic manner. The sunspot cycle averages eleven years in length which has been called as 11-year cycle. The variation in solar constant is thus also responsible for the climate change.

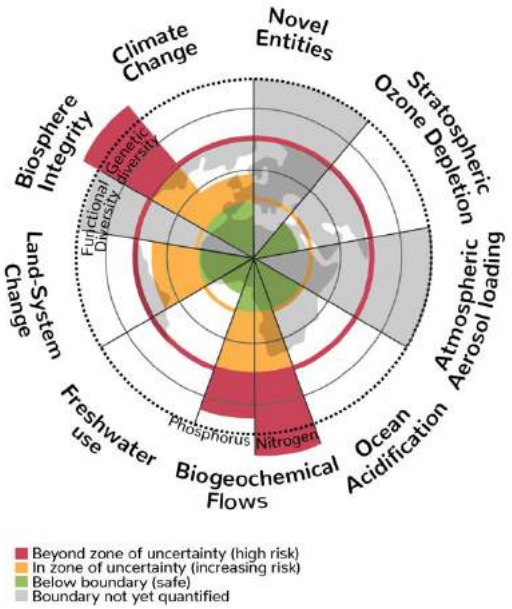


Student Notes:

Student Notes:

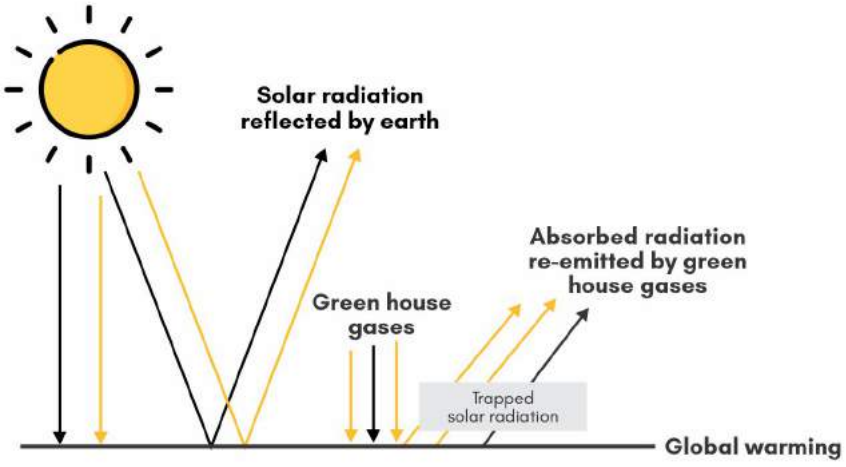
Planetary boundaries

- They represent a system or process that is important **for regulating and maintaining stability of the planet**.
- They define **global biophysical limits** that humanity should operate within to ensure a stable and resilient Earth system—i.e. conditions that are necessary to foster prosperity for future generations.
- There are **nine planetary boundaries-**
  - Climate change
  - Bio diversity loss
  - Biogeochemical flows
  - Ocean acidification
  - Land use change
  - Freshwater use
  - Ozone depletion
  - Atmospheric aerosols
  - Chemical pollution



16.3. The Greenhouse Effect

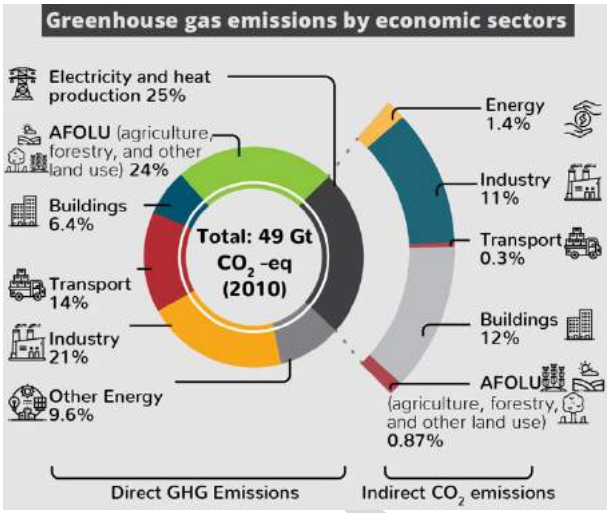
Solar radiation warms the Earth's surface and the atmosphere. About one third of the radiation is reflected back into space, about **20% is absorbed by the atmospheric gases** and the remaining amount reaches the earth surface and is absorbed by it.



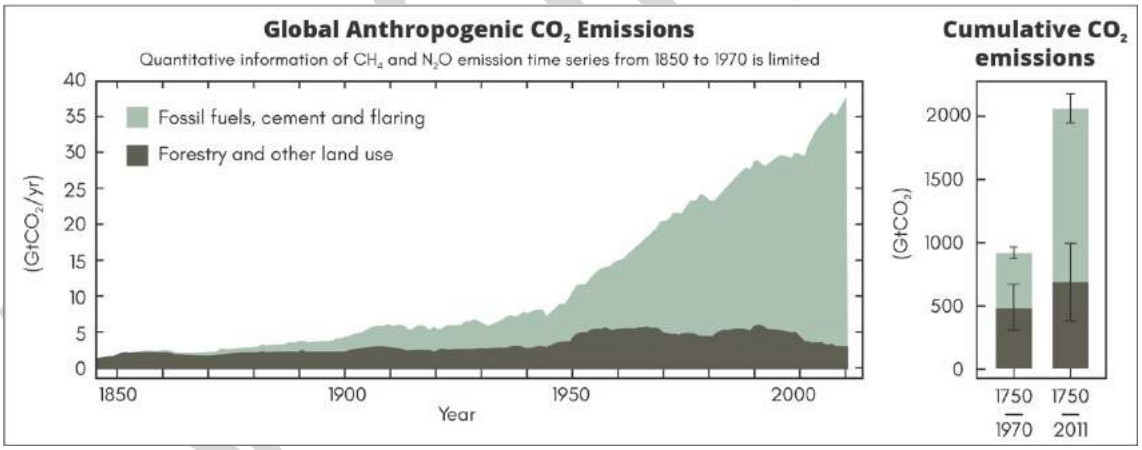
The **energy so absorbed is remitted** in the form of **infrared radiation**. The atmospheric gases absorb some of this radiation and hence do not allow all the emitted energy to escape into the space. Thus, some of the heat is trapped by these gases and the atmosphere becomes warmer. It is this phenomenon which raises the average temperature of earth from -18°C to +15°C and is very vital for life on the earth. The situation is analogous to a **greenhouse** which traps heat and its glass walls do not allow the heat to go out thereby increasing the inside temperature. Therefore, this effect is called **greenhouse effect**.

The gases such as carbon dioxide, methane, ozone, chlorofluorocarbons and water vapours are responsible for greenhouse effect and are called ***greenhouse gases***. The contribution of water to greenhouse effect is about two-thirds and that of carbon dioxide is about one-quarter. The other gases nitrogen (N_2), oxygen (O_2), argon (Ar) present in the atmosphere are incapable of absorbing infrared radiation. The concentration of water vapours in the atmosphere has not changed significantly but that of greenhouse gases has shown a marked increase since the industrial revolution. The anthropogenic (human) activities such as generation of energy from

fossil fuels and deforestation have increased CO2 concentration. The increase in the concentration of CO_2 and other greenhouse gases leads to an **enhanced greenhouse effect**. This is causing an increase in the global temperature which is known as **global warming**. Studies suggest that temperature has already increased by 0.3°C - 0.6°C since 1860 and the last two decades of the twentieth century were the warmest particularly the year 1998. From 1850 onwards, the decade 2000-2010 had been the warmest one particularly the two years 2005 and 2010 were the warmest years.



Gas	Sources and Causes
Carbon dioxide (CO_2)	Burning of fossil fuels, deforestation
Chlorofluorocarbons(CFCs)	Refrigeration, solvents, insulation foams, aero propellants, industrial and commercial uses
Methane (CH_4)	Growing paddy, excreta of cattle and other livestock, termites, burning of fossil fuel, wood, land fills.
Nitrogen oxides (N_2O)	Burning of fossil fuels, fertilizers; burning of wood and crop residue.



16.4. Global Warming Potential

Greenhouse gases (GHGs) warm the Earth by absorbing energy and slowing the rate at which the energy escapes to space, they act like a blanket insulating the Earth. Different GHGs can have different effects on the Earth's warming.

Two key ways in which these gases differ from each other are their ability to absorb energy (their "radiative efficiency"), and how long they stay in the atmosphere (also known as their "lifetime").

The Global Warming Potential (GWP) was developed to allow comparisons of the global warming impacts of different gases. Specifically, it is a measure of h**ow much energy the emissions of 1 ton of a gas will absorb** over a given period of time, **relative to the emissions of 1 ton of carbon dioxide** (CO_2). The **larger the GWP**, the **more that a given gas warms the Earth compared to CO_2** over that time period. The time period usually used for GWPs is 100 years.

CO_2, by definition, has a GWP of 1 regardless of the time period used, because it is the gas being used as the reference. CO_2 remains in the climate system for a very long time: CO_2 emissions cause increases in atmospheric concentrations of CO_2 that will last thousands of years.

Methane (CH_4) is estimated to have a GWP of 28–36 over 100 years. CH_4 emitted today lasts about a decade on average, which is much less time than CO_2. But CH_4 also absorbs much more energy than CO_2.

Greenhouse Gas (GHG)	Atmospheric Lifetime (yrs)	Global Warming Potential (GWP)
Carbon dioxide (CO_2)	50-200	1
Methane (CH_4)	12±3	21
Nitrous oxide (N_2O)	120	310
Hydroflurocarbons (HFCs)	1.5 to 209	150 to 11,700
Perfluorocarbons (PFCs)	2,600 to 50,000	6,500 to 9,200
Sulfur Hexafluoride (SF_6)	3,200	23,900

Nitrous Oxide (N_2O) has a GWP 265–298 times that of CO_2 for a 100-year timescale. N_2O emitted today remains in the atmosphere for more than 100 years, on average.

Chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), hydrochlorofluorocarbons (HCFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6) are sometimes called **high-GWP gases** because, for a given amount of mass, they trap substantially more heat than CO_2.

16.5. Evidences of Global Warming

Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen.

- **Atmosphere:** Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850. The period from 1983 to 2012 was one of the warmest 30-year period of the last 800 years in the Northern Hemisphere.
    - In addition to robust multi-decadal warming, the globally averaged surface temperature exhibits substantial decadal and interannual variability.

Limiting Global Warming to 1.5°C above pre-industrial levels

In Paris Agreement 2015, Parties to the United Nations Framework Convention on Climate Change (UNFCCC) agreed **to limit global temperature increase to well below 2°C above pre-industrial levels and to pursue efforts to limit the increase to 1.5 C.**

- In 2018, the Intergovernmental Panel on Climate Change (IPCC) Special Report on Global Warming of 1.5°C (IPCC SR 1.5°C) warned that the **impacts of warming at 2°C would be significantly worse than those at 1.5°C.**
- According to IPCC SR 1.5°C, to avoid or limit any overshoot of the 1.5°C temperature goal, CO2 emissions will need to be phased out almost entirely by 2050.
- Human-induced global warming has **in 2017 already reached 1°C above preindustrial levels**; the current climate efforts of countries will take the world to 1.5°C between 2030 and 2052.

What happens at 2°C that does not happen at 1.5°C?

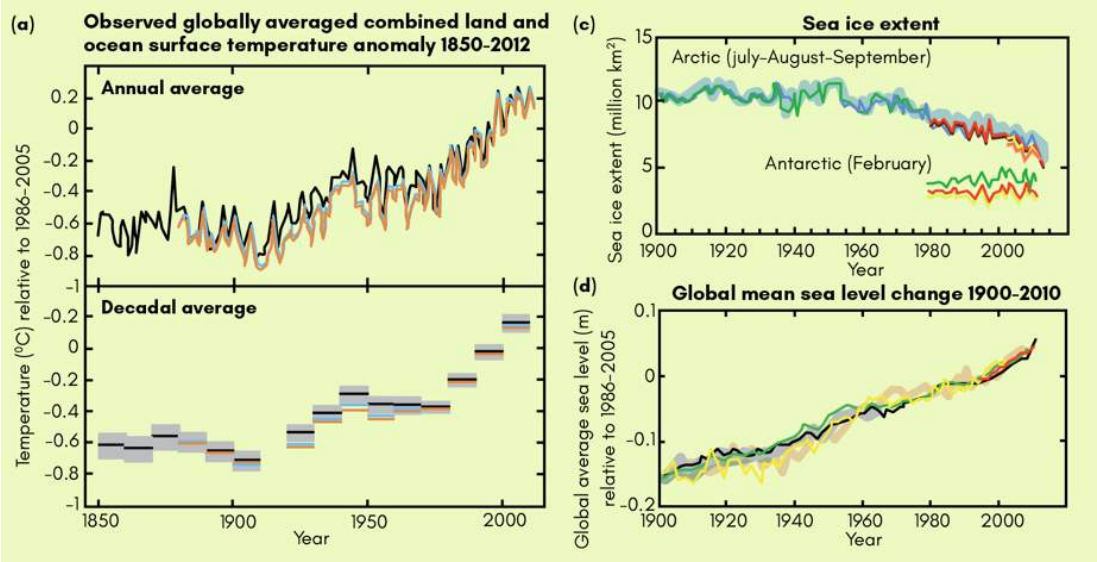
- An additional 150 million people could be at risk from malaria
- 25 million fewer undernourished people by the end of the century, if the 1.5°C goal was achieved
- 1.5°C could prevent 153 million premature deaths due to air pollution by 2100, as compared to the 2°C scenario

Thus, limiting global warming to 1.5°C should be targeted because

- It **would reduce challenging impacts** on ecosystems, human health and well-being, making it easier to achieve the United Nations Sustainable Development Goal.
- Allowing the global temperature to temporarily exceed or 'overshoot' 1.5°C would mean a **greater reliance on techniques** that remove CO2 from the air to return global temperature to below 1.5°C by 2100.
- The effectiveness of such techniques is unproven at large scale, and some may carry significant risks for sustainable development.

Student Notes:

- It is observed that globally the **troposphere has warmed** and the **lower stratosphere has cooled** since the mid-20th century.
- It is also observed that in precipitation change averaged over global land areas since 1901 is low prior to 1951 and medium afterwards. Averaged over the mid-latitude land areas of the Northern Hemisphere, **precipitation has likely increased since 1901**.



- **Ocean:** Ocean warming **dominates the increase in energy stored in the climate system**, accounting for more than 90% of the energy accumulated between 1971 and 2010 with only about 1% stored in the atmosphere.
  - On a global scale, the **ocean warming is largest near the surface**, and the upper 75 m warmed by 0.11°C per decade over the period 1971 to 2010
  - It is very likely that regions of high surface salinity, where evaporation dominates, have become more saline, while regions of low salinity, where precipitation dominates, have become fresher since the 1950s. These regional trends in ocean salinity provide indirect evidence for changes in evaporation and precipitation over the oceans and thus for changes in the global water cycle.
- **Cryosphere:** Over the last two decades, the Greenland and Antarctic ice sheets have been losing mass. Glaciers have continued to shrink almost worldwide. Northern Hemisphere spring snow cover has continued to decrease in extent.
  - Glaciers have lost mass and contributed to sea level rise throughout the 20th century. The rate of ice mass loss from the Greenland ice sheet has substantially increased over the period 1992 to 2011.
  - The annual mean Arctic sea ice extent decreased over the period 1979 to 2012. The rate of decrease was very likely in the range 3.5 to 4.1% per decade. Arctic sea ice extent has decreased in every season and in every successive decade since 1979, with the most rapid decrease in decadal mean extent in summer.
- **Sea Level:** Over the period 1901–2010, global mean sea level rose by 0.19m. The rate of sea level rise since the mid-19th century has been larger than the mean rate during the previous two millennia.
  - About 75% of the observed global mean sea level rise is mainly due to glacier mass loss and ocean thermal expansion from warming, since the early 1970s.
  - Rates of sea level rise over broad regions can be several times larger or smaller than the global mean sea level rise for periods of several decades, due to fluctuations in ocean circulation. Since 1993, the regional rates for the Western Pacific are up to three times larger than the global mean, while those for much of the Eastern Pacific are near zero or negative.

Student Notes:

SPECIAL REPORT ON THE OCEAN AND CRYOSPHERE IN A CHANGING CLIMATE (SROCC) by Intergovernmental Panel on Climate Change (IPCC)

It covers how the ocean and cryosphere have and are expected to change with ongoing global warming.

Focus Area

High-mountain regions

- By the end of the century, glaciers are projected to lose around 18% of their mass compared to 2015 levels under a low-emissions scenario and around a third under a high-emissions scenario.
- Due to a "pronounced imbalance" between current glacier mass and climate, glaciers will continue to melt even with no further climate change.

Sea Ice at the Earth's poles

- Arctic surface air temperatures over the past two decades have increased at more than double the global average. This rapid phenomenon is known as **"Arctic amplification**". In part, it stems from the rapid loss of sea ice cover in the region resulting into decreasing albedo.
- In contrast to the Arctic, the Antarctic continent has seen less uniform air temperature changes over the past 30-50 years, with warming over parts of West Antarctica and no significant overall change over East Antarctica. Multiple factors contribute to this regional variability in Antarctic sea ice extent including the "meridional winds", which flow north-to-south or vice versa.
- Human-caused warming at the surface in Antarctica is delayed by the Southern Ocean circulation, which transports heat downwards into the deep ocean.
- Greenland ice sheet currently losing mass at around twice the rate of its Antarctic counterpart. Melting in Greenland has increased up to five times greater than the level seen in preindustrial times becoming the largest terrestrial contributor to global sea level rise between 2005 and 2016.
- Blooms in phytoplankton occurring earlier in the year and even happening in autumn - a phenomenon rarely observed in Arctic waters previously.

Permafrost

- Permafrost is defined as "ground (soil or rock containing ice and frozen organic material) that remains at or below Zero degrees Celsius for at least two consecutive years". The northern hemisphere has an area of permafrost thrice larger than Antarctica's. There is approximately twice as much carbon in permafrost than is currently in the Earth's atmosphere.
- By 2100, near surface permafrost area will decrease by 2-66% and 30-99% under various projections.
- The stimulated plant growth in permafrost areas - from warmer conditions and CO2 fertilisation could help sequestering new carbon into plant biomass and increasing carbon inputs into the surface soil.

Oceans

- The current rate of Sea Level Rise (SLR) is now larger than the mean rate of the previous two millennia. Human-caused climate change is "very likely" to have been the "dominant cause" of SLR seen since 1970.
- Surface warming combined with a surge in freshwater runoff entering the top layer of the oceans is making the oceans more stratified – meaning the top is less dense than the deeper parts, and there is less mixing between the different levels.
- In general, future increases in stratification will trap nutrients in the ocean interior and reduce upper ocean nutrient levels.
- The areas known as oxygen minimum zones, where only specially adapted organisms can survive, are projected to grow larger in the future as the overall levels of oxygen in seawater drops.

Student Notes:

Depletion of Ozone layer

Formation and breakdown of Ozone

The upper stratosphere consists of considerable amount of ozone (O_3), which protects us from the harmful ultraviolet (UV) radiations (λ 255 nm) coming from the sun. These radiations cause skin cancer (melanoma) in humans. Therefore, it is important to maintain the ozone shield. Ozone in the stratosphere is a product of UV radiations acting on dioxygen (O_2) molecules. The UV radiations split apart molecular oxygen into free oxygen (O) atoms. These oxygen atoms combine with the molecular oxygen to form ozone.

$$O_2(g) \xrightarrow{UV} O(g) + O(g)$$

$$O(g) + O_2(g) \xrightleftharpoons{UV} O_3(g)$$

Ozone is thermodynamically unstable and decomposes to molecular oxygen. Thus, a dynamic equilibrium exists between the production and decomposition of ozone molecules.

In recent years, there have been reports of the depletion of this protective ozone layer because of the presence of certain chemicals in the stratosphere.

The main reason of ozone layer depletion is believed to be the release of chlorofluorocarbon compounds (CFCs), also known as freons. These compounds are nonreactive, non-flammable, non- toxic organic molecules and therefore used in refrigerators, air conditioners, in the production of plastic foam and by the electronic industry for cleaning computer parts etc.

Once CFCs are released in the atmosphere, they mix with the normal atmospheric gases and eventually reach the stratosphere. In stratosphere, they get broken down by powerful UV radiations, releasing chlorine free radical. The chlorine radicals are continuously regenerated and cause the breakdown of ozone. Thus, CFCs are transporting agents for continuously generating chlorine radicals into the stratosphere and damaging the ozone layer.

Ozone Depleting Substances

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

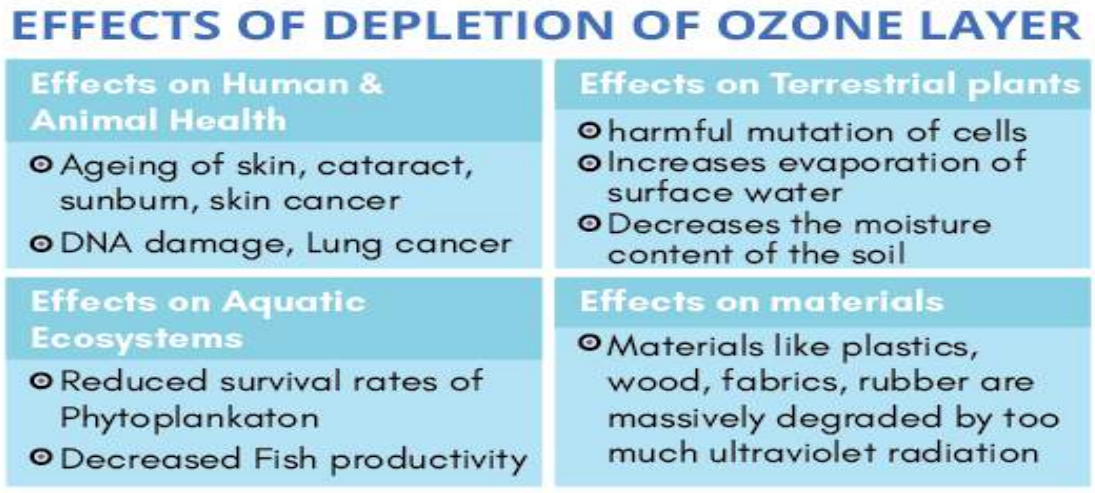
Role of Polar Stratospheric Clouds

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

$$Cl\dot{O}\,(g) + NO_2\,(g) \rightarrow ClONO_2(g)$$
$$\dot{C}l\,(g) + CH_4\,(g) \rightarrow \dot{C}H_3(g) + HCl(g)$$
$$ClONO_2(g) + H_2O\,(g) \rightarrow HOCl\,(g) + HNO_3\,(g)$$
$$ClONO_2(g) + HCl\,(g) \rightarrow Cl_2\,(g) + HNO_3\,(g)$$

When sunlight returns to the Antarctica in the spring, the sun's warmth breaks up the clouds and HOCl and Cl2 are photolysed by sunlight, as given in reactions. The chlorine radicals thus formed, initiate the chain reaction for ozone depletion.

$$HOCl\,(g) \xrightarrow{h\nu} \dot{O}H\,(g) + \dot{C}l(g)$$
$$Cl_2\,(g) \xrightarrow{h\nu} 2\dot{C}l\,(g)$$



16.6. Consequences of Climatic Change

16.6.1. On Hydrological cycle

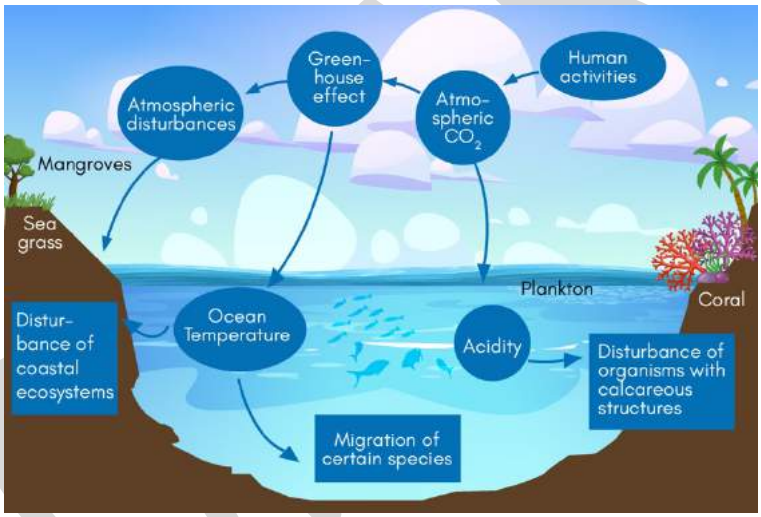
Changes in the hydrological cycle (glacier melts, changes in evapotranspiration, impact on catchment areas etc.) due to climate change can lead to diverse impacts and risks, and they are conditioned by and interact with non-climatic drivers of change (such as population increase, economic development, urbanization, and land use) and water management responses. These impacts are:

- **Reduced availability of water resources**: About 80% of the world's population already suffers serious threats to its water security, as measured by indicators including water availability, water demand, and pollution. Climate change can alter the availability of water and therefore threaten water security.
- **Agriculture:** Water demand and use for food and livestock feed production is governed not only by crop management and its efficiency, but also by the balance between atmospheric moisture deficit and soil water supply. Thus, changes in climate (precipitation, temperature, radiation) will affect the water demand of crops grown in both irrigated and rainfed systems. Rainfed agriculture is vulnerable to increasing precipitation variability. Differences in yield and yield variability between rainfed and irrigated land may increase with changes in climate and its variability.
- **Energy Production:** Climate change affects hydropower generation through changes in the mean annual streamflow, shifts of seasonal flows, and increases of streamflow variability (including floods and droughts), as well as by increased evaporation from reservoirs and changes in sediment fluxes. Therefore, the impact of climate change on a specific hydropower plant will depend on the local change of these hydrological characteristics, as

well as on the type of hydropower plant and on the (seasonal) energy demand, which will itself be affected by climate change. Run-of-river power plants are more susceptible to increased flow variability than plants at dams.

- **Municipal Services:** Higher ambient temperatures, which reduce snow and ice volumes and increase the evaporation rate from lakes, reservoirs, and aquifers. These changes decrease natural storage of water. Moreover, higher ambient temperatures increase water demand, and with it the competition for the resource. Shifts in timing of river flows and possible more frequent or intense droughts, which increase the need for artificial water storage. Higher water temperatures, which encourage algal blooms and increase risks from cyanotoxins and natural organic matter in water sources, requiring additional or new treatment of drinking water.
- **Freshwater Ecosystem:** Freshwater ecosystems have suffered more strongly from human activities than have marine and terrestrial ecosystems. Between 1970 and 2000, populations of freshwater species included in the Living Planet Index declined on average by 50%.

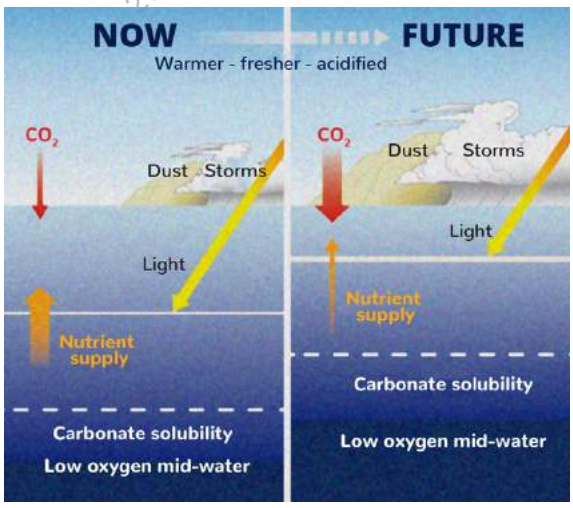
16.6.2. On Oceans



The oceans cover about 71% of Earth's surface to an average depth of 3700 m. Climate controls ocean temperatures, chemistry, circulation, upper ocean stratification, nutrient supply, and sunlight exposure. These drivers affect marine ecosystems through direct effects on organisms, amplified by their changing interactions with other species. Food webs are modified by changes in phytoplankton growth and the availability of live organisms or their decomposing bodies.

16.6.2.1. Ocean warming

The effect of temperature on ecosystems largely result from organismal responses. Organisms respond to temperature driven changes in the physical environment such as stratification, reduced sea ice cover and freshening.



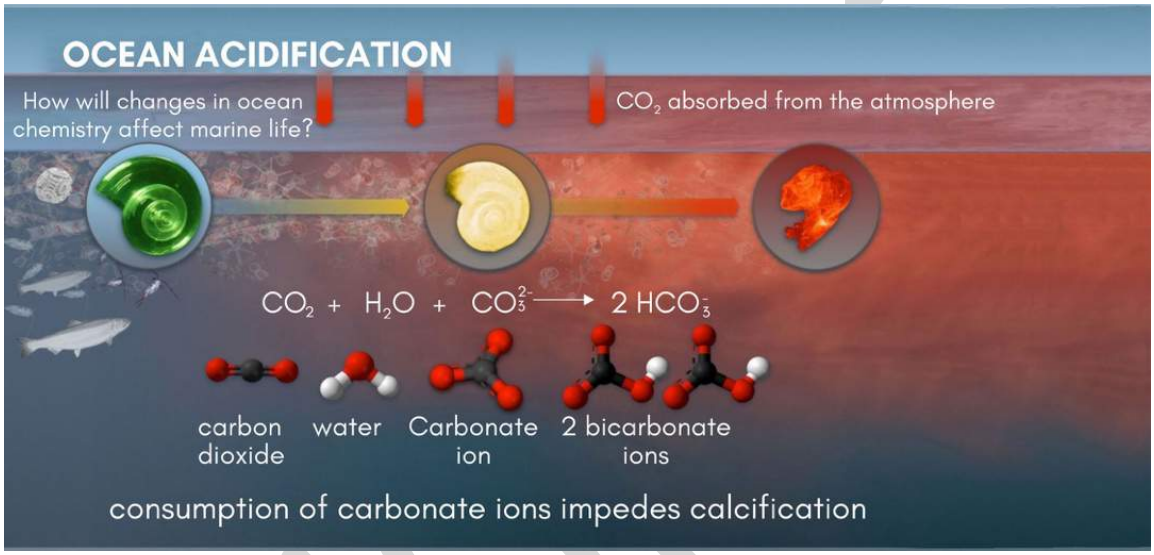
- The ocean has layers of warmer and colder water, saltier or less saline water, and hence less or more dense water. Warming of the ocean and the addition of more freshwater at the surface through ice melt and higher precipitation increases the formation of more stable layers stratified by density, which leads to less mixing of the deeper, denser, and colder nutrient-rich layers with the less dense nutrient-limited layers near the surface. With less mixing, respiration by organisms in the mid-water layers of stratified oceans will produce oxygen-poor waters, so-called oxygen minimum zones (OMZs).
    - A warming ocean may initially enhance the metabolic rates of microbes & stimulate their overall growth. Eventually with warming, the thermal tolerance of some groups will be challenged, leading to the replacement of species.

Student Notes:

- At temperature extremes, oxygen supply capacity becomes constrained in relation to demand, metabolism becomes thermally limited for marine invertebrate & fishes.
- Corals host zooxanthallae, in their tissues, which provide the host with organic carbon from photosynthesis with nitrogen& enables the corals to build and sustain carbonate reefs. High light, rapid salinity changes, and small increases in temperature can trigger Coral Bleaching, the loss of zooxanthallae and tissue colour.

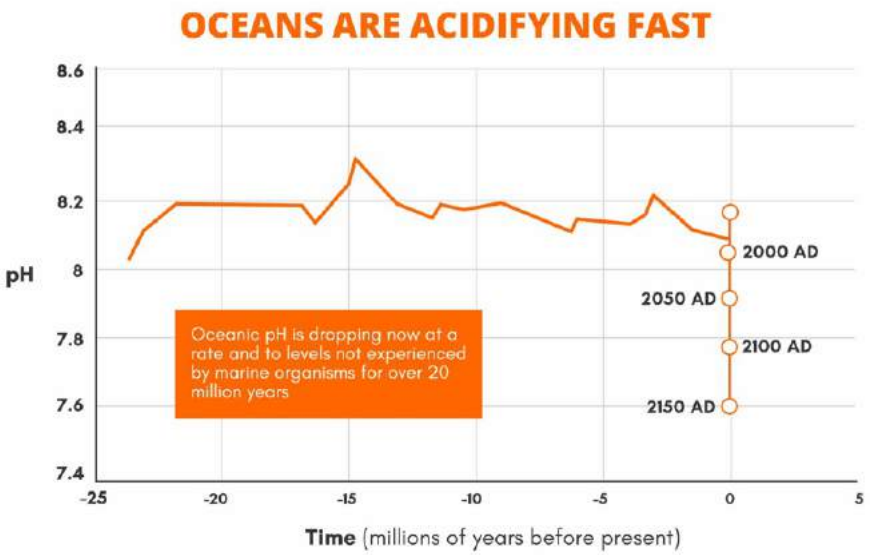
16.6.2.2. Ocean Acidification

One of the major differences in terms of the effect of climate change on the oceans compared to land is ocean acidification. The ocean absorbs over 25% of all anthropogenic emissions from the atmosphere each year. As CO_2 dissolves in sea wa ter it f**orms carbonic acid, thereby decreasing the ocean's pH**, leading to a suite of changes collectively known as ocean acidification.



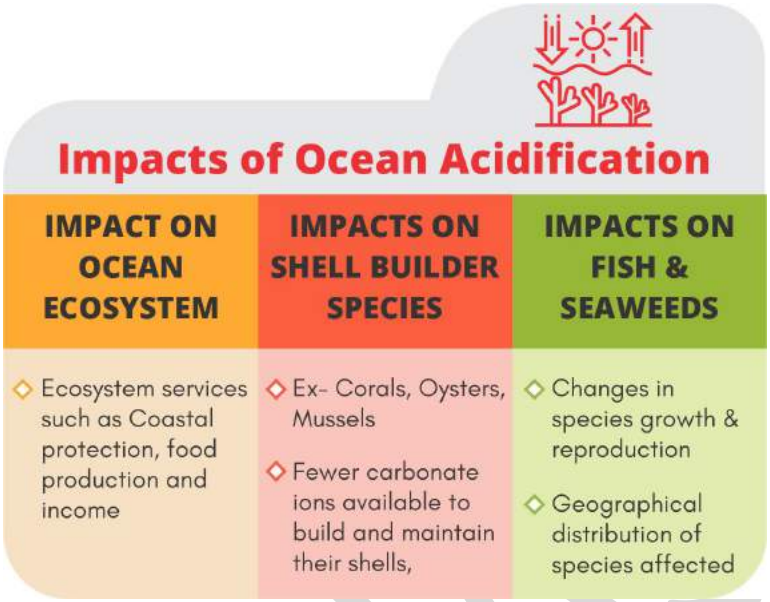
Ocean acidification is happening in parallel with other climate-related stressors, including **ocean warming and deoxygenation**. This completes the set of climate change pressures on the marine environment – heat, acidity and oxygen loss – often referred to as the 'deadly trio'.

Since the beginning of the Industrial Revolution, the pH of surface ocean waters has fallen by 0.1 pH units. Since the pH scale, is logarithmic, this change represents approximately a 30% increase in acidity.



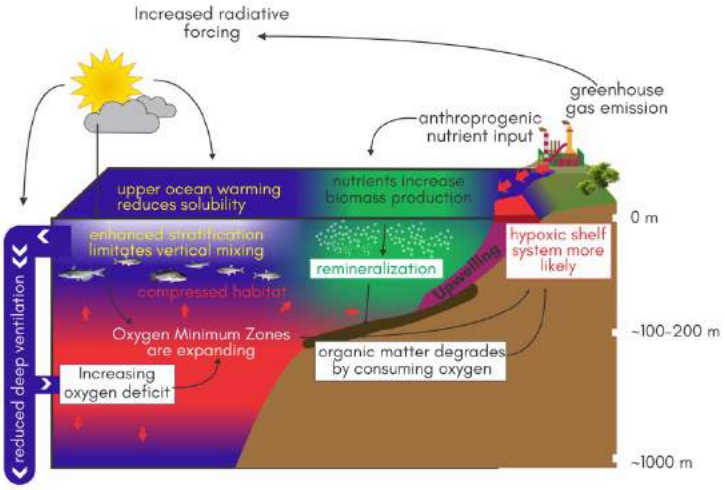
Future predictions indicate that the oceans will continue to absorb carbon dioxide, further increasing ocean acidity. Estimates of future carbon dioxide levels, indicate that by the end of this century the surface waters of the ocean could have acidity levels nearly 150% higher.

This mirrors what is also happening inside organisms once they take up the additional CO_2. Marine species that are dependent on calcium carbonate ($CaCO_3$), such as shellfish, sea stars, and corals, may find it difficult to build their shells and skeletons under ocean acidification. In general, animals living and breathing in water like fish, squid, and mussels have between five and 20 times less CO_2 in their blood than terrestrial animals, so CO_2-enriched water will affect them in different and potentially more dramatic ways than species that breathe in air.



16.6.2.3. Ocean Deoxygenation

Ocean deoxygenation refers to the **loss of oxygen** from the oceans. The **ocean gains oxygen** in the upper layer due to **photosynthesis** by autotrophic organisms and oxygen from the atmosphere **dissolving** in the under-saturated waters.



The **ocean loses oxygen** throughout the whole water column:

- **at the surface**- due to the outgassing of oxygen to the atmosphere in over-saturated waters,
- **from the surface to depths-** due to the respiration of aerobic organisms and oxidation of reduced chemical species.

This equilibrium has been disturbed in the recent decades. The **global ocean oxygen inventory losses** from 1960 to 2010 are close to 2%. Volume of areas depleted of oxygen, known as "**anoxic waters**", have quadrupled. Among the best-known areas subject to low oxygen are the **Baltic Sea** and **Black Sea**.

Causes behind Ocean Deoxygenation

The loss of oxygen in the ocean has **two major causes:**

- **Climate Change:** As the ocean warms due to global warming, it **induces Ocean warming-driven deoxygenation.**
  - Warmer ocean water **holds less oxygen** and is **more buoyant** than cooler water. This leads to **reduced mixing of oxygenated water** near the surface with deeper waters (deeper waters naturally contain less oxygen).
  - This further intensifies with changes in currents and wind patterns.

- Warmer water also **raises oxygen demand** from living organisms (**increases the metabolic rates)**. As a result, less oxygen is available for marine life.
- Warming of bottom waters may result in **enhanced destabilization of methane gas hydrates**, leading to enhanced release of methane from sediments and subsequent aerobic respiration of methane to CO2.

Eastern boundary upwelling systems (EBUS) are one of the ocean's most productive biomes.

- These ecosystems are defined by ocean currents that bring **nutrient rich but oxygen-poor water** to the eastern edges of the world's ocean basins.
- EBUS are key regions for the climate system due to the complex of oceanic and atmospheric processes that connect the open ocean, troposphere and land, and the fact that they host **Oxygen Minimum Zones (OMZs),** responsible for the **world's largest fraction of water column denitrification** and for the **largest estimated emission of the greenhouse gas nitrous oxide**.
- As **naturally oxygen poor systems**, EBUS are especially vulnerable to further changes in global ocean deoxygenation and so what happens to the oxygen content of EBUS will ultimately ripple out and affect many hundreds of millions of people.

- **Nutrient pollution (Eutrophication)-** It causes oxygen loss in coastal waters as fertiliser, sewage, animal and aquaculture waste cause excessive growth of algae, which in turn deplete oxygen as they decompose.

The main **features of a coastal area** that becomes deoxygenated are:

- **high biological production** from over-enrichment by high nitrogen and phosphorus loads;
- a **stratified water column** from salinity, temperature or both, mostly in water depths < 100 m; and
- **long water residence time** allows for development of phytoplankton blooms, containment of fluxed organic matter and the development of stratification.

Impact

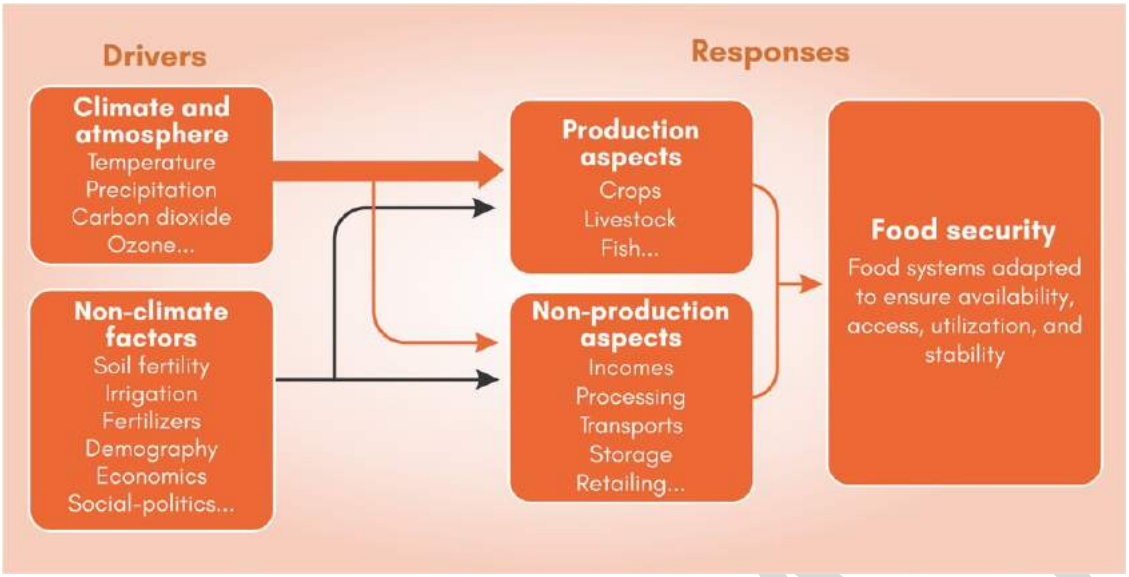
- **On Climate Change**- decreasing oxygen concentrations will increase greenhouse gas emission with increased release of methane and N2O.
- **On Feedback mechanisms**- Oxygen loss is directly related to carbon and other nutrient cycles in the sediments.
  - e.g. The **recycling of phosphorus (P) in marine systems is enhanced** when oxygen in sea water is low. The resulting increased availability of phosphorous can further enhance productivity and, upon sinking of the organic matter, enhance the oxygen demand in deeper waters. This positive feedback-loop between productivity, oxygen loss and increased P availability can contribute to further deoxygenation.

16.6.3. On Food Security and Food Production System

Food Security is dependent on access and consumption patterns, food utilization & nutrition, & overall stability of the system as much as food production & availability.

Climate Change impacts on Access: Change in the levels and volatility of food prices is a key determinant of food access. Climate change will be a contributing factor to food price increase and hence its affordability, the vulnerability of households to reduced food access depends on their channel of food access.

Climate Change impacts on stability: Increased incidence of climate extremes reduces incentives to invest in agricultural production. It may lead to greater emphasis on low-return but low-risk subsistence crops, a lower likelihood of applying purchased inputs such as fertilizer, a lower likelihood of adopting new technologies, lower investments. All of these responses generally lead to both lower current and future farm profits.



Climate Change impacts on utilization: Climate change impacts on utilization may come about through changes in consumption patterns, as well as changes in nutrient content of food and food safety. The effects are a decrease in dietary quality as well as quantity, which are magnified by pre-existing vulnerabilities and lead to long term loss of health, productivity capacity, and low incomes.

Climate change impacts on Food production: Increase of atmospheric CO2 by greater than 100 ppm since preindustrial times has enhanced water use efficiency and yields, especially for crops such as wheat & rice, although these benefits played a minor role in driving overall yield trends.

However, the **Special Report On Climate Change And Land (SRCCL) by Intergovernmental Panel on Climate Change (IPCC)** points out that there will be reduction in nutritional quality of staple crops- due to increased atmospheric concentrations of carbon dioxide (CO_2).

Emissions of CO_2 often are accompanied by O_3 that harms crop yields. Impacts are more severe over India & China. For the major crops (wheat, rice, and maize) in tropical and temperate regions, climate change without adaptation will negatively impact production for local temperature increases of 2°C or more above late-20th-century levels, although individual locations may benefit.

Climate change impacts on Fisheries production: There is high probability that climate change will impact on fisheries production with significant negative impacts particularly for developing countries in tropical areas, while more northerly, developed countries may experience benefits.

Climate change impacts on livestock: It will include effects on forage and feed, direct impacts of changes in temperature and water availability on animals, and indirect effects via livestock diseases.

16.6.4. On Population Displacement and Human Mobility

- Various studies have pointed out that disasters due to climate change have been displacing more people than conflicts. This phenomenon is being **referred to as Environmental Migration.**
- According to Global Report on Internal Displacement (GRID, 2019), in 2018, of the total **new 28 million internally displaced people** in 148 countries, **61% were due to disasters (such as** floods, windstorms, earthquakes or droughts) as compare to 39% due to conflict and violence.
- In **India**, climate change led to the displacement of 2.7 million Indians in 2019 (highest in the world).

Student Notes:

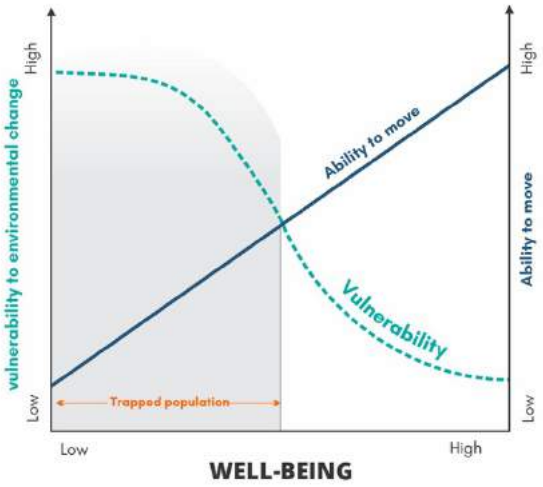
- The United Nations High Commissioner for Refugees (**UNHCR**) predicts that in the next 50 years between **250 million and 1 billion** humans will leave their homes because of climate change.

How climate change affect the movement of people and their living conditions?

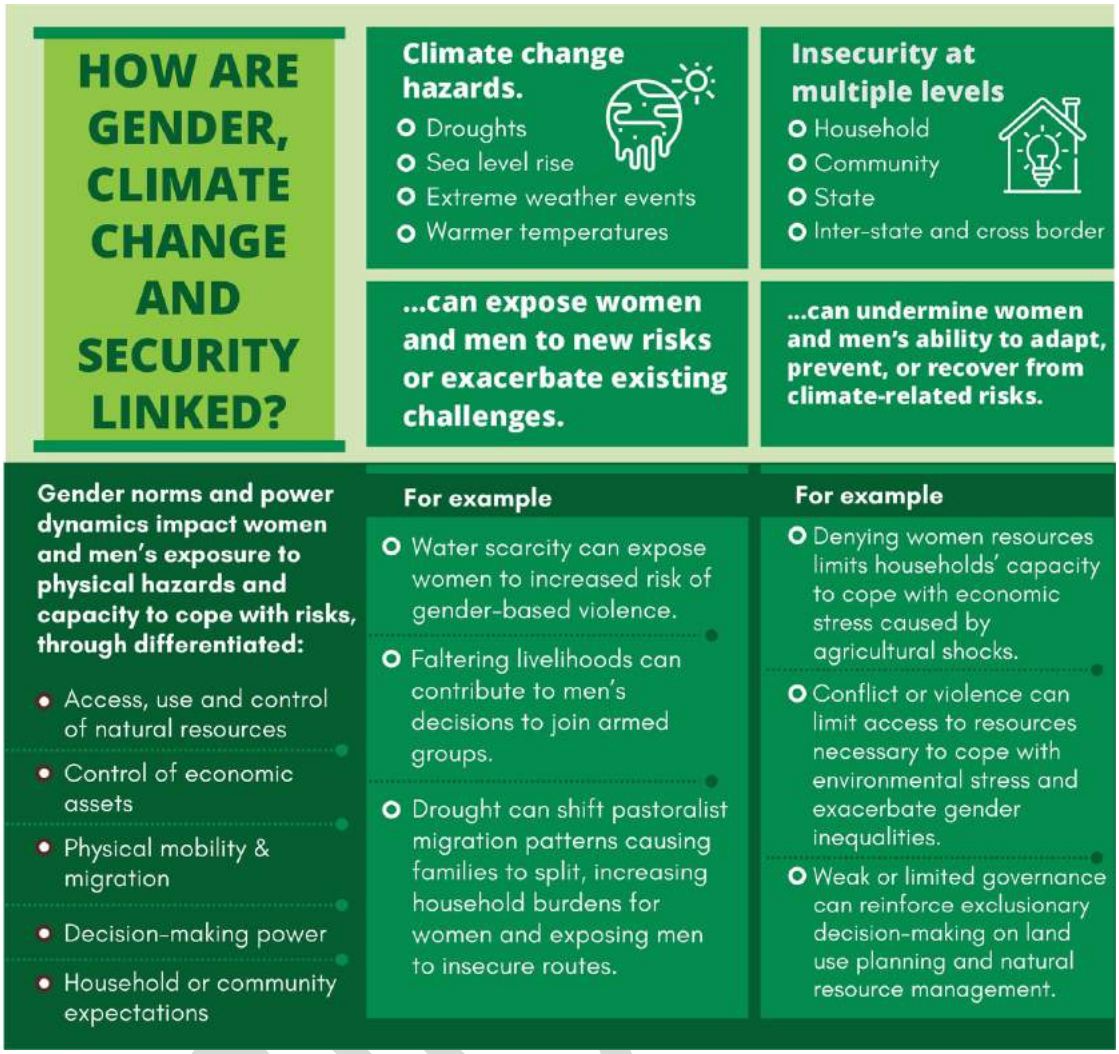
- **Higher risk of humanitarian emergencies** due to greater frequency and intensity of weather-related natural disasters.
- **Rising sea levels** may make coastal areas and low-lying islands uninhabitable.
- **Competition over shrinking natural resources** may exacerbate tensions.
- **Exacerbate pre-existing vulnerabilities**: When household income in rural areas decreases, livelihood stress linked to climate change could, in some places, result in lower levels of outmigration. As migration requires resources, those people wanting to move but could not due to lack of resources become **trapped populations**.

International Conventions on Environmental Migrants

- **New York Declaration for Refugees and Migrants, UNHCR (2016):** It seeks to protect the human rights of all refugees and migrants, regardless of their status.
- **The Global Compact on safe, orderly and regular migration,2018:** It is the first-ever UN global agreement on a common approach to international migration in all its dimensions. 'Climate refugees', migrants who move due to natural disasters and climate change, are now recognised under its Objective.
  - Recently, to advance its objectives **Global Refugee Forum (GRF)** was held in Geneva, Switzerland.
- **The Peninsula Principles on Climate Displacement Within States (2013):** The Principles provide a comprehensive normative framework, based on principles of international law, human rights obligations and good practice, within which the rights of climate displaced persons within States can be addressed.
- **Nansen Initiative Protection Agenda for Cross-Border Displaced Persons (2015):** It's a state-led consultative process to build consensus on a protection agenda addressing the needs of people displaced across borders in the context of disasters and the effects of climate change.
- **Platform on Disaster Displacement (2016):** It was launched to implement the recommendations of the **Nansen Initiative Protection Agenda**.
- **Climate Migrants and Refugees Project:** It aims to spread the word about this challenge, its potential impacts, and to seek out solutions and connections that will help the people most threatened by climate change live safe, dignified, and prosperous lives.



Climate migration discussions should not lose their focus on preventive measures. The **Paris Agreement offers anchorage for climate action** that considers human mobility to avert, minimize and address displacement in the context of climate change. **Full use of all already existing bodies of laws and instruments** such as highlighted already in the 2011 International Dialogue on Migration and the recently adopted Global Compact for Safe, Orderly and Regular Migration. **Human rights-based approaches are key for addressing climate migration. Regular migration pathways** can provide relevant protection for climate migrants and facilitate migration strategies in response to environmental factors.



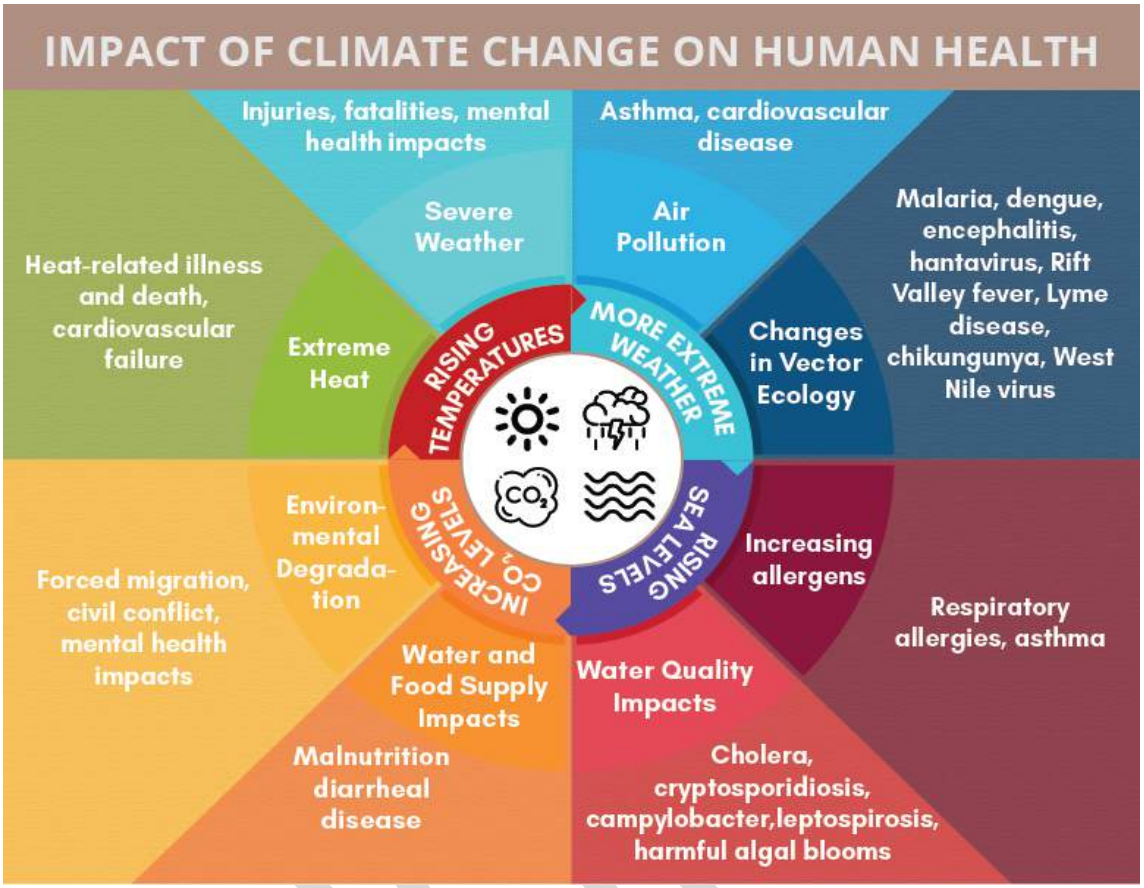
- Women can (and do) play a **critical role** in response to climate change due to **their local knowledge** of resources and leadership in e.g. **sustainable resource management** and/or leading **sustainable practices at the household and community level.**
- Parties to the UNFCCC have recognized the importance of involving women and men equally in UNFCCC processes and in the development and implementation of **national climate policies that are gender-responsive** by establishing a dedicated agenda item under the Convention addressing issues of gender and climate change and by including overarching text in the Paris Agreement.
- **Lima Work Programme on Gender** (COP-2014) aims to advance implementation of gender responsive climate policies and mandates across all areas of the negotiations.

16.6.5. On Human Health

The World Health Organization (WHO) estimates that climate change may have caused more than 150,000 deaths in the year 2000 alone, with an increase in deaths likely in the future.

- Warming of regions would allow disease-carrying insects, animals and microbes to survive in areas where they were once blocked by cold weather.
- Studies indicate that climate change may seriously **compromise human health particularly among children and the elderly.** Higher temperatures, extreme weather events, and higher climate variability could **elevate risk of heat strokes, cardiovascular and neurological diseases, and stress-related disorders.**
- Heat stress in urban areas is often compounded by the **heat island effect.** Warmer, higher moisture conditions, on average, are also **more favourable for the spread of vector-borne diseases** such as malaria and dengue fever.

- In addition, a decrease in the availability or affordability of food and potable water caused by climate change may lead to **reduced nutritional intake, particularly among economically weaker sections.**



16.6.6. On Economy

If no action is taken to curtail the global carbon emissions, **climate change could cost around 5 to 20 percent of the annual global gross domestic product**, in comparison, it would take 1 percent of GDP to lessen the most damaging effects of climate change.

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

- A recent report of the World Bank found that climate change could effectively negate economic progress, pushing **45 million Indians into extreme poverty** over the next 15 years.
- Climate change may significantly alter shoreline habitats and cost millions for the **relocation of ports and shore infrastructure.** The value of global assets exposed to sea level rise is projected to be between $6-$9 trillion or 12-20% of the global GDP.
- Globally, more intense hurricanes and downpours could **cause billions of dollars in damage to property and infrastructure.**
- High sea temperatures also threaten the **survival of coral reefs**, which generate an **estimated $375 billion per year in goods and services.**

Student Notes:

16.6.7. On Energy infrastructure and supply

Rising temperatures are likely to **increase energy demand for space cooling**, which if met by thermal power would further add to the global warming by increasing GHG emissions.

In addition, thermal power plants require substantial amounts of water for cooling to generate electricity. A rise in water withdrawal by power plants would **directly compete with water withdrawal for agriculture and domestic consumption,** particularly in water stressed areas.

On the other hand, **power plants sited around the coast** that use sea water for cooling are **vulnerable to damage** from sea-level rise, cyclones, and storm surge.

16.6.7.1. India Cooling Action Plan—a 20 year road map (From 2018 to 2038)

- India's **per capita space cooling consumption** is nearly 1/4th of global average consumption. (Global average-272kWh whereas India's 69 kWh).
- However, according to recent report, the current technology used in conventional cooling systems in air conditioners and refrigerators, coupled with an increasing demand for such appliances and rising global temperatures, could spur a 64 % increase in household energy use and produce over 23 million tonnes of carbon emissions by 2040.
- This presents an urgent need (for India and other tropical countries) to develop a sustainable plan addressing both concerns.

Key targets of ICAP

- Reduce cooling demand across sectors by 20% to 25% by 2037-38.
- Reduce refrigerant demand by 25% to 30% by 2037-38,
- Reduce cooling energy requirements by 25% to 40% by 2037-38,
- Recognize "cooling and related areas" as a thrust area of research under national S&T Programme,
- Training and certification of 100,000 servicing sector technicians by 2022-23, synergizing with Skill India Mission

About Cooling Action Plan

- **India** is one of the first countries in the world to develop a **comprehensive** 'Cooling Action Plan', to fight ozone layer depletion adhering to the Montreal Protocol.
- It provides an **integrated vision**:
  - To address the cooling requirement across different sectors of the economy such as residential and commercial buildings, cold-chain, refrigeration, transport and industries.
  - To lists out actions which can help reduce the cooling demand, enhancing energy efficiency and better technology options.

Key actions included under ICAP

- **Cooling buildings naturally through better design:** Passively cooled building designs with natural and mechanical ventilation.
- Adopting **comfortable range of thermostat** set-points in commercial buildings as well as for affordable housing projects under the Pradhan Mantri Aawas Yojana for economically weaker sections.
- **Improving efficiency of cooling appliances**: The plan makes ACs a focus area as the majority of energy consumption in space cooling is by room air-conditioners. A drive for **widespread adoption** of **5-star labelled** fans and room air conditioners in new and existing public buildings.

Key Benefits of ICAP

- **Thermal comfort for all** – Provision for cooling for Economically Weaker Sections and Low Income Group's housing.
- **Sustainable cooling** – Reducing both direct and indirect Green House Gases **emissions** related to cooling.
- **Doubling Farmers Income** – Through better cold chain infrastructure–less wastage of produce leading to better value of produce to farmers.
- **Skilled workforce** by creating jobs in service sector. For example- Skilling of AC and refrigerator service technicians.
- **Make in India** – domestic manufacturing of air-conditioning and related cooling equipment's,
- **Robust R&D** on alternative cooling technologies to provide push to innovation in cooling sector.

- **Reducing cost** of efficient air-conditioning through public procurement schemes.
- **Skilling and certifying** AC and refrigerator service technicians.
- Promoting **renewable energy-based** energy efficient cold chains
- Investing in **research and development (R&D)** of refrigerant gases that do not harm or warm the planet.

16.6.8. On Urban Areas

Climate change will lead to increased frequency, intensity, and/or duration of extreme weather events such as heavy rainfall, warm spells and heat events, drought, intense storm surges, and associated sea level rise. Several urban aspects of these changes are described below.

Urban temperature variation: Increased frequency of hot days and warm spells will exacerbate urban heat island effects, causing heat-related health problems and, possibly, increased air pollution, as well as an increase in energy demand for warm season cooling. Conversely, widespread reduction in periods of very cold weather will mean a decline in heating demands and potential reduction in mortality from cold waves.

Drought and water scarcity: Drought can have many effects in urban areas, including increases in water shortages, electricity shortages (where hydropower is a source), water-related diseases (through use of contaminated water), and food prices and food insecurity from reduced supplies. These may all contribute to negative economic impacts and increased rural to urban migration.

Coastal flooding, sea level rise: Rising sea levels, the associated coastal and riverbank erosion, or flooding in conjunction with storm surge could have widespread effects on populations, property, and coastal vegetation and ecosystems, and present threats to commerce, business, and livelihoods.

Inland flooding: Heavy rainfall and storm surges would impact urban areas through flooding, which in turn can lead to the destruction of properties and public infrastructure, contamination of water sources, water logging, loss of business and livelihood options, and increase in water-borne and water-related diseases.

Urban Heat Islands (UHI)

The major factors responsble for UHI:

- **Direct pollution:** From various sources of heat in city from fires, industry, home, agriculture burning in surround areas.
- **Absorption of heat:** Heat conserving properties of the bricks, fabric and concrete materials of the city.
- **Urban geometry:** The height and spacing of buildings affects the amount of radiation received and emitted by urban infrastructure. The tall buildings within many urban areas provide multiple surfaces for the reflection and absorption of sunlight, increasing the intensity with which urban areas are heated.
- **Blanketing effect** by atmospheric pollution on outgoing radiation
- **Lack of vegetation** in urban region reduces the natural cooling effect from the shade and evapotranspiration.

Effects of UHI on urban areas

- **Increase in demand for Energy**: Increased temperatures during summer in cities amplify energy demand for air conditioning contributing to higher electricity consumption.
- **Increase in greenhouse gas emissions and air pollution**: Increased energy demand increases the production of energy from fossils fuels and thermal power plants leading to air pollution in surrounding areas.
- **Discomfort and danger to human health**: Health is impacted due to general exhaustion, heat strokes, heat cramps, headaches and respiratory problems.

- **Secondary impacts on weather and climate:** This includes changes of local wind patterns, formation of fog and clouds, precipitation rates and humidity. The unusual heat can lead to intense vertical movement of air leading to thunderstorms and precipitation
- **Impact on Plants, Forest and animals**: High temperatures may create disturbances on biological life of plants

How to counter UHI effect from the region?

- **Use of light-colored concrete and white roofs**: to increase the albedo.
- **Use of green roofs**: The roof of a building is partially or completely covered with vegetation which absorbs rainwater; provides insulation helping to lower urban air temperatures.
- **Construction of green buildings**: These should be constructed in a manner that is resource-efficient, environmentally sustainable. For e.g.: Efficient use of sun light within the building to lower the overall energy usage of the building thus reducing the effect of UHI.
- **Planting trees in cities**: Trees provide shade, absorb carbon dioxide, release oxygen and fresh air, and provide a cooling effect.
- **Improvement in technologies and infrastructure**: By promoting fuel efficiency to reduce the emission. Adhering to higher standards of emission norms like Bharat Stage VI.

16.6.9. On Rural Areas

Climate change in rural areas will take place against the background of the trends in demography, economics, and governance that are shaping those areas.

Economic base and Livelihood: Climate change will affect rural livelihoods, or "the capabilities, assets (stores, resources, claims, and access) and activities required for a means of living". Rural livelihoods are dependent on natural resources (e.g., agriculture, fishing, and forestry), and their availability will vary in a changing climate. This will have effects on human security and wellbeing.

Infrastructure: River flooding and sea level rise will produce temporary loss of land and land activities, and damage to transportation infrastructure particularly on coastal areas. Flooding events may cause sediment transport and damage roads and bridges as well as affecting reservoir storing capacity. Importantly, in rural areas usually there are few alternatives once a road is blocked and that may increase vulnerability of rural areas when facing extreme hydro-climatological events that impact transportation infrastructure.

Spatial and Regional Interconnections: It is difficult to establish a causal relationship between environmental degradation and migration. Many authors argue that migration will increase during times of environmental stress, and will lead to an increase in abandonment of settlements.

Knowledge: Rural areas are increasingly exposed to diffusion of knowledge through migration, trade and investment flows, technology transfers, and improved communication and transport facilities, although differentials on knowledge access and diffusion (e.g., access to high speed Internet) between rural and urban areas remain, even in high income countries. Future impacts of climate change on these channels of integration will affect the pace and intensity of knowledge transfers.
If trade, migration, and investment flows will be intensified as a result of climate change, this will have a positive impact on knowledge transfer both from and to rural areas.

16.7. Changes in Climate in the Indian region

India is a vast country with many climate zones. The regional climate over the Indian subcontinent involves **complex interactions of the atmosphere–ocean– land–cryosphere system** on different space and time scales. In addition, **anthropogenic activities** have influenced the regional climate in recent decades. In a **first ever attempt** to document and assess climate change in different parts of India, Ministry of Earth Sciences' (MoES) has come up with the report titled '**Assessment of Climate Change over the Indian Region'**. As per the report, following are the observed and projected changes in various climatic dimensions over the Indian region:

Temperature Rise	• India's average temperature has **risen by around 0.7°C during 1901–2018**
	• By the end of the twenty-first century, relative to the recent past (1976–2005 average) it is projected-
	  o Average temperatures **to rise by approximately 4.4°C**.
	  o frequency of summer (April–June) **heat waves over India is projected to be 3 to 4 times higher**
	  o Amplification of heat stress is expected across India, particularly over the Indo-Gangetic and Indus river basins.
	• **Causes:** The surface air temperature changes over India are attributed mostly by greenhouse gases and partially offset by other anthropogenic forcing including aerosols and LULC change.

Sea-level rise in the North Indian Ocean (NIO)	• While, the major contribution to global mean sea-level rise is from glacier melt, thermal expansion (thermosteric) has dominated sea-level rise in the NIO. The NIO rose at a rate of 3.3 mm year during 1993–2017 against a rate of 1.06–1.75 mm per year during 1874–2004. The water along India's coasts is expected to rise by 20-30 cm by 2100. • **SST of the tropical Indian Ocean has risen by 1°C on average** during 1951–2015, markedly higher than the global average SST warming of 0.7°C. • **Causes:** Sea-level rise of the NIO during the recent 3–4 decades are closely linked to the weakening trend of summer monsoon winds and the associated slowdown of heat transport out of the NIO.
Change in Rainfall pattern	• **Summer monsoon rainfall (June to September) over India** which contribute to more than 75% of the annual rainfall has **declined by 6%** between 1951-2015 especially in the densely populated Indo-Gangetic plains and the Western Ghats. • The **frequency of localized heavy rain occurrences has significantly increased** by 75% during 1950–2015. • Monsoon onset dates are likely to be early or not to change much, and the monsoon retreat dates are likely to be delayed, resulting in lengthening of the monsoon season. • **Causes:** Global-scale anthropogenic forcing such as GHGs as well as regional-scale forcing such as aerosols and LULC changes i.e. increasing urbanisation.
Floods	• Flooding events over India have also **increased since 1950**, in part due to enhanced occurrence of localized, short-duration intense rainfall events. • Flooding occurrences due to intense rainfall are projected to increase in the future. • Higher rates of glacier and snowmelt in a warming world would enhance stream flow and compound flood risk over the Himalayan river basins. The Indus, Ganga and Brahmaputra basins are considered particularly at risk of enhanced flooding in the future in the absence of additional adaptation and risk mitigation measures.
Droughts	• The **area affected by drought has increased by 1.3% per decade** over the the last 6–7 decades. • Climate model projections indicate a **high likelihood of increase in the frequency (>2 events per decade), intensity and area under drought** conditions in India by the end of the twenty-first century. • **Causes:** increased variability of monsoon precipitation and increased water vapour demand in a warmer atmosphere that tend to decrease soil moisture content.
Tropical Cyclonic Storms	• The intensity of tropical cyclones (TC) is closely **linked to ocean SST and heat content**. • There has been a significant **reduction in the annual frequency of tropical cyclones over the NIO** basin since the middle of the twentieth century (1951–2018). In contrast, the **frequency of very severe cyclonic storms (VSCSs) during the post-monsoon season has increased** significantly (+1 event per decade) during the last two decades (2000–2018). • Climate models **project a rise in the intensity of tropical cyclones** in the NIO basin during the twenty-first century.

Himalayan Cryosphere	• The Hindukush Himalayas (HKH) (largest area of permanent ice cover outside the North and South Poles, also known as the 'Third Pole') underwent **rapid warming at a rate of about 0.2^{O}C per decade** during the last 6–7 decades. Higher elevations of the Tibetan Plateau (> 4 km) experienced even stronger warming in a phenomenon alluded to as **Elevation Dependent Warming.** With continued global warming, the **temperature in the HKH is projected to rise by about 5.2°C** during the twenty-first century. • The HKH experienced a **significant decline in snowfall and glacial area** in the last 4–5 decades. With continuing warming, climate models project a continuing decline in snowfall over the HKH during the 21st century. • The Kathmandu-based International Centre for Integrated Mountain Development's (ICIMOD) "Hindu Kush Himalaya Assessment" reveals that **more than one-third of the glaciers in the region could retreat by 2100, even if the global temperature rise is capped at 1.5ºC.**

Some Implications of changing climate over various regions of India

Food Security: Due to lack of irrigation, a large number of farmers are dependent on monsoon rainfall to practice agriculture (between 50 to 60% of Indian agriculture is rainfed, without access to any form of irrigation).

- Rising temperatures, heat extremes, floods, droughts and increasing year-to-year rainfall variability can disrupt rainfed agricultural food production and adversely impact crop yield. Example- As per the NITI Aayog document, of the total pulses, oilseeds & cotton produced in the country, 80% pulses, 73% oilseeds and 68% cotton come from rain-fed agriculture.
- Ocean warming has reduced the abundance of some fish species by killing parts of the coral reefs they depend on.

Water security: The growing propensity for droughts & floods because of changing rainfall patterns would be detrimental to surface and groundwater recharge.

- Also, the rising sea level leads to intrusion of saltwater in the coastal aquifers contaminating the ground water. E.g. in Gujarat, Tamil Nadu, and Lakshadweep etc.
- Declining trend in snowfall and retreat of glaciers in HKH region may impact the water supply in the major rivers and streams including the Indus, Ganges, and Brahmaputra

Damage to coastal infrastructure

- Potential coastal risks include loss of land due to increased erosion, damage to coastal projects & infrastructure such as buildings, roads, monuments, and power plants, salinization of freshwater supplies and a heightened vulnerability to flooding. Damage to coastal infrastructure.
- For example, higher sea levels and receding coastlines escalate the destructive potential of storm surge associated with cyclonic storms that may be additionally compounded by land subsidence occurring in parts of the country due to factors such as the declining water table depth.

Social Issues

- Large scale migration induced due to climatic disasters such as droughts, cyclones and floods cause social distress at the source and destination places. This reflects into unorganised nature of jobs, slums in urban areas and also social tensions.
- According to World Migration Report 2020 released by the UN, Climate change displaced 2.7 million Indians in 2018. Report also highlights that the largest new internal displacements in Asia resulted from disasters
- Moreover, repeated crop failures add to the burden of already distressed farmers who then resort to suicides.

Cascading of climatic hazards-

- Multiple negative climate events when acting in tandem could create an extreme situation.
- For instance, a region may experience an abnormally long or intense summer heat wave followed by intense monsoon floods that alternate with lengthening dry spells.

Student Notes:

16.8. UPSC Previous Year's Questions

Student Notes:

Prelims

2011

1. The formation of ozone hole in the Antarctic region has been a cause, of concern. What could be the reason for the formation of this hole?

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

Answer: (b)

2. Consider the following:

1. Photosynthesis
2. Respiration
3. Decay of organic matter
4. volcanic action

Which of the above add carbon dioxide to the carbon cycle on Earth?

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

Answer: (c)

2012

1. The increasing amount of carbon dioxide in the air is slowly raising the temperature of the atmosphere, because it absorbs

(a) the water vapour of the air and retains its heat
(b) the ultraviolet part of the solar radiation
(c) all the solar radiations
(d) the infrared part of the solar radiation

Answer: (d)

2. What would happen if phytoplankton of an ocean is completely destroyed for some reason?

1. The ocean as a carbon sink would be adversely affected.
2. The food chains in the ocean would be adversely affected.
3. The density of ocean water would drastically decrease.

Select the correct answer using the codes given below:

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

Answer: (a)

3. Consider the following statements:

Chlorofluorocarbons, known as ozone-depleting substances, are used.

1. in the production of plastic foams
2. in the production of tubeless tyres
3. in cleaning certain electronic components
4. as pressurizing agents in aerosol cans

Which of the statements given above is/are correct?

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

Answer: (d)

Student Notes:

4. The acidification of oceans is increasing. Why is this phenomenon a cause of concern?
1. The growth and survival of calcareous phytoplankton will be adversely affected.
2. The growth and survival of coral reefs will be adversely affected.
3. The survival of some animals that have phytoplanktonic larvae will be adversely affected.
4. The cloud seeding and formation of clouds will be adversely affected.

Which of statements given above is / are correct?
(a) 1,2 and 3 only (b) 2 only (c) 1 and 3 only (d) 1,2,3 and 4

Answer: (d)

2014

1. The scientific view is that the increase in global temperature should not exceed 2°C above pre-industrial level. If the global temperature increases beyond 3°C above the pre-industrial level, what can be its possible impact/impacts on the world?
1. Terrestrial biosphere tends toward a net carbon source.
2. Widespread coral mortality will occur.
3. All the global wetlands will permanently disappear.
4. Cultivation of cereals will not be possible anywhere in the world.

Select the correct answer using the code given below.
(a) 1 only (b) 1 and 2 only (c) 2, 3 and 4 only (d) 1, 2, 3 and 4

Answer: (b)

2. Which of the following adds/add carbon dioxide to the carbon cycle on the planet Earth?
1. Volcanic action
2. Respiration
3. Photosynthesis
4. Decay of organic matte

Select the correct answer using the code given below.
(a) 1 and 3 only (b) 2 only (c) 1, 2 and 4 only (d) 1, 2, 3 and 4

Answer: (c)

3. What is Greenhouse Gas Protocol?
(a) It is an international accounting tool for government and business leaders to understand, quantify and manage greenhouse gas emissions
(b) It is an initiative of the United Nations to offer financial incentives to developing countries to reduce greenhouse gas emissions and to adopt eco-friendly technologies
(c) It is an inter-governmental agreement ratified by all the member countries of the United Nations to reduce greenhouse gas emissions to specified levels by the year 2022
(d) It is one of the multilateral REDD+ initiatives hosted by the World Bank

Answer: (a)

2019

1. Consider the following:
1. Carbon monoxide
2. Methane
3. Ozone
4. Sulphur dioxide

Which of the above are released into the atmosphere due to the burning of crop/biomass residue?
(a) 1 and 2 only (b) 2, 3 and 4 only
(c) 1 and 4 only (d) 1,2,3 and 4

Answer: (d)

16.9. UPSC Previous Years Mains Questions

1. How does the cryosphere affect global climate? 2017
2. 'Climate Change' is a global problem. How India will be affected by climate change? How Himalayan and coastal states of India will be affected by climate change? 2017
3. Bring out the relationship between the shrinking Himalayan glaciers and the symptoms of climate change in the Indian sub-continent. 2014
4. The impact of climate change on water resources in India. 2011

16.10. Vision IAS Previous Years Test Series Questions

1. Explain the role of Himalayas in influencing the climate of South Asia. Enumerate the changes observed recently in the Himalayan region with respect to climate and geomorphology. What are the possible anthropogenic causes behind them?

Approach:

- Explain the climatic influence of Himalayas w.r.t. rainfall regime and temperature.
- Mention the climatic changes w.r.t. warm weather, rainfall pattern and geological changes w.r.t. increasing height, seismicity, river course, etc.
- List the anthropogenic causes such as dams, global warming.

Answer:

Significance of Himalayas in influencing the climate of South Asia:

- Divide the Sub-Tropical jet stream into northern and southern branches. Only after withdrawal of southern branch does the high pressure system recedes and the monsoon advances.
- Intercept the summer monsoon winds and cause rainfall.
- They also prevent the cold continental air masses of Central Asia from entering into India. Thus it prevents India from becoming a Cold-desert.
- Snowfall in the Himalayas causes cold waves in North India.

Changes observed in climate and geomorphology:

- Average annual temperature has increased in the foothills, middle mountains as well as the higher Himalayas in the past few years.
- Total annual precipitation changes are quite variable, decreasing at one site and increasing at a site nearby, indicating erratic nature of rainfall.
- Reduced snowfall in frequency and amount has caused reduction in extent and duration of snow cover and in flow of rivers.
- Tree lines have been moving to higher elevation due to increasing temperature.
- Diversion of rivers has affected natural flows.
- Frequency of hazardous events such as cloud bursts, breach of glacial dammed lakes as well as seismicity has increased.

Anthropogenic causes behind the change in climate in Himalayas:

- Greenhouse gases induced Global warming is the most important cause of erratic climatic changes.
- Deposition of soot and aerosols near the ground has significantly impacted the albedo, such as in Tibetan glaciers.
- Multiple dams, such as those by China on the Tsangpo or by India on tributaries of Ganga/Yamuna/Indus in the Himalayan region have affected flow of rivers in the area. While dams do act as a buffer to absorb excess water flows, they seriously impact water ecology. Unintended releases can also cause floods in downstream areas. Besides, seepage of water causes loosening of rocks and can cause Earthquakes.

Student Notes:

2. Global warming would not only result in change in global climate but will also adversely impact biodiversity, global food production, global health and world politics. Comment.

Approach:

- Explain the meaning of global warming.
- Then bring out various effects of global warming on global climate, biodiversity, global food production, global health and world politics.

Answer:

Global warming can be defined as a gradual increase in the overall temperature of the earth's atmosphere generally attributed to the greenhouse effect caused by increased levels of carbon dioxide, CFCs, and other pollutants. Global warming may have wider adverse effects. These can be:

Effect on global climate

- Increased frequency of heavy precipitation, draught, increased wind speed prolonged heat waves and cold waves; shift in seasons may lead to catastrophic damages.
- It will also modify ocean current circulations and air circulation leading to change in local climates.

Impact on biodiversity

- Approximately 20-30% species assessed so far are likely to be at increased risk of extinction, if increase in global average temperature exceeds 1.5-2.5 degree Celsius.
- There will be huge migration of fauna and flora to newer areas
- Acidification of ocean due to increased Carbon Dioxide will lead to decrease the phytoplankton leading to increased vulnerability of marine biodiversity.
- Melting of glaciers will lead to rise in sea level threatening species living in deltas and mangroves

Impact on Global food production

- As per report, one degree rise in temperature may lead to drop of food productivity by 30%. Adding to it the increased complexities of pests, diseases effecting the productivity
- As per latest IPCC report, global warming could lead to improving conditions for food production in mid to higher latitudes over the next few decades. Conversely, part of subtropics, and low latitudes could experience declining food production.
- Fisheries too become vulnerable.

Impact on Global health

- Global warming may lead to spread the outreach of vector borne diseases to higher latitudes.
- Ground level pollutions (eg. smog) may increase leading to respiratory health issues and various other allergic diseases
- The global warming may lead to scarcity of food leading to malnutrition.

Impact on world politics

- Already growing tension between developed and developing nations regarding taking the responsibility under CBDR.
- It will cause large scale migration of people especially from small islands and poor countries leading to economic and social pressure on resources of developed nations.

- Energy and food security and regional tension over natural resources like water may lead to regional clashes.

Need of the hour is for nations to come together and implement their respective INDCs (Intended Nationally determined contributions) under UNFCCC to counter global warming.

3. What role have volcanoes played in formation of earth's atmosphere in the past? Elaborate on the impact of volcanic activity on climate change in contemporary times.

Approach:

- Briefly discuss the role played by volcanoes in formation of earth's atmosphere.
- Bring out the impact on gasses released from volcanic eruptions on global climate.
- Discuss how it impacts cooling of the planet.

Answer:

Volcanism as an agent of planetary out-gassing was a major contributor to initial development of earth's atmosphere. Volcanic activity released essential gasses such as water vapor, carbon dioxide, methane, ammonia and very little free oxygen from the interior of the earth through a process called degassing.

Volcanic eruptions injected ash and sulphur-rich aerosol clouds into the atmosphere which shaded sunlight and reduced the amount of solar radiation reaching the Earth's surface thus cooling the planet. As the earth cooled, water vapor condensed to form rain dissolving carbon dioxide and other gases.

Some researchers also suggest that submarine volcanoes, produced a reducing mixture of gases and lavas, effectively scrubbing oxygen from the atmosphere, binding it into oxygen containing minerals. However, when terrestrial volcanoes increased, the overall quantity of oxygen in the atmosphere increased. These processes continued for sometime resulting in the composition of atmosphere as what we see today with minor variation owing to anthropogenic and other natural causes.

Volcanic eruptions and climate change:

- Volcanic eruptions pour sulfur dioxide and other particles into the stratosphere. Gases react with water to form aerosols that linger in the stratosphere, reflecting sunlight and heat from the sun and thus lowering temperatures in the troposphere, and **changing atmospheric circulation patterns**.
- The sulphur-rich aerosols particles also contribute to an **accelerated rate of ozone depletion**.
    - **For Example:** A large volcanic eruption such as the Pinatubo eruption in 1991 can have a global cooling effect of 0.1°–0.3°C for several years.
- Intense volcanism has significantly increased the amount of **carbon dioxide** in the atmosphere and causes global warming. Volcanic eruptions produce **more than 100 million tons** CO_2 each year.
    - **For Example:** The 1980 eruption of Mount St. Helens vented approximately 10 million tons of CO_2 into the atmosphere in only 9 hours.
- Dark lava flow absorbs more of the solar energy, so a large enough lava flow could warm a local region.

Thus volcanoes can have both a cooling and warming effect on climate. However, in the long term frequent volcanic eruptions will have a net effect of cooling the earth and counter global warming.

Student Notes:

4. Analyze the impact of climate change on the third pole of the world.

Approach:

- Introduce by stating the importance of the region.
- Mention the impact of climate change in the region.
- Conclude by briefly mentioning the steps that can be taken to mitigate the impact.

Answer:

The **Tibetan Plateau,** which holds the Hindu Kush Himalaya (HKH) ice sheet, is known as the world's **"Third Pole."** It is home to the world's highest peaks, unique cultures, diverse flora, fauna, and a vast reserve of natural resources. It is the **source of 10 major river basins**, and provides ecosystem services (including water, food, and energy) that directly sustain the livelihoods of 240 million people.

The region is experiencing rapid changes primarily driven by climate change. This would result in catastrophic changes in the region such as:

- The mountains are already **prone to natural disasters** such as landslides/avalanches etc. Climate change induced extreme weather events will increase the vulnerability of the inhabitants**.**
- As a result of the HKH **glacial melt**, more water is expected to surge through the Indus, Ganges and Brahmaputra rivers, **forcing a change to the agricultural practices** in the valleys around them. Even the traditional mountain food systems are under threat from rapid environmental changes.
- When glaciers melt, they flow into lakes and rivers. Changes to the timing and magnitude of this melting leads to an **increase in the number and size of glacier lakes, which can suddenly flood.**
- The western disturbances **significantly impact temperature patterns of the Himalayan regions besides precipitation.** The changes in the westerly disturbance due to climate change are also believed to increase the mass of some glaciers in the Karakoram and western Himalayas, popularly known as the "**Karakoram Anomaly**".
- Climate change is also adversely impacting ecosystems and **leading to biodiversity loss** in the HKH region.
- Air pollutants originating within and near the HKH **amplify** the effects of greenhouse gases and **accelerate melting of the cryosphere through the deposition of black carbon and dust.**

Therefore, the HKH is sensitive to global climate change through its impacts on atmospheric dynamics and thermal forcing. Some of the steps that can be taken to mitigate and adapt to the climate change are-

- **Mainstreaming policy instruments** on adaptation in their planning and budgeting processes.
- **Institutional capacity on adaptation** needs to be built and fit to purpose at each level of governance.
- **Local-level autonomous responses** to climate variability and extreme events must be systematically studied, documented, and validated.
- HKH countries and institutions must work together to build mechanisms and fora to address key challenges, such as **data sharing**, and incentivize **regional cooperation** and cross-learning at the regional scale.

CHAPTER - 17 - COMBATING CLIMATE CHANGE

17. Combating Climate Change

17.1. Climate Change Mitigation

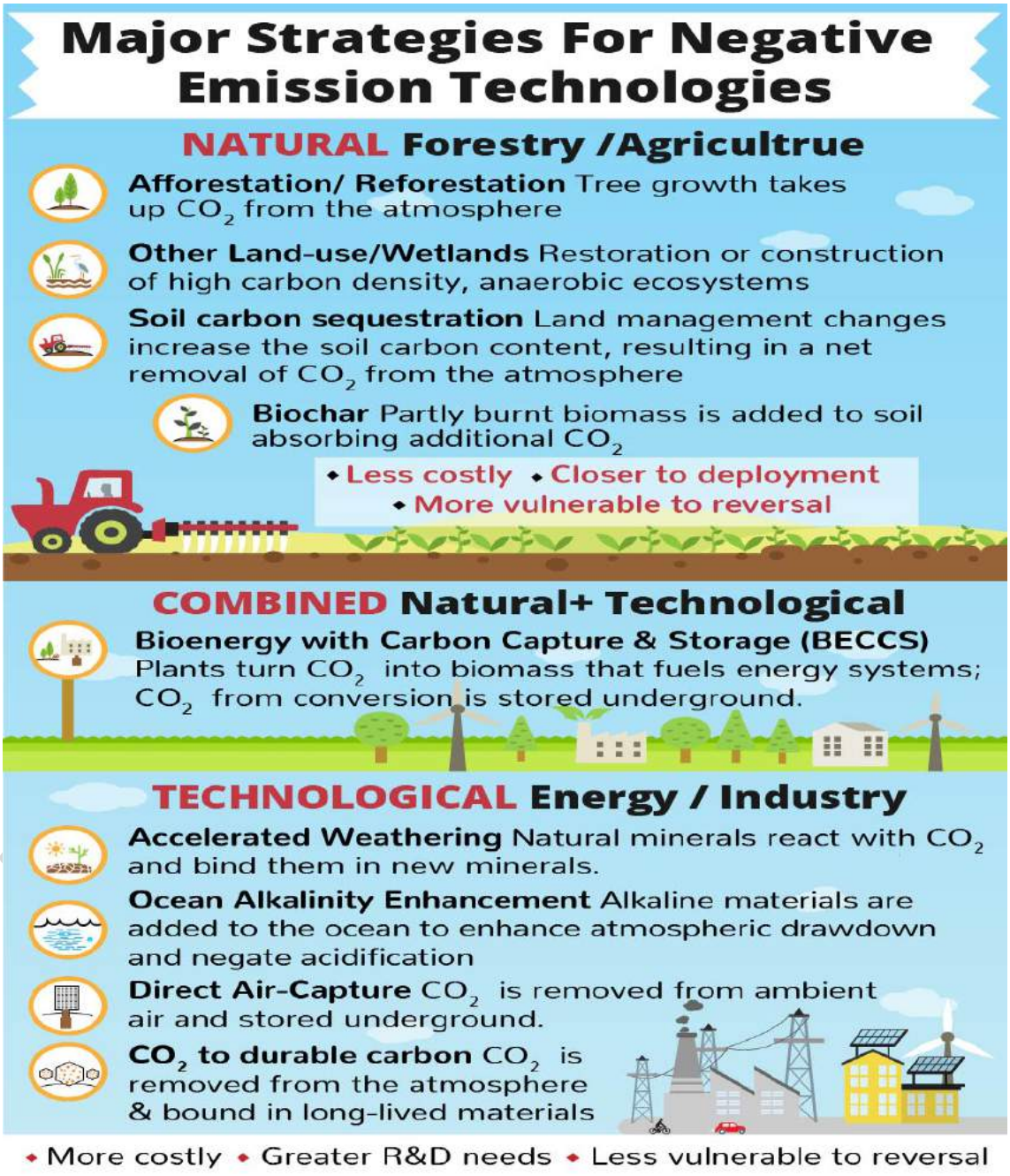
According to the United Nation Environment Programme, Climate Change Mitigation refers to **efforts to reduce or prevent emission of greenhouse gases**. Mitigation can mean using new technologies and renewable energies, making older equipment more energy efficient, or changing management practices or consumer behaviour. It can be as complex as a plan for a new city, or as a simple as improvements to a cook stove design.

SECTORS	MITIGATION STRATEGIES
Energy System	• Energy efficiency improvements and fugitive emission reductions in fuel extraction as well as in energy conversion, transmission, and distribution systems. • Fossil fuel switching and low-GHG energy supply technologies such as renewable energy (RE), nuclear power, and carbon dioxide capture and storage (CCS).
Transport Sector	• Modal shift to lower-carbon transport systems • Lowering energy intensity (MJ/passenger km or MJ/tonne km) • Reducing carbon intensity of fuels (CO_2eq/MJ) • Behavioural change- avoiding journeys where possible
Buildings	• Carbon Efficiency- Fuel switching to low-carbon fuels • Energy efficiency of technology- Efficient appliances, efficient lighting, efficient heating, ventilation & air conditioning systems, smart meters & smart grids. • System/infrastructure efficiency- nearly/net zero & energy plus buildings, urban planning.
Industry	• Energy efficiency, • Emissions efficiency, • Material efficiency in production by reducing yield losses in materials production, manufacturing, and construction and Re-using old material, • Material efficiency in product design, • Reducing overall demand for product services
AGRICULTURE	
Forestry	• Conservation of existing Carbon pools in forest vegetation and soil by controlling deforestation protecting forest in reserves • Improved biomass stocks by planting trees on non-forested agricultural lands. This can include either monocultures or mixed species plantings. • Management of forests for sustainable timber production including extending rotation cycles, reducing damage to remaining trees, reducing logging waste, implementing soil conservation practices, fertilization, etc. • Protecting secondary forests and other degraded forests whose biomass and soil carbon densities are less than their maximum value and allowing them to sequester carbon by natural or artificial regeneration, rehabilitation of degraded lands, long-term fallows.
Cropland Management	• High input carbon practices, e.g., improved crop varieties, crop rotation, use of cover crops, perennial cropping systems, agricultural biotechnology. • Improved water availability in cropland including water harvesting and application. • Drainage management to reduce emissions, reduce Nitrogen runoff • Replanting to native grasses and trees. Increase Carbon sequestration • Biochar Application • Use of animal manures and other biosolids for improved management of nitrogen; integrated livestock agriculture techniques.

	• Agroforestry (including agropastoral and agrosilvopastoral systems) • Integration of biomass production with subsequent processing in food and bioenergy sectors
Demand Side Mitigation	• Reduced losses in the food supply chain and in final consumption reduces energy use and GHG emissions from agriculture, transport, storage and distribution, and reduce land demand. • Changes in human diets towards less emission intensive products

Student Notes:

17.2. Negative Emission Technologies



17.2.1. Afforestation and Restoration

- Forests and their trees are prime regulators within the water, energy and carbon cycles and provide the foundations for carbon storage, for cooling terrestrial surfaces and for distributing water resources.
- Absorption of CO_2 through forest growth is already accounted for in the land use category of national GHG inventories.

- In temperate areas, carbon stocks have generally increased in recent years while decreasing in tropical areas owing to forest degradation and deforestation.
- Reducing the rate of tropical deforestation has been long identified as one of the most effective and economic means of limiting emissions and mitigating climate change.

17.2.2. Land Management

- A critical depository of carbon is in soils. Many cultivated soils have lost 50–70% of their original Soil Organic Carbon (SOC), so it should be possible to manage agricultural lands to partly reverse the loss of carbon.
- SOC can be increased by growing **cover crops, leaving crop residues to decay in the field, applying manure or compost, using low- or no-till systems, and employing other land management techniques such as row intercropping and grass strips, restoring hedges between fields and agroforestry, adjusting grazing periods in pasture,** to increase SOC and stabilise soil structure.
- The mitigation potential is greatest in **warm and moist climates**.
- This approach is the objective of the **'4 per mille' initiative,** which followed the COP21 meeting in Paris in December 2015.
- By increasing carbon content by 0.4% per annum, sufficient carbon would be sequestrated to stop the current 2–3 ppm increase each year in the atmospheric concentration of CO2.

17.2.3. Carbon Capture and Storage (CCS)

It is the process of capturing waste carbon dioxide (CO_2) from large point sources, such as fossil fuel power plants, transporting it to a storage site, and depositing it where it will not enter the atmosphere, normally an underground geological formation and then applies a suite of measurement, monitoring, and verification (MMV) technologies to ensure the safety, efficacy, and permanence of the captured CO_2's isolation from the atmosphere.

17.2.3.1. Carbon Capture Utilization Storage (CCUS)

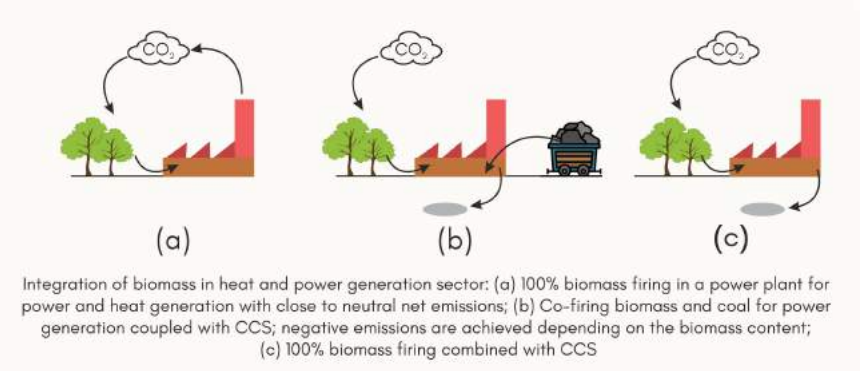
It is a process that captures carbon dioxide emissions from sources like coal-fired power plants and either reuses or stores it so it will not enter the atmosphere.

In **CCS, emissions are forced into underground rocks** at great cost and **no economic benefit** while **CCUS aims at using CO_2 emissions** by exploiting the resource itself and **creating new markets around it**. CO_2 has commercial and industrial uses, particularly for Enhanced Oil Recovery (EOR) in depleting oil fields.

17.2.3.2. Bioenergy with Carbon Capture and Storage (BECCS)

BECCS has been seen as a backstop technology to remove CO_2 from the atmosphere in case the world faced an emergency from the climate system (e.g. dangerous carbon cycle feedbacks).

- Biomass **captures CO_2 during growth and stores it in the form of organic material**, such as trunks, stalks, roots, etc. The biomass is **subsequently burned in a power plant** (or converted in another energy conversion plant), producing electricity (or another energy carrier).
- The CO_2 that is produced during biomass combustion is captured and stored underground, thereby effectively removing it from the atmosphere.



Integration of biomass in heat and power generation sector: (a) 100% biomass firing in a power plant for power and heat generation with close to neutral net emissions; (b) Co-firing biomass and coal for power generation coupled with CCS; negative emissions are achieved depending on the biomass content; (c) 100% biomass firing combined with CCS

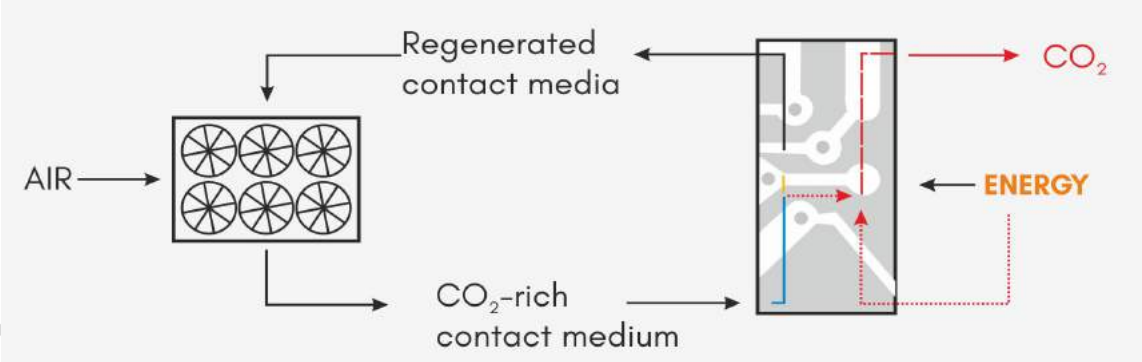
- As indicated, the use of biomass for BECCS is not limited to the power sector, but can also be integrated in other sectors, such as hydrogen, biofuel, or biogas production.

17.2.3.3. Enhanced Weathering

- The natural carbon cycle includes processes that remove CO_2 from the atmosphere over various timescales through inorganic chemistry.
- Primary mechanisms include the following-
  - CO_2 dissolves in seawater and is mineralised slowly, ultimately descending to deep ocean sediments (2000–8000 years is needed for this system to reach equilibrium).
  - The critical factor is **calcium (or magnesium) carbonate minerals** entering the ocean after weathering on land where their alkalinity compensates for the initial acidification when CO_2 dissolves. Accelerating this could thus increase the rate of CO_2 absorption by the oceans.
  - **Weathering of silicate minerals and entry of calcium (or magnesium) silicate** into the oceans can also affect marine chemistry in a similar way by reacting with CO_2 to produce (biogenic, amorphous, or dissolved) silica and (soluble) bicarbonate.
  - CO_2 can also react directly with calcium (or magnesium) silicate to produce a solid calcium (or magnesium) carbonate, a key reaction of the long-term carbon cycle.
- These processes involve mineral carbonation and accelerating such natural processes offers a potential means of increasing the removal rate of CO_2 from the atmosphere at a large scale.

17.2.3.4. Direct Air Capture and Carbon Storage (DACCS)

Approximately half of current anthropogenic GHG emissions are from distributed sources such as transport and residential heating. Capturing these emissions at the source is often impractical. It is, however, possible to **capture this CO_2 by collecting it directly from the ambient air**. This is called 'direct air capture' (DAC).



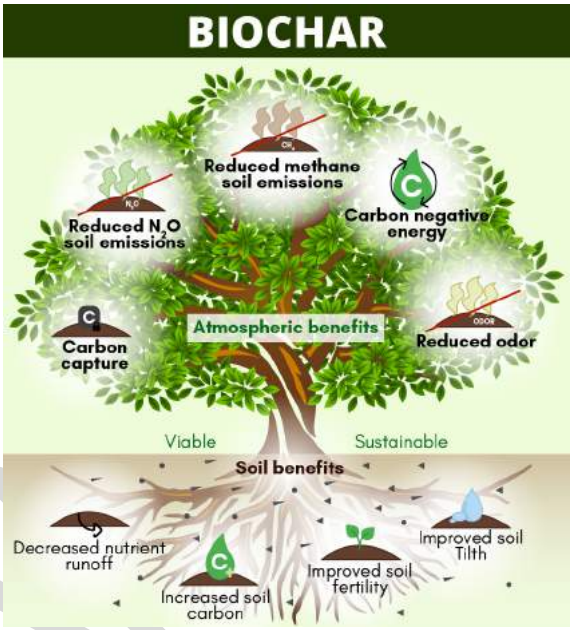
Important DACCS processes include the following:

- **Absorption-** using a strong base solution, typically sodium hydroxide (NaOH). The resulting sodium carbonate (Na_2CO_3) solution has to be treated to recover the NaOH, which can be done with the Kraft process whereby lime is used to causticise the Na_2CO_3back to NaOH, producing $CaCO_3$. The limestone is then treated at high temperatures to release the CO_2 (calcination) and regain the original lime.
- **Adsorption-** using a solid sorbent. Typically, chemical based sorbents such as immobilised amines on porous support structures are used. Regeneration is commonly done through an increase in temperature and/or a decrease in pressure. Additionally, some anion-exchange resins have been developed that absorb CO_2 when dry and release it when moist; a so-called humidity-swing.
- **Other concepts-** Besides absorption and adsorption, there is possibility of **extracting CO_2 from seawater using membranes**, which then reabsorbs CO_2 from the atmosphere. The is also possibility of **removing CO_2 from air by dry ice deposition** using a laboratory prototype & cooling the air to the point where CO_2 solidifies and can be separated.

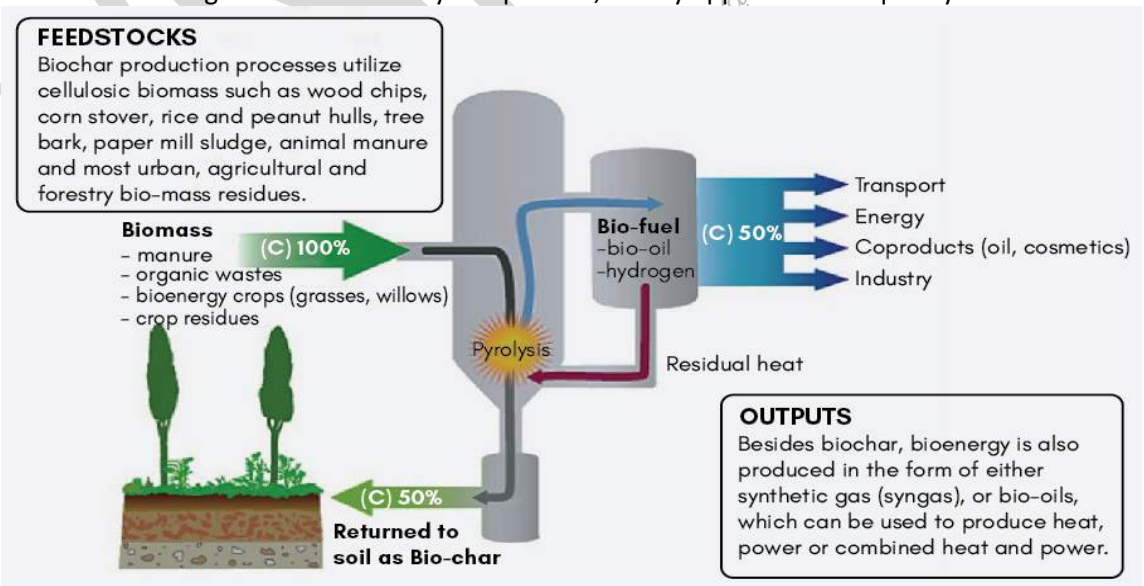
17.2.3.5. Ocean Fertilization

The oceans currently provide one of the largest natural sinks for CO_2, via the so-called **'solubility pump'** (since CO_2 is slightly soluble in seawater), and the **'biological pump'** (since microscopic plants take up CO_2 to make organic matter constituting the base of the ocean food web). Both of these sinks could potentially be enhanced. The biological pump could be enhanced by ocean fertilisation, i.e. by providing additional essential nutrients where these are in short supply.

17.2.3.6. Biochar



- This 2,000 year-old practice that converts agricultural waste into a soil enhancer that can hold carbon, boost food security, and increase soil biodiversity, and discourage deforestation. The process creates a fine-grained, highly porous charcoal that helps soils retain nutrients and water.
- Biochar is found in soils around the world as a result of vegetation fires and historic soil management practices.
- Biochar can be an important tool to increase food security and cropland diversity in areas with severely depleted soils, scarce organic resources, and inadequate water and chemical fertilizer supplies.
- Biochar also improves water quality and quantity by increasing soil retention of nutrients and agrochemicals for plant and crop utilization. More nutrients stay in the soil instead of leaching into groundwater and causing pollution.
- There are many different ways to make biochar, but all of them involve heating biomass with little or no oxygen to drive off volatile gasses, leaving carbon behind. This simple process is called thermal decomposition usually from pyrolysis or gasification. These methods can produce clean energy in the form of gas or oil along with the biochar. This energy may be recoverable for another use, or it may simply be burned and released as heat. It's one of the few technologies that is relatively inexpensive, widely applicable and quickly scalable.



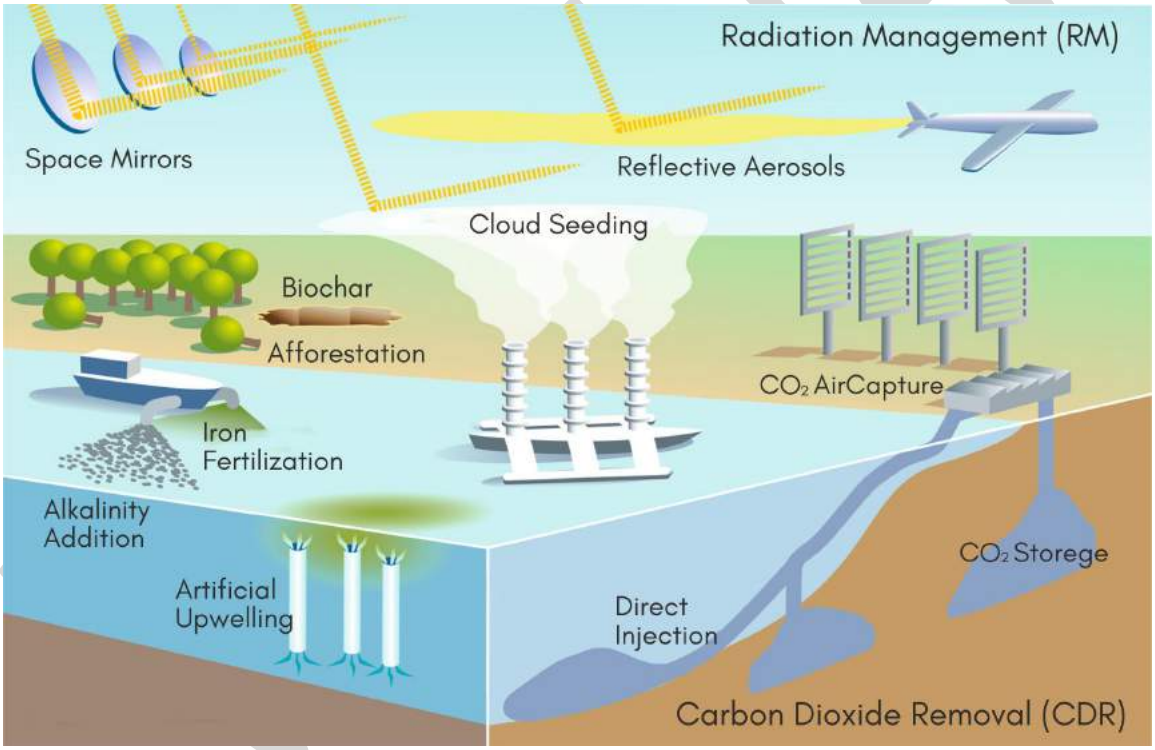
Student Notes:

17.2.4. Geo-Engineering

Geo- Engineering/Climate engineering/climate intervention schemes are projects designed to tackle the effects of climate change directly, usually by removing CO2 from the air or limiting the amount of sunlight reaching the planet's surface.

Generally, there are two categories of engineering solutions-

- Greenhouse gas removal through Carbon capture and storage (CCS), enhanced weathering etc. **(Explained in above section)**
- Reduction of global warming by cutting down the heat absorbed by our planet from the sun through-
    - **Stratospheric aerosol injection** which involves spraying into the stratosphere fine, light-coloured particles designed to reflect back part of the solar radiation (global dimming). Sulphur Dioxide gas is used for the process.
    - **Cirrus cloud manipulation**- Here the cirrus clouds are removed or thinned so that their long-wave trapping capacity is reduced and thus cools the surface.
    - **Marine cloud brightening**- The low warm clouds which are highly reflective to sunlight are modified to increase their reflectivity.
    - **Space sunshade**- Obstructing sunrays with space-based mirrors o Using pale-coloured roofing material or growing high albedo crops.



17.3. Carbon Pricing

Carbon pricing is an instrument that captures the external costs of greenhouse gas (GHG) emissions - the costs of emissions that the public pays for, such as damage to crops, health care costs from heat waves and droughts, and loss of property from flooding and sea level rise - and ties them to their sources through a price, usually in the form of a price on the carbon dioxide (CO_2) emitted.

Types of Carbon Pricing: There are 2 major types of carbon pricing

- **Emissions Trading Systems (ETS):** ETS - also referred to as a cap-and-trade system - caps the total level of GHG emissions and allows those industries with low emissions to sell their extra allowances to larger emitters.

Student Notes:

- **A carbon tax** directly sets a price on carbon by defining a tax rate on GHG emissions or - more commonly - on the carbon content of fossil fuels. It is different from an ETS in that the emission reduction outcome of a carbon tax is not pre-defined but the carbon price is.

Other mechanisms to price the carbon emission

- **An offset mechanism** designates the GHG emission reductions from project- or program-based activities, which can be sold either domestically or in other countries. Offset programs issue carbon credits according to an accounting protocol and have their own registry. These credits can be used to meet compliance under an international agreement, domestic policies or corporate citizenship objectives related to GHG mitigation.
- **Results-Based Climate Finance (RBCF)** is a funding approach where payments are made after pre-defined outputs or outcomes related to managing climate change, such as emission reductions. Many RBCF programs also simultaneously aim to reduce poverty, improve access to clean energy and offer health and community benefits.
- **Internal carbon pricing** is a tool an organization uses internally to guide its decision-making process in relation to climate change impacts, risks and opportunities.

Significance of Carbon Pricing

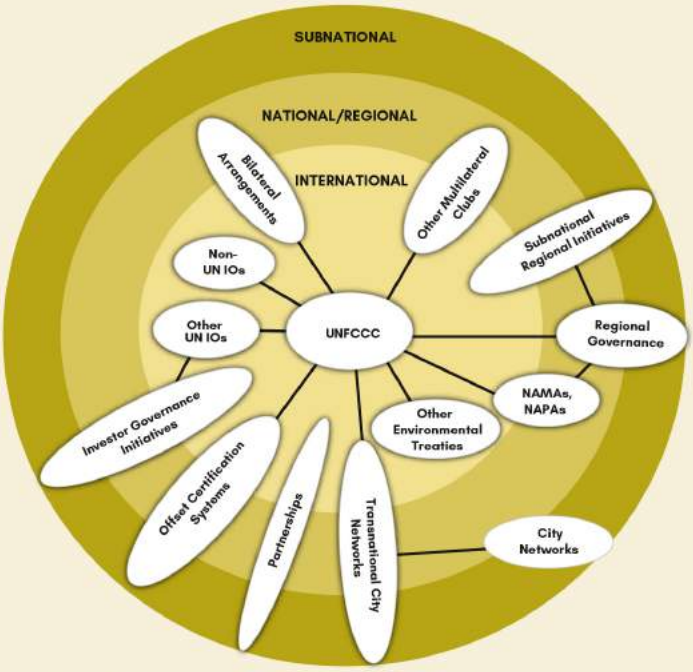
- A price on carbon helps **shift the burden** for the damage from GHG emissions back to those who are responsible for it and who can avoid it.
- Instead of dictating who should reduce emissions where and how, a carbon price **provides an economic signal to emitters**, and allows them to decide to either transform their activities and lower their emissions, or continue emitting and paying for their emissions. In this way, the overall environmental goal is achieved in the **most flexible and least-cost** way to society.
- Placing an adequate price on GHG emissions is of fundamental relevance to **internalize the external cost of climate change** in the broadest possible range of economic decision making and in setting economic **incentives for clean development**.
- It can help to **mobilize the financial investments** required to stimulate clean technology and market innovation, fueling new, low-carbon drivers of economic growth.
- **For governments**, carbon pricing is one of the instruments of the climate policy package and a **source of revenue** needed to reduce emissions.
- **Businesses** use internal carbon pricing to evaluate the impact of mandatory carbon prices on their operations and as **a tool** to identify potential climate risks and revenue opportunities.
- **Long-term investors** use carbon pricing to analyze the potential impact of climate change policies on their investment portfolios, allowing them to reassess investment strategies and reallocate capital toward low-carbon or climate-resilient activities.

Concerns related to Carbon Pricing

- **Carbon leakage:** the phenomenon by which carbon-intensive industries or firms shift operations to lower-cost jurisdictions.
- **Policy overlap or inconsistency:** Policy makers must work carefully and deliberately to avoid potential overlap of and interaction between policy instruments, which could undermine the effectiveness of carbon pricing mechanisms.
- **Ineffective use of revenues:** effectiveness of many carbon pricing initiatives depends on how these revenues are spent.

Note: Further details of Carbon markets are covered under Kyoto Protocol

17.4. International Efforts for Climate Change Mitigation



UNFCCC	Kyoto Protocol, Clean Development Mechanism, International Emissions Trading
Other UN Intergovernmental organizations	Intergovernmental Panel on Climate Change, UN Development Programme, UN Environment Programme, UN Global Compact, International Civil Aviation Organization, International Maritime Organization, UN Fund for International Partnerships
Non-UN IOs	World Bank, World Trade Organization
Other environmental treaties	Montreal Protocol, UN Conference on the Law of the Sea, Environmental Modification Treaty, Convention on Biological Diversity
Other multilateral 'clubs'	Major Economies Forum on Energy and Climate, G20, REDD+ Partnerships
Bilateral arrangements	e.g., US-India, Norway-Indonesia
Partnerships	Global Methane Initiative, Renewable Energy and Energy Efficiency Partnership, Climate Group
Offset certification systems	e.g., Gold Standard, Voluntary Carbon Standard
Investor governance initiatives	Carbon Disclosure Project, Investor Network on Climate Risk
Regional governance	e.g., EU climate change policy
Subnational regional initiatives	Regional Greenhouse Gas Initiative, California emissions-trading system
City networks	US Mayors' Agreement, Transition Towns
Transnational city networks	C40, Cities for Climate Protection, Climate Alliance, Asian Cities Climate Change Resilience Network
NAMAs, NAPAs	Nationally Appropriate Mitigation Actions (NAMAs) of developing countries; National Adaptation Programmes of Action (NAPAs)

Conference is consulting together formally; a type of negotiations, there is only broad theme.

Convention is a meeting or gathering to formulate or deliberate on a generally accepted principle, a framework in which the parties decide the basic guidelines

Protocol is an agreement that diplomatic negotiators formulate for a final convention where the parties set specific aims or legal obligations.

17.4.1. UN Framework Convention on Climate Change (UNFCCC)

It is the landmark international treaty unveiled at the **United Nations Conference on Environment and Development in Rio de Janeiro in June 1992**.

The UNFCCC commits signatory countries to **limit anthropogenic (i.e., human induced) greenhouse gas emissions** to levels that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure the food production is not threatened and to enable economic development to proceed in a sustainable manner.

The UNFCC aims to **stabilise concentrations of greenhouse gases in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system within a**

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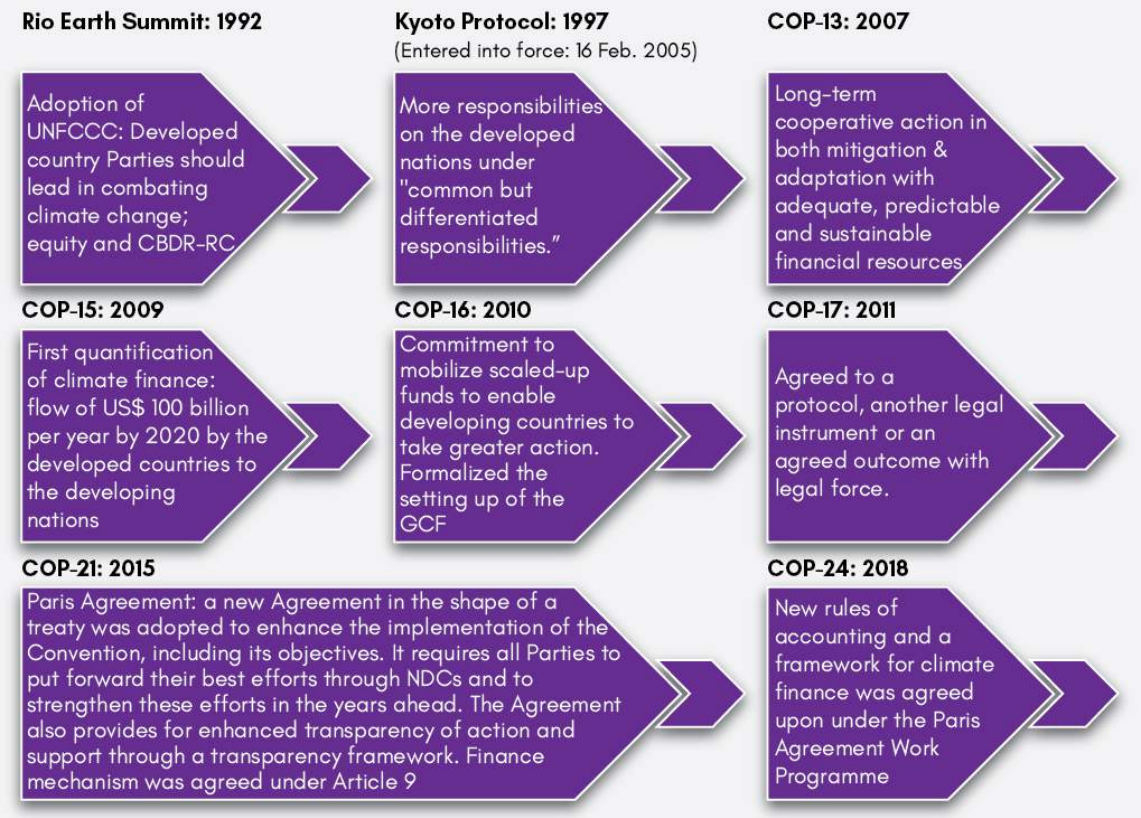
timeframe sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable the economic development to proceed in a sustainable manner.

Conference of the Parties (COP)

It is the supreme decision-making body of the Convention. All States that are Parties to Convention are represented at COP. It meets every year, unless the Parties decide otherwise.



17.4.1.1. Kyoto Protocol

The Kyoto Protocol was adopted on 11 December 1997. Owing to a complex ratification process, it **entered into force on 16 February 2005**.

The Kyoto Protocol operationalizes the United Nations Framework Convention on Climate Change by committing industrialized countries and economies in transition to limit and reduce greenhouse gases (GHG) emissions in accordance with agreed individual targets.

The Convention itself only asks those countries to adopt policies and measures on mitigation and to report periodically.

The Kyoto Protocol is based on the principles and provisions of the Convention and follows its annex-based structure. It **only binds developed countries**, and places a heavier burden on them under the principle of "**common but differentiated responsibility and respective capabilities**", because it recognizes that they are largely responsible for the current high levels of GHG emissions in the atmosphere.

In its Annex B, the Kyoto Protocol **sets binding emission reduction targets for 37 industrialized countries and economies in transition and the European Union**. Overall, these targets add up to an average 5 per cent emission reduction compared to 1990 levels over the five year period 2008–2012 (the first commitment period).

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Emission Targets and Initial Assigned Amount

The core commitment under the Kyoto Protocol, requires each **Annex I Party to ensure that its total emissions from GHG sources over the commitment period do not exceed its allowable level of emissions.**

The allowable level of emissions is called the Party's assigned amount. Each Annex I Party has a specific emissions target, which is set relative to its emissions of GHGs in its base year. The Annex B emissions target and the Party's emissions of GHGs in the base year determine the Party's initial assigned amount for the Kyoto Protocol's five-year first commitment period (2008 – 2012).

The quantity of the initial assigned amount is denominated in individual units, called assigned amount units (AAUs), each of which represents an allowance to emit **one metric tonne of carbon dioxide equivalent (t CO_2 eq)**.

Classification of Parties to the Kyoto Protocol

Classification	Description
Annex I	These are the industrialized (developed) countries and "economies in transition" (EITs). EITs are the former centrally-planned (Soviet) economies of Russia and Eastern Europe. The European Union-15 (EU-15) is also an Annex I Party.
Annex II	Annex II Parties are made up of members of the Organization for Economic Cooperation and Development (OECD). Annex II Parties are required to provide financial resources to enable developing countries in reducing their greenhouse gas emissions (climate change mitigation) and manage the impacts of climate change (climate change adaptation)
Annex B	Parties listed in Annex B of the Kyoto Protocol are Annex I Parties with first or second round Kyoto greenhouse gas emissions targets.
Non-Annex I	Parties to the UNFCCC not listed in Annex I of the Convention are mostly low-income developing countries. Developing countries may volunteer to become Annex I countries when they are sufficiently developed.
Least-Developed Countries (LDCs)	49 Parties are LDCs, and are given special status under the treaty in view of their limited capacity to adapt to the effects of climate change.

The Kyoto Mechanisms

One important element of the Kyoto Protocol was the establishment of flexible market mechanisms, which are based on the trade of emissions permits. Under the Protocol, countries must meet their targets primarily through national measures. However, the Protocol also offers them an additional means to meet their targets by way of three market-based mechanisms:

- **International Emissions Trading**: Emissions Trading-mechanism allows parties to the Kyoto Protocol to buy 'Kyoto units' (emission permits for Greenhouse Gas) from other countries to help meet their domestic emission reduction targets.
- **Clean Development Mechanism (CDM)**: Countries can meet their domestic emission reduction targets by buying Greenhouse Gas reduction units from (projects in) non Annex I countries to the Kyoto protocol.
- **Joint implementation (JI)**: Any Annex I country can invest in emission reduction projects (referred to as "Joint Implementation Projects") in any other Annex I country as an alternative to Reducing Emissions Domestically.

Emission Trading

Parties with commitments under the Kyoto Protocol (Annex B Parties) have accepted targets for limiting or reducing emissions. These targets are expressed as levels of allowed emissions, or assigned amounts, at over the 2008-2012 commitment period. The allowed emissions are divided into assigned amount units (AAUs).

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Emissions trading, allows countries that have emission units to spare - emissions permitted them but not "used" - to sell this excess capacity to countries that are over their targets.

Thus, a new commodity was created in the form of emission reductions or removals. Since carbon dioxide is the principal greenhouse gas, people speak simply of trading in carbon. Carbon is now tracked and traded like any other commodity. This is known as the "carbon market."

Other trading units in the carbon market

More than actual emissions units can be traded and sold under the Kyoto Protocols emissions trading scheme.

The other units which may be transferred under the scheme, **each equal to one tonne of CO_2**, may be in the form of:

- **A removal unit (RMU)** on the basis of land use, land-use change and forestry (LULUCF) activities such as reforestation
- An **emission reduction unit (ERU)** generated by a joint implementation project
- A **certified emission reduction (CER)** generated from a clean development mechanism project activity

Carbon markets under the Paris Agreement (Article 6)

Carbon markets are one of the tools to tackle the climate change problem. The argument behind carbon trading is that the best way to take climate action is to reduce emissions where it is least costly to do so.

Article 6 under Paris Agreement contains three separate mechanisms for "voluntary cooperation" towards climate goals: two based on markets and a third based on "non-market approaches".

- **Market Mechanism 1 (Article 6.2)** – It sets up a carbon market which allows countries on voluntary direct bilateral cooperation basis to sell any extra emission reductions {called as Internationally Transferred Mitigation Outcomes (ITMO)} they have achieved compared to their Nationally Determined Contributions (NDCs) target.
- **Market Mechanism 2 (Article 6.4)** - A new international carbon market would be created for the trading of emissions reductions created anywhere in the world by the public or private sector. This new market referred to as the "Sustainable Development Mechanism" (SDM) seeks to replace the CDM.
- **The non-Market Approach**- to boost "mitigation, adaptation, finance, technology transfer and capacity building", in situations where no trade is involved. This could involve similar activities without the added element of trading. E.g., a country could support a renewable energy scheme overseas via concessional loan finance, but there would be no trading of any emissions cuts generated.

Monitoring emission targets

The Kyoto Protocol also established a rigorous monitoring, review and verification system, as well as a compliance system to ensure transparency and hold Parties to account. Under the Protocol, countries' actual emissions have to be monitored and precise records have to be kept of the trades carried out.

Registry system- track and record transactions by Parties under the mechanisms. The UN Climate Change Secretariat, based in Bonn, Germany, keeps an international transaction log to verify that transactions are consistent with the rules of the Protocol.

Reporting is done by Parties by submitting annual emission inventories and national reports under the Protocol at regular intervals.

A compliance system ensures that Parties are meeting their commitments and helps them to meet their commitments if they have problems doing so.

Adaptation- The Kyoto Protocol, like the Convention, is also designed to assist countries in adapting to the adverse effects of climate change. It facilitates the development and deployment of technologies that can help increase resilience to the impacts of climate change.

The Adaptation Fund- It was established to finance adaptation projects and programmes in developing countries that are Parties to the Kyoto Protocol. In the first commitment period, the Fund was financed mainly with a share of proceeds from CDM project activities. In Doha, in 2012,

it was decided that for the second commitment period, international emissions trading and joint implementation would also provide the Adaptation Fund with a 2% share of proceeds.

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17.4.1.2. Bonn CoP 6, 2001

A major breakthrough was achieved at the second part of the sixth Conference of the Parties meeting in Bonn, with governments reaching a broad political agreement on the operational rulebook for the 1997 Kyoto Protocol.

17.4.1.3. Marrakesh CoP 7, 2001

The seventh Conference of the Parties results in the **Marrakesh Accords**, setting the stage for ratification of the Kyoto Protocol. This would formalize agreement on operational rules for International Emissions Trading, the Clean Development Mechanism and Joint Implementation along with a compliance regime and accounting procedures.

To enhance climate technology development and transfer, the TEC has the following functions:

- Provide an overview of countries' climate technology needs and analyse policy and technical issues related to climate technology development and transfer.
- Recommend actions to promote climate technology development and transfer
- Recommend guidance on climate technology policies and programmes
- Promote and facilitate collaboration between climate technology stakeholders
- Recommend actions to address barriers to climate technology development and transfer
- Seek cooperation with climate technology stakeholders and promote coherence across technology activities
- Catalyse the development and use of climate technology road maps and action plans.

17.4.1.4. Bali CoP 13, 2007

- Governments adopted the Bali Road Map, a set of decisions that represented the various tracks that were seen as key to reaching a global climate deal.
- The Bali Road Map includes the **Bali Action Plan**, which launched a "new, comprehensive process to enable the full, effective and sustained implementation of the Convention through long-term cooperative action, now, up to and beyond 2012", with the aim of reaching an agreed outcome and adopting a decision at COP15 in Copenhagen.
- Governments divided the plan into five main categories: shared vision, mitigation, adaptation, technology and financing.
- Other elements in the Bali Road Map included-
  - A decision on deforestation and forest management,
  - A decision on technology for developing countries,
  - The establishment of the Adaptation Fund Board,
  - The review of the financial mechanism, going beyond the existing Global Environmental Facility

17.4.1.5. Copenhagen CoP 15, 2009

- It produced the Copenhagen Accord. The accord endorsed the continuation of the Kyoto protocol and emphasised a "strong political will to urgently combat climate change in accordance with the principle of common but differentiated responsibilities and respective capabilities".
- It was not adopted by all governments
- It committed developed countries to $30 billion fast-start financing (in 2010-2012) for adaptation and mitigation in developing countries, with priority given to the least developed countries.

17.4.1.6. Cancun CoP 16, 2010

Key Outcomes

- to commit to a maximum temperature rise of 2 degrees Celsius above pre-industrial levels, and to consider lowering that maximum to 1.5 degrees in the near future.

Student Notes:

- to make fully operational by 2012 a technology mechanism to boost the innovation, development and spread of new climate-friendly technologies;
- to **establish a Green Climate Fund** to provide financing to projects, programmes, policies and other activities in developing countries via thematic funding windows;
- Establishment of Technology Mechanism which included **Technology Executive Committee** and **Climate Technology Centre and Network.**
- **Cancun Adaptation Framework**, which included setting up an Adaptation Committee to promote the implementation of stronger, cohesive action on adaptation.
- On the mitigation front, developed countries submitted economy-wide emission reduction targets and agreed on strengthened reporting frequency and standards and to develop low-carbon national plans and strategies.
- Developing countries submitted nationally appropriate mitigation actions (NAMAs), to be implemented subject to financial and technical support.

17.4.1.7. Durban CoP 17, 2011

Key outcomes

- **Second commitment period of the Kyoto Protocol:** The continuation of the current international legal system through a second commitment period of the Kyoto Protocol till 2020.
- **Launch of new platform of negotiations:** The launch of a new platform of negotiations under the Convention to deliver a new and universal greenhouse gas reduction protocol, legal instrument or other outcome with legal force by 2015 for the period beyond 2020.
- **Conclusion in 2012 of existing broad-based stream of negotiations:** A decision to conclude within 2012 the work of the existing broad-based stream of negotiations that includes all member nations under the Convention.
- **Global Review:** To scope out and then conduct a fresh global review of the emerging climate challenge, based on the best available science and data, first to ensure whether a maximum two-degree rise is enough or whether an even lower 1.5 degree rise is required, and then to ensure that collective action is adequate to prevent the average global temperature rising beyond the agreed limit.

17.4.1.8. Doha CoP 18, 2012

The **Doha Amendment to the Kyoto Protocol** was adopted for a second commitment period, starting in 2013 and lasting until 2020. However, the Doha Amendment has **not yet entered into force**; a total of 144 instruments of acceptance are required for entry into force of the amendment.

The amendment includes:

- Governments decided on an **8 year second commitment period** that started on January 1st 2013.
- The legal requirements that will allow a smooth continuation of the Protocol were agreed, and the valuable accounting rules of the Protocol were preserved.
- Countries that are taking on further commitments under the Kyoto Protocol agreed to review their emission reduction commitments at the latest by 2014, with a view to increasing their respective levels of ambition.
- The Kyoto Protocol's Market Mechanisms – the Clean Development Mechanism (CDM), Joint Implementation (JI) and International Emissions Trading (IET) – will continue.
- Access to the mechanisms remains uninterrupted for all developed countries that have accepted targets for the second commitment period.
- Surplus assigned amount units (AAUs) can be carried over without limit from the first to the second commitment period of the Kyoto Protocol by Parties included in Annex I that have a target for the second commitment period.
- A revised list of GHG to be reported on by Parties in the second commitment period.

During the first commitment period, 37 industrialized countries and economies in transition and the European Community committed to reduce GHG emissions to an average of five percent against 1990 levels. During the second commitment period, Parties committed to reduce GHG emissions by at least 18% below 1990 levels in the eight-year period from 2013 to 2020.

Student Notes:

17.4.1.9. Warsaw CoP 19, 2013

Key Outcomes:

- Decisions towards a universal agreement in December 2015, which will enter into force in 2020
- Governments resolved to strengthen measures to **close the "ambition gap"** - the gap between what has been pledged to date and what is required to keep the world below a maximum average 2 degrees Celsius temperature rise - before the new agreement enters into force in 2020.
- Governments established the **Warsaw International Mechanism for Loss and Damage**. The mechanism will address losses and damages associated with long-term climate change impacts in developing countries that are especially vulnerable to such impacts.
- In view of developed countries' commitment to mobilize USD 100 billion annually by 2020 to support developing countries in their climate change actions, developed countries agreed to make their efforts in this regard.
- Cutting emissions from deforestation - "**the Warsaw Framework for REDD+"**
- Terms of reference for the **Climate Technology Centre and Network (CTCN),** established in Cancun 2010 were finalised.

17.4.1.10. Lima CoP 20, 2014

Key Outcomes

- Pledges were made by both developed and developing countries prior to take the **capitalization of the new Green Climate Fund (GCF) past an initial $10 billion target**.
- Levels of transparency and confidence-building measures as several industrialized countries submitted themselves to questioning about their emissions targets under a new process called a **Multilateral Assessment**.
- The **Lima Ministerial Declaration on Education and Awareness** called on governments to put climate change into school curricula and climate awareness into national development plans.
- Recognition of National Adaptation Plans (NAPs) offers an important way of delivering climate change resilience.
- **Lima Work Programme on Gender**: The Lima conference agreed a Lima Work Programme on Gender to advance gender balance and to promote gender sensitivity in developing and implementing climate policy.
- Executive Committee of the Warsaw International Mechanism on Loss and Damage was confirmed for two years with a balanced representation of members from developing and developed countries.
- Information hub to be launched on the UNFCCC web site, spotlighting actions by countries carrying out REDD+ activities.
- UNFCCC NAMA Day- A special event took place on actions to reduce emissions with the help of so-called “nationally appropriate mitigation actions” (NAMAs).

17.4.1.11. The Paris Agreement (CoP 21), 2015

The Paris Agreement is a **legally binding international treaty on climate change**. It was adopted by 196 Parties at COP 21 in Paris, on 12 December 2015 and entered into force on 4 November 2016. The Paris Agreement is **a landmark** in the multilateral climate change process because, for the first time, a **binding agreement brings all nations into a common cause** to undertake ambitious efforts to combat climate change and adapt to its effects.

Student Notes:

Long-term temperature goal: The Paris Agreement, in seeking to strengthen the global response to climate change, reaffirms the goal of limiting global temperature increase to well below 2 degrees Celsius, while pursuing efforts to limit the increase to 1.5 degrees.

Implementation of the Paris Agreement requires **economic and social transformation**, based on the best available science. The Paris Agreement works on a **5- year cycle** of increasingly ambitious climate action carried out by countries. By 2020, countries submit their plans for climate action known as **nationally determined contributions (NDCs)**.

In their NDCs, countries communicate actions they will take to **reduce their Greenhouse Gas emissions** in order to reach the goals of the Paris Agreement. Countries also communicate in the NDCs actions they will take to **build resilience to adapt** to the impacts of rising temperatures.

Financial, Technical & Capacity Building Support

Finance: The Paris Agreement reaffirms that developed countries should take the lead in **providing financial assistance** to countries that are less endowed and more vulnerable, while for the first time also encouraging voluntary contributions by other Parties.

Technology: This agreement establishes **a technology framework** to provide overarching guidance to the well-functioning Technology Mechanism.

Capacity-Building: The Paris Agreement places **great emphasis on climate-related capacity-building** for developing countries and requests all developed countries to enhance support for capacity-building actions in developing countries.

Loss and damage: The Paris Agreement recognizes the importance of averting, minimizing and addressing loss and damage associated with the adverse effects of climate change, including extreme weather events and slow onset events, and the role of sustainable development in reducing the risk of loss and damage.

Global stocktake: With the Paris Agreement, countries established an **enhanced transparency framework (ETF)**. Under ETF, starting in 2024, countries will report transparently on actions taken and progress in climate change mitigation, adaptation measures and support provided or received. The information gathered through the ETF will feed into the **Global stocktake** which will assess the collective progress towards the long-term climate goals.

17.4.1.12. Marrkesh CoP- 22, 2016

- Countries negotiated to prepare the fine print for Paris deal. It sought to make the rules that would help in the implementation of the law i.e. Paris Agreement.
- The countries have agreed to complete the rule book by 2018 as the Agreement would come into force from 2020

17.4.1.13. Bonn Climate Meet (CoP- 23), 2017

It set the stage for negotiation in 2018. It is divided into three parts which deals with-

- Completion of the Work Programme under Paris Agreement.
- **Talanoa Dialogue**: Talanoa dialogue is a facilitative dialogue in 2018, to take stock of the collective efforts of Parties in relation to progress towards the long term goal referred to Paris Agreement and to inform the preparation of nationally determine contributions (NDCs).
- **Pre-2020 implementation and ambition:** Parties agreed that there will be two stock-takes to discuss pre-2020 commitments -- in 2018 and 2019 -- before the Paris Agreement becomes operative in 2020.
- **Gender Action Plan**: The first ever Gender Action Plan to the UNFCCC was adopted at COP23 (role of gender in climate actions had earlier been included in the Lima work programme).
- **Local communities and indigenous people's platform**: It is a new platform to include indigenous people's voices in the implementation of the Paris Agreement.

Student Notes:

- **Loss and damage**: No financial commitments were agreed upon between the negotiating parties on the issue of loss and damage.

17.4.1.14. Katowice CoP 24, 2018

- All countries "shall" use the latest emissions accounting guidance from the IPCC.
- The schemes and methodologies for the implementation of Sustainable Development Mechanism- SDM would be discussed in COP-25. The SDM is intended to replace the Kyoto Protocol's "Clean Development Mechanism" (CDM) for carbon offsets
- The rules set the structure for the stocktake process, which is to be divided into three stages: Information collection, technical assessment and consideration of outputs.
- Developed country Parties shall biennially communicate indicative quantitative and qualitative information on programmes, including projected levels, channels and instruments, as available public financial resources to be provided to developing country Parties.
- Decided that the "adaptation fund" – a financial mechanism set up under the Kyoto Protocol – should continue under the Paris Agreement.

17.4.1.15. Madrid CoP 25, 2019

- **On Emission Reductions:** Rather than strong language setting out a clear timeline for nations to enhance their NDCs in 2020, it merely reiterated the invitation to parties to communicate. The text then "urges parties to consider that gap" when they "recommunicate" or "update" their NDCs, though it does not specify a fixed timeline.
- **On Loss and Damage:** The final texts essentially note that the Green Climate Fund (GCF) already supports activities that can be defined as relating to "loss and damage", with a suggestion that it and other funds could do more in this area in the future.
- Also, the Santiago Network was established, as part of the WIM, to catalyse the technical assistance required by the most vulnerable countries.
- **On Climate Finance:** Negotiators were unable to agree on when they should take a decision on whether and how the work programme for the Long Term Finance agenda should continue post-2020.
- **On Carbon Market:** The conference closed without setting rules for carbon markets under Article 6 of the Paris Agreement. The decision was deferred till COP26 next year.
- **On Gender Action Plan:** Decision was made on a new five-year gender action plan (GAP), intended to "support the implementation of gender-related decisions and mandates in the UNFCCC process".

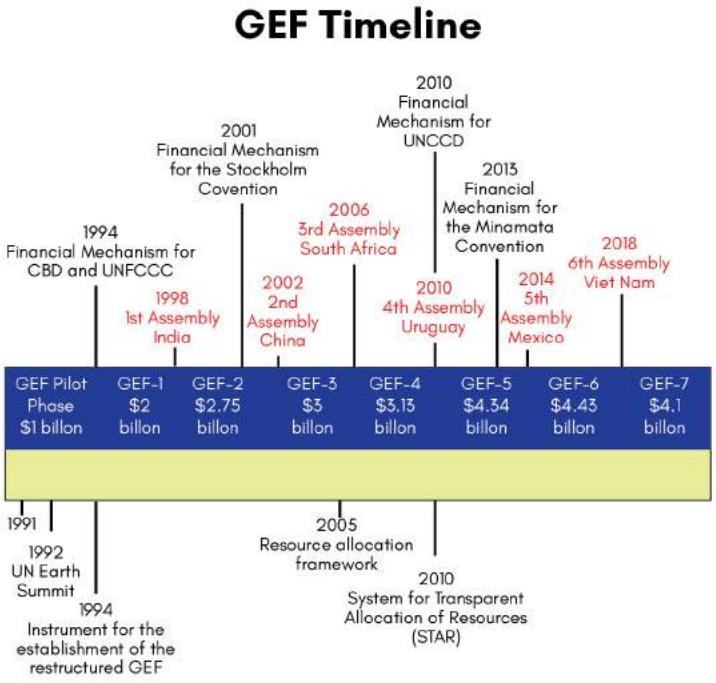
17.4.2. Financial Mechanisms

17.4.2.1. Global Environment Facility (GEF)

- It is a financial mechanism established under the **1992 Rio Earth Summit**.
- It is **managed by World Bank.**
- Presently, it involves an international partnership of 183 countries, international institutions, civil society organizations and the private sector that addresses global environmental issues.
- The Council is the GEF's main governing body, comprises 32 Members appointed by and from among GEF member countries (14 from developed countries, 16 from developing countries and 2 from economies in transition).
- The GEF Assembly is composed of all 183-member countries which meets every four years to review general policies, GEF's operation and the membership of the Facility.
- **Environmental Conventions under GEF financial mechanism**
  - Convention on Bio diversity (CBD)
  - Convention to combat desertification (UNCCD)
  - Framework convention on climate change (UNFCCC)

- Stockholm Convention on Persistent Organic Pollutants
- Minamata Convention
- Montreal Protocol (provides support)

- GEF is
  - Strategically focusing its investments to catalyze transformational change in key systems that are driving major environmental loss, in particular energy, cities and food;
  - Prioritizing integrated projects and programs that address more than one global environmental problem at a time, building on the GEF's unique position and mandate to act on a wide range of global environmental issues; and
  - Implementing new strategies and policies to enhance results, including stronger engagement with the private sector, indigenous peoples, and civil society, and an increased focus on gender equality.



The GEF's climate change adaptation strategy, which is financed through the Least Developed Countries Fund (LDCF) and the Special Climate Change Fund (SCCF), aims at supporting developing countries to move to a climate resilient development pathway while reducing exposure to the immediate risks posed by climate change.

Least Developed Countries Fund (LDFC)

- 194 parties to the United Nations Framework Convention on Climate Change (UNFCCC) decided to establish the Least Developed Countries Fund (LDCF) in 2001.
- The fund, managed by the GEF, supports the world's most vulnerable countries in their efforts to adapt to the effects of climate change. The LDCF is the only fund dedicated to supporting climate adaptation action in LDCs.
- The LDCF was designed to address the special needs of the LDCs under the UNFCCC. As part of its mandate, the LDCF has helped countries prepare and implement National Adaptation Programs of Action (NAPAs), and also supports the National Adaptation Plan (NAP) process. The LDCF also supports the LDC work program under the UNFCCC.

GEF/UNDP Small Grants Programme (SGP)

- The program is funded by Global Environment Facility (GEF) and executed by the United Nation Development Program (UNDP).
- It was launched alongside the Rio Earth Summit in 1992.
- It provides direct financial and technical support to communities and Civil Society Organizations for various projects that conserve and restore the environment while enhancing people's well- being and livelihoods.
- In India the program is hosted through the National Host Institution (NHI) i.e. - Centre for Environment Education (CEE)
  - It is a national level institution supported by Ministry of Environment and Forest, Government of India as a "centre of excellence".

- Adaptation priorities supported by the LDCF include- agriculture and food security; natural resources management; disaster risk management and prevention; coastal zone management; climate information services; and infrastructure. The LDCF focuses on enhancing the resilience of key sectors and ecosystems, supporting nature-based solutions, and financing on-the-ground adaptation activities that provide concrete results in support of vulnerable communities.

Special Climate Change Fund (SCCF)

The Special Climate Change Fund (SCCF) was established in response to guidance from the Conference of the Parties (COP7) in Marrakech in 2001. The SCCF complements the Least Developed Countries Fund (LDCF). The SCCF is open to all vulnerable developing countries. With guidance from the United Nations Framework Convention on Climate Change (UNFCCC), the SCCF targets various climate vulnerable sectors for adaptation and technology transfer.

17.4.2.2. Green Climate Fund (GCF)

- The Green Climate Fund (GCF) is the world's largest dedicated fund helping developing countries reduce their greenhouse gas emissions and enhance their ability to respond to climate change.
- It was set up by the **United Nations Framework Convention on Climate Change** (UNFCCC) at Cancun CoP in 2010.
- GCF has a crucial role in serving the Paris Agreement, supporting the goal of keeping average global temperature rise well below 2 degrees C. It does this by channelling climate finance to developing countries, which have joined other nations in committing to climate action.
- Advanced economies have agreed to jointly mobilize significant financial resources. Coming from a variety of sources, these resources address the pressing mitigation and adaptation needs of developing countries.
- GCF's activities are aligned with the priorities of developing countries through the principle of country ownership, and the Fund has established a direct access modality so that national and sub-national organisations can receive funding directly, rather than only via international intermediaries.
- The Fund pays particular attention to the needs of societies that are highly vulnerable to the effects of climate change, in particular Least Developed Countries (LDCs), Small Island Developing States (SIDS), and African States.
- GCF aims to catalyse a flow of climate finance to invest in low-emission and climate-resilient development, driving a paradigm shift in the global response to climate change.
- World Bank is the Interim Trustee of the fund.

Adaptation Fund- Refer to Kyoto Mechanism

17.5. Climate Change as an Intergovernmental Political Issue

Climate Change, though part of Earth's atmospheric cycle, was never seen as an anthropogenic problem up till almost the 20th Century. This was primarily due to two reasons- one, the change in climate happened over centuries and hence was not seen as a threat. Secondly, the link between anthropogenic activities and climate change was not clearly established. Since the late 19th Century, rapidly increasing populations, industrialization and consequently increasing carbon footprint accelerated the pace of climate change. This link was first identified by Fourier in 1827 in France. This awareness about climate change and its contribution through human activities gave way to following developments-

Environmental issues reached the global stage, but not specifically climate change: In 1972, the first international environmental summit took place in Stockholm, Sweden. This UN-convened conference marked a turning point in the development of international environmental politics and led to the creation of the United Nations Environment Programme (UNEP). Climate change, however, just remained a footnote at the Stockholm Conference.

Student Notes:

Concerns regarding Climate change raised globally: It the late 1970s, the World Meteorological Organization (WMO) began to express concern that human activities - notably the emission of carbon dioxide - might lead to serious warming of the lower atmosphere. The issue however continued to be viewed largely as a scientific concern, and not a pressing political "problem".

Climate change seen as a political issue: Scientific concerns about global warming started spilling over into political concerns, when some politicians took note of scientists' warnings about the risks posed by increased greenhouse gas emissions (GHGs) and recognised climate change as an issue that needed international cooperation at the First World Climate Conference in 1979, and the Toronto Conference on the Changing Climate in 1988.

Establishment of IPCC: In 1988, the WMO and the UNEP established the International Panel on Climate Change (IPCC) to investigate and report on scientific evidence on climate change and possible international responses to climate change. The IPCC has gone on to produce five comprehensive assessments since then.

First global agreement on climate change: The first assessment report of IPCC in 1990 led to the drafting of the United Nations Framework Convention on Climate Change (UNFCCC) in 1991, which was opened for signature at the Earth Summit in Rio de Janeiro in 1992 and came into force in 1994.

17.6. Ongoing debates and Issues central to the Climate Change negotiations

Do ongoing negotiations ensure fairness and equity?:

- The Paris Climate Agreement (PCA), 2015 represented a clear shift from the Kyoto Protocol (KP) framework in its much more symmetrical treatment of all parties, developed and developing alike, diluting the principle of common but differentiated responsibilities.
- This reduces the responsibilities of developed countries while increasing the responsibilities of the developing world, and passing on the larger share of burden of mitigation to them. Such actions coupled with a lack of adequate finance, technology, and capacity building, within the context of increasing climate change impacts, adds more strain upon an already struggling set of countries.

Are climate targets under NDCs ambitious enough?

- Present course of NDCs is projected to cause an increase in temperature of 2.8-3°C. But the final declaration of the latest COP25 does not explicitly call on countries to increase their climate pledges made under the Paris Agreement.
- Also, there is no official body or mechanism under PCA which identifies countries that need to commit to greater reductions in order to achieve the "below 2°C" goal. This is in addition to absence of any mechanism which can ensure compliance on the currently declared NDCs.

Where will the finances come from?

- Effective combatting of climate change requires transferring of adequate financial and technological resources from the developed countries to the developing countries. With this objective, a Green Climate Fund (GCF) was created in 2010 and developed countries had pledged to mobilise US$ 100 billion per year by 2020 through this fund. However, as of July 2020, only $10.3 billion had been pledged to the GCF.

How to establish an effective market and non-market mechanism?

Several contentious issues have emerged in establishing a carbon market for present climate framework, such as-

- How to account for bilateral trade between countries ensuring only one nation claims credit for emissions cuts and that there is no **"double counting"**.

- How to ensure an **"overall mitigation in global emissions" (OMGE)**, meaning a net benefit for the atmosphere, rather than just emissions in one place being offset elsewhere

Who will help vulnerable countries overcome loss and damage caused by climate change?

- The 2013 international framework to address loss and damage – known as the **Warsaw International Mechanism (WIM)** intended that developed countries provide developing countries with finance, technology and capacity-building to help victims of climate change recover after extreme weather events or slower-onset climate disasters such as sea-level rise.
- But developed countries have strongly opposed any commitments to provide new finance to cover losses, rather preferring to encourage the creation of insurance schemes. They have also sought to **avoid any liability and compensation claims** for their historic responsibility in causing climate change.
- A report by a coalition of climate and environmental organizations estimated rich countries should provide an **additional $50 billion per year by 2022 and $300 billion annually by 2030** to address loss and damage

Other Issues

Lack of uniform timelines in NDCs, which cover a range of timeframes out to 2025 or 2030 further complicates the process.

Lack of uniformity in common metrics: Common metrics refer to standard conversion equivalents of CO2 for non- CO2 emissions such as methane and Nitrous Oxide (for estimation of emission reductions). Lack of consensus on these common metrics creates ambiguity for estimating non- CO2 emissions and leads to confusion in the level of progress made by countries.

Growing Disconnect: Ongoing negotiations have been criticized due to the disconnect that highlights the difference between the urgency underlined by the latest science, the demands for more ambitious climate targets from activists around the world, and the extremely slow paced nature of the talks.

Withdrawal of USA: The United States, the history's largest emitter of greenhouse gases, has left the PCA effective from November, 2020. This development can have adverse impacts on the ongoing negotiations since cooperative environmental regimes can be sustained only if parties perceive that other parties are making appropriate sacrifices.

Commitments made under Kyoto still incomplete: Only 37 of the nearly 200 participating countries were willing to bind themselves to reducing their GHG emissions in the framework of the second Kyoto phase until 2020. These 37 countries currently emit only 15% of the world's GHGs. India has been vocal about the need for an examination of whether richer countries have done enough in the years running up to 2020.

India's Interests

- India supports early and ambitious global climate action through international negotiations given its intrinsic vulnerabilities on this issue—be it the potential impacts of climate change on India's monsoon-dependent agriculture, or its glacier-fed river systems among others. However, it also desires to secure enough 'policy space' and 'carbon space' within it to ensure its future development.
- **India's Position-** India's positions in global climate negotiations can be illustrated by:
  - Continued support to international negotiations: India is a party to the Paris Agreement and Kyoto Protocol and more recently has signed the Kigali Amendment to Montreal protocol as well.
  - Belief in common but differentiated responsibility (CBDR) and awareness about its responsibilities: India has showed exibility in its stance towards CBDR by putting forth voluntary commitments while opposing moves to dilute the concept of dierentiated responsibility and pushing for clear commitments from developed countries on pre-2020 actions, emission reduction, -nance, and technology transfers.

- **India's Role in Shaping Climate Change Negotiations-**
  - Leading as a role model: India is the only major emitter in the world where actions to combat emissions are compatible with the goal of limiting global warming to an average of 2°C. Over the years, India has also strengthened its domestic policies to tackle climate change
  - Representing interests of developing nations: The original draft of the First Assessment Report of the IPCC had noted that both developed and developing countries had 'common responsibilities' on climate change. However, India worked closely with other developing nations to ensure that this was amended to become the CBDR of industrialized and developing countries
  - At the 'Conference of Select Developing Countries on Global Environmental Issues' convened in New Delhi in 1990, India succeeded in securing the general support of the developing world for its basic international positions on climate change
  - India, in concert with other members of the alliances like G77, BASIC and LMDC, played a key role in ensuring that ideas of 'equity' and 'dierentiation' remained registered in dierent operational parts of the PCA.
  - Providing alternate channels to fight Climate Change: As a mark of its global commitment towards addressing climate change, India launched an initiative together with France- the 'International Solar Alliance'- aimed at significantly expanding the global adoption of solar energy
- **Future Potential-** India could become a global climate leader with a "1.5℃ compatible" rating if it enhances its NDC target, abandons plans to build new coal--red power plants, and instead develops a strategy to phase out coal for power generation before 2040. Moving to an absolute target instead of the GDP intensity target would enhance transparency and certainty.

17.7. India and Climate Change

17.7.1. National Action Plan on Climate Change (NAPCC)

Government of India is implementing the National Action Plan on Climate Change (NAPCC) with a focus on promoting understanding of climate change and establishing linkage between adaptation and mitigation consistent with the national priority for achieving sustainable development.

It comprises of eight national missions representing multipronged, long term and integrated strategies for achieving key goals in the context of climate change. All national missions were approved by the Prime Minister's Council on Climate Change (PMCCC) and are being implemented now.

MISSIONS	MAJOR OBJECTIVES/TARGETS	PROGRESS
National Solar Mission (NSM)	Achieve 100 GW of solar power in seven years starting from 2014-15.	The cumulative capacity of 36.9 GW was commissioned till November 2020. Around 36 GW solar energy capacity is under installation, and an additional 19 GW capacity has been tendered.
National Mission for Enhanced Energy Efficiency (NMEEE)	• To achieve growth with ecological sustainability. • Mandating reduction in energy consumption in large energy-consuming industries. • Financing for PPP to reduce energy consumption through demand-side management programs in the municipal, buildings, and agriculture sectors,	• The Perform Achieve and Trade (PAT) Scheme is one of the initiatives under the NMEEE, and was initiated in March 2012. • PAT Cycle I (2012-2015) has over achieved the target, saving around 31 million tonnes of CO2 (Mt CO2). • PAT Cycle II (2016-17 to 2018-19)- emission reduction of 61.34 MtCO2 was achieved.

	• Energy incentives, including reduced taxes on energy-efficient appliances.	• PAT Cycle III (2017-18 to 2019-20) concluded on 31 March 2020, results of this cycle are awaited. • Currently PAT Cycle IV is under implementation.
National Mission For a Green India (GIM)	Improved ecosystem services by Increasing forest/tree cover by 5 mha and improving quality of forest cover on another 5 m ha (a total of 10 mha).	A sum of ` 343.08 crore has been released to 13 states during the period 2015-16 to 2019-20 for undertaking afforestation activities over an area of 1.42 lakh ha.
National Mission on Sustainable Habitat (NMSH)	• Development of sustainable habitat standards. • Promoting energy efficiency as a core component of urban planning by extending the existing Energy Conservation Building Code (ECBC). • Strengthening the enforcement of automotive fuel economy standards, and • Using pricing measures to encourage the purchase of efficient vehicles and incentives for the use of public transportation.	• The mission is being implemented through three programmes- Atal Mission on Rejuvenation and Urban Transformation, Swachh Bharat Mission, and Smart Cities Mission. • Under the ECBC, 335 demonstration building have been supported with technical assistance for compliance in the states/UTs. Cumulative built-up area of 0.16 billion m2 ensures an approximate energy saving of 0.17 BU. • Under the Smart Cities Mission, 1987 projects have already been completed so far, while 4375 projects are under completion. Smart Cities Mission requires cities to have at least 10% energy coming from solar and at least 80% buildings to be energy efficient and green. • Urban Transport Modal Shift- As on June 2020, 700 km of metro rail was operational in 18 major cities and a Bus Rapid Transit (BRT) network of about 450 km was operational in 11 cities across the country carrying 10 million passengers daily. • Smart roads, smart solar, smart water, PPPs and vibrant public spaces projects are being implemented under the Mission. • Swachh Bharat Mission- 6.2 Million household toilets, against the mission target of 5.8 million, and 0.59 million community & public toilets, against the mission target of 0.50 million, have been constructed as in December 2020. Under the mission, 100% door-to-door waste collection has been achieved in more than 83 thousand wards. • 4340 (99%) of the total 4372 cities have been declared Open Defecation Free (ODF) in the country.
National Water Mission (NWM)	• Focuses on monitoring of ground water, aquifer mapping, capacity building, water quality monitoring and other baseline studies.	• The National Institute of Hydrology is the nodal agency to get the State Specific Action Plan (SSAP) for the water sector for 16 selected states. Five

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	• Promoting citizen and state action for water conservation, augmentation, and preservation. • Focusing attention on overexploited areas. • Promoting basin-level integrated water resources management.	states have completed the first phase of SSAP. • 6.376 new ground water monitoring wells created.
National Mission for Sustainable Agriculture	Enhancing food security by making agriculture more productive, sustainable, remunerative, and climate resilient.	• 7960 farm machinery banks established in 2018-19 to reduce crop residue burning. • Under Rainfed Area Development Programme, an area of about 74,175.41 ha and 55,902.92 ha was brought under different Integrated Farming System approach in 2018-19 and 2019-20 respectively. • During 2018-19 & 2019-20, an area of 4.14 lakh ha was covered under organic farming. At present, 25.34 lakh ha, is under organic farming.
National Mission for Sustaining Himalayan Eco-systems	• To continuously assess the health status of the Himalayan Ecosystem. Enable policy bodies in their policy formulation functions. • Start of new centres relevant to climate change in the existing institutions in the Himalayan States. • Regional cooperation with neighbouring countries in Glaciology.	• The key achievements include setting up of the Centre of Glaciology at Wadia Institute of Himalayan Geology. • A national network programme on Himalayan Cryosphere has been launched. • A mega programme named Human and Institutional Capacity Building (HICAB) programme for the Indian Himalayan Region was launched during the 2018-19 and six state level knowledge networks have been supported in the states of Jammu & Kashmir, Himachal Pradesh, Assam, Meghalaya, Manipur and Arunachal Pradesh in the Himalayan Region. Under this programme, 18 projects and 7 Major R&D programmes are getting implemented. • In addition, three Centres of Excellence, one each at Kashmir University, Sikkim University and Tezpur University have been supported under the mission.
National Mission on Strategic Knowledge for Climate Change (NMSKCC)	• To gain a better understanding of climate science, formation of knowledge networks among the existing knowledge institutions engaged in research and development.	• Key achievements include setting up of 12 Centres of Excellence and 10 State Climate Change Centres. • 8 Global Technology Watch Groups (GTWGs) in the areas of Renewable Energy Technology, Advance Coal Technology, Enhanced Energy

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	• Development of national capacity for modelling the regional impact of climate change on different ecological zones within the country.	Efficiency, Green Forest, Sustainable Habitat, Water, Sustainable Agriculture and Manufacturing have been set up.

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17.7.2. State Action Plan on Climate Change (SAPCC)

With the formulation of the NAPCC, the need to achieve coherence between actions at national and sub-national level became apparent. Therefore, the Ministry motivated the State Governments to prepare their State Action Plans on Climate Change (SAPCC) in line with the strategies outlined in NAPCC. MoEF&CC has also provided financial support to states for enhancing their capacities for undertaking climate change activities.

17.7.3. National Adaptation Fund on Climate Change (NAFCC):

National Adaptation Fund on Climate Change (NAFCC) was launched in 2015 with an initial outlay of Rs. 350 crore to meet the cost of adaptation to climate change for the State and Union Territories of India that are particularly vulnerable to the adverse effects of climate change.

The overall aim of the fund is to support concrete adaptation activities which are not covered under on-going activities through the schemes of State and National Government that reduce the adverse effects of climate change facing community, sector and states.

The Scheme has been taken as Central Sector Scheme with **National Bank for Agriculture and Rural Development (NABARD) as the National Implementing Entity** (NIE).

Besides, enhancing adaptive capacity at national and state level, national conference / workshop, awareness/information dissemination, Research and Development and establishing a coordination and monitoring unit have also been proposed.

17.7.4. Climate Change Action Programme (CCAP)

Climate Change Action Programme (CCAP) is a central scheme which was approved by the Cabinet in January 2014 at a total cost of Rs. 290 crore for duration of five years.

Its objective is to create and strengthen the scientific and analytical capacity for assessment of climate change in the country, putting in place appropriate institutional framework for scientific and policy initiatives and implementation of climate change related actions in the context of sustainable development.

Some of the components of the CCAP scheme include the National Carbonaceous Aerosols Programme (NCAP), Long Term Ecological Observatories (LTEO), and Coordinated Studies on Climate Change for North East Region (CSCCNER).

17.7.5. India's Second Biennial Update Report (BUR)

It has been submitted to UNFCCC in December 2018.

The report shows that-

- Emission intensity of India's GDP came down by 21% between 2005 & 2014 and its achievement of climate goal for pre-2020 period is on track.
- A total of 2.607 billion tons of CO2 equivalent of GHGs were emitted from all activities (excluding Land use, Land-Use Change, and Forestry (LULUCF)) in India. Energy sector accounted for 73%, Industrial Processes and Product Use (IPPU) 8%, agriculture 16% and waste sector 3%.
- About 12% of emissions were offset by the carbon sink action of forestland, cropland and settlements.

17.7.6. India's post-2020 climate goals

For post-2020 period, in response to the decisions of the Conference to the Parties, India submitted its Nationally Determined Contribution (NDC) to the UNFCCC on 2nd October, 2015, outlining the climate actions intended to be taken under the Paris agreement. The **eight goals put forth by India in its NDC are:**

1. To put forward and further propagate a healthy and sustainable way of living based on traditions and values of conservation and moderation.
2. To adopt a climate friendly and a cleaner path than the one followed hitherto by others at corresponding level of economic development.
3. To reduce the emissions intensity of its GDP by 33 to 35 percent by 2030 from 2005
4. To achieve about 40 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).
5. To create an additional carbon sink of 2.5 to 3 billion tonnes of CO2 equivalent through additional forest and tree cover by 2030.
6. 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.
7. 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.
8. 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.

17.7.7. Other Initiatives

Plan, Policies & Schemes	Energy Efficiency measures- • Perform Achieve and Trade (PAT)- Market based mechanism to enhance Energy Efficiency through certification of energy saving which can be traded. • Star Rated Appliances to provide the consumer an informed choice about the energy saving and thereby the cost saving potential of the marketed household and other equipment. • Energy Conservation Building Code 2017 to establish minimum energy performance standards for buildings in India. • Street Lighting National Programme (SLNP): Deployment of LED street lights that are approximately 50% more energy efficient than incandescent bulbs and High-Pressure Sodium (HPS) lighting. • Unnat Jeevan by Affordable LEDs and Appliances for All (UJALA) to address India's high cost of electrification and high emissions from inefficient lighting. • Green Rating for Integrated Habitat Assessment (GRIHA) to recognize energy-efficient buildings, as well as to stimulate their large scale replication • Zero Defect and Zero Effect (ZED) to rate Micro, Small and Medium Enterprises (MSMEs) on quality control and certification for energy efficiency, enhanced resources efficiency, pollution control, use of renewable energy and waste management using ZED Maturity Assessment Model. Afforestation Measures: • National Afforestation Programme for afforestation and reforestation of degraded forests and non -forest areas. • Nagar Van Udyan Yojana: Aims at ecological rejuvenation of the city forests by creating/ developing at least one city forest in each city having Municipal Corporation/ Class I Cities for providing wholesome healthy living environment. Promotion of Renewable Energy: • Renewable energy targets: Solar Energy (100 GW by 2022), Wind Energy (60 GW by 2022) and Small Hydro and Biomass(15 GW by 2022)

	• Green Energy Corridor Project that aims at synchronizing electricity produced from renewable sources, such as solar and wind, with conventional power stations in the grid. • Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME India) under National Electric Mobility Mission Plan 2020 for promoting eco-friendly vehicles in the country – hybrid and electric technologies. Waste Management • Swachh Bharat Mission for Solid Waste Management including the establishment of waste to energy plants • Steel Scrap Recycling Policy to create a mechanism for treating waste streams and residues produced from dismantling and shredding facilities in compliance to Hazardous & Other Wastes (Management & Transboundary Movement) Rules, 2016. Agriculture • Pradhan Mantri Krishi Sinchayee Yojana for end-to-end solutions in irrigation supply chain and aims to use micro irrigation technologies extensively to save water, increase production and productivity of crops in a sustainable manner and help in achieving food security • Rainfed Area Development (RAD) to explore potential utilization of natural resources base/assets available/created through watershed development and soil conservation activities/interventions under MGNREGS, NWDPRA, RVP&FPR, RKVY, IWMP etc.
Financial Tools	• Framework for Energy Efficient Economic Development (FEEED) to ease the financing of energy efficiency projects. • Energy Efficiency Financing Platform (EEFP) to provide a platform to interact with Financial Institutions (FIs) and project developers for implementation of energy efficiency projects. • Green bonds issued by financial, non-financial or public entities where the proceeds are used to finance 100% green projects and assets specifically linked to climate-change mitigation, adaptation and resilience. India also has the second largest Emerging green bond market after China. • Compensatory Afforestation Management and Planning Authority (CAMPA) Funds for promoting afforestation and regeneration activities as a way of compensating for forest land diverted to non-forest uses. • India joined the International Platform on Sustainable Finance (IPSF) that acknowledges the global nature of financial markets which has the potential to help finance the transition to a green, low carbon and climate resilient economy by linking financing needs to the global sources of funding.
International Collaborations	• International Solar Alliance (ISA) to provide a dedicated platform for cooperation among solar-resource-rich countries, through which the global community, including governments, bilateral and multilateral organizations, corporates, industry, and other stakeholders, can contribute to help achieve the common goal of increasing the use and quality of solar energy in meeting energy needs of prospective ISA member countries in a safe, convenient, affordable, equitable and sustainable manner. • Clean Development Mechanism which allows emission reduction or removal projects in developing countries to generate carbon offset credit, each equivalent to one tonne of carbon dioxide. These certified emission reduction credits (CERs) could be traded, sold and used by industrialized countries to meet part of their emission reduction targets under Kyoto Protocol. • REDD+ Reducing emissions to achieve additional carbon sequestration, emission reduction, improve forest-based livelihoods, conservation of rare, endemic, and endangered species found in the area and improvement of watershed hydrology.
Others	• Smart Cities Mission for providing a clean and sustainable urban environment through the adoption of 'smart solutions'. • Atal Mission for Rejuvenation and Urban Transformation (AMRUT) for providing basic services (e.g. water supply, sewerage, urban transport) to households and

	build amenities in cities which will improve the quality of life for all, especially the poor and the disadvantaged is a national priority. • Pradhan Mantri Ujjwala Yojana for providing LPG connections to BPL households thus reducing the demand for traditional biomass from forests. • National Policy on Biofuels – 2018 which aims at taking forward the indicative target of achieving 20% blending of bio-fuels with fossil-based fuels by 2030. • Dedicated Freight Corridor for construction of six freight corridors traversing the entire country to provide a safe and efficient low carbon freight transportation system

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17.8. Global Efforts Related to Ozone Depletion

17.8.1. Initial efforts

- In 1974 scientists published their first scientific hypotheses that chemicals we produced could harm the stratospheric ozone layer.
- The scientists found that the chlorofluorocarbon gases (CFCs), which were widely used and viewed as posing no harm, could migrate to the stratosphere, remain intact for decades to centuries, and by releasing chlorine, break down the ozone layer.
- In 1977 the United Nations Environment Programme (UNEP) concluded a **World Plan of Action on the Ozone Layer**, which called for intensive international research and monitoring of the ozone layer.
- In 1981, UNEP's Governing Council authorized UNEP to draft a global framework convention on stratospheric ozone protection.
- ***The Vienna Convention***, concluded in 1985, is a framework agreement in which States agree to cooperate in relevant research and scientific assessments of the ozone problem, to exchange information, and to adopt "appropriate measures" to prevent activities that harm the ozone layer.
    - The obligations are general and contain no specific limits on chemicals that deplete the ozone layer.
    - During the Vienna Convention negotiations, countries discussed a possible protocol that would provide specific targets for certain chemicals, but no consensus was reached.
    - The Vienna Convention went forward on its own, however, and was opened for signature in March, 1985.
- A working group under UNEP began negotiations on a protocol, and the Montreal Protocol was concluded in September, 1987, only nine months after the formal diplomatic negotiations opened in December, 1986. It went into effect on January 1, 1989.
    - **A State must be party to the Vienna Convention in order to become a party to the Montreal Protocol.**

17.8.2. The Montreal Protocol

- The Montreal Protocol on Substances that Deplete the Ozone Layer is the landmark multilateral environmental agreement that **regulates the production and consumption** of nearly 100 man-made chemicals referred to as **ozone depleting substances** (ODS).
- Adopted on 15 September 1987, the Protocol is to date the **only UN treaty ever that has been ratified every country on Earth** - all 198 UN Member States.
- The Montreal Protocol phases down the consumption and production of the different ODS in a step-wise manner, with different timetables for developed and developing countries.
- Under this treaty, all parties have specific responsibilities related to the phase out of the different groups of ODS, control of ODS trade, annual reporting of data, national licensing systems to control ODS imports and exports, and other matters. Developing and developed countries have equal but differentiated responsibilities, but most importantly, both groups of countries have binding, time-targeted and measurable commitments.

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17.8.3. Multilateral Fund under Montreal protocol

- The Multilateral Fund for the Implementation of the Montreal Protocol was established in 1991 under Article 10 of the treaty.
- The Fund's objective is to provide financial and technical assistance to developing country parties to the Montreal Protocol whose annual per capita consumption and production of ODS is less than 0.3 kg to comply with the control measures of the Protocol.
- The Multilateral Fund's activities are implemented by four international agencies - UN Environment Programme (UNEP), UN Development Programme (UNDP), UN Industrial Development Organisation (UNIDO) and the World Bank.

17.8.4. Phase out of HCFCs – the Montreal Amendment

- Hydro chlorofluorocarbons (HCFCs) are gases used worldwide in refrigeration, air-conditioning and foam applications, but they are being phased out under the Montreal Protocol since deplete the ozone layer.
- HCFCs are both ODS and powerful greenhouse gases: the most commonly used HCFC is nearly 2,000 times more potent than carbon dioxide in terms of its global warming potential (GWP).
- Recognizing the potential benefits to the Earth's climate, in September 2007 the Parties decided to accelerate their schedule to phase out HCFCs. **Developed countries** have been reducing their consumption of HCFCs and will **completely phase them out by 2020**.
- **Developing countries** agreed to start their phase out process in 2013 and are now following a stepwise reduction until the complete **phase-out of HCFCs by 2030.**

17.8.5. Phase down of HFCs – the Kigali Amendment

- Another group of substances, **hydrofluorocarbons (HFCs), were introduced as non-ozone depleting alternatives to support the timely phase out of CFCs and HCFCs**. HFCs are now widespread in air conditioners, refrigerators, aerosols, foams and other products.
- While these chemicals do not deplete the stratospheric ozone layer, some of them have high GWPs ranging from 12 to 14,000. Overall HFC emissions are growing at a rate of 8% per year and annual emissions are projected to rise to 7-19% of global CO2 emissions by 2050. Uncontrolled growth in HFC emissions therefore challenges efforts to keep global temperature rise at or below 2°C this century. Urgent action on HFCs is needed to protect the climate system.
- The Parties to the Montreal Protocol reached agreement at their 28th Meeting of the Parties on 15 October 2016 in Kigali, Rwanda to phase-down HFCs.
- **Countries agreed to add HFCs to the list of controlled substances**, and approved a timeline for their gradual reduction by 80-85 per cent by the late 2040s. The first reductions by developed countries are expected in 2019. Developing countries will follow with a freeze of HFCs consumption levels in 2024 and in 2028 for some nations.
- The pathway to implement the HFC phase down is to reduce dependency on high-GWP alternatives and increase the adoption of low-GWP, energy-efficient technologies as part of the HCFC phase-out process under the Montreal Protocol. Such a "smart approach" can achieve the Montreal Protocol's objective of eliminating HCFCs while at the same time achieving energy efficiency gains and CO2 emissions reduction — a "climate co-benefit."

17.9. India's Efforts regarding Ozone Depletion

India is a Party to the Vienna Convention for the Protection of the Ozone Layer and the Montreal Protocol on Substances that Deplete the Ozone Layer and it's all the amendments/adjustments.

India has been producing and using nine of the 96 ODSs controlled under the Montreal Protocol. These are Chlorofluorocarbons (CFCs) viz. CFC-11, CFC-12, CFC-113; Carbon Tetrachloride (CTC), HYdrochloro-fluorocarbons (HCFCs), Halon-1211, Halon1301, Methyl Chloroform and Methyl Bromide. Out of these, all ODSs except HCFCs, have been phased out. Currently HCFCs are being phased out as per the accelerated phase out schedule of the Montreal Protocol.

Ozone Cell-The Ministry of Environment, Forest and Climate Change (MoEF&CC) has set up the Ozone Cell as a National Ozone Unit (NOU) to render necessary services for effective and timely implementation of the Protocol and its ODS phase-out program in India. The Ministry has also constituted an Empowered Steering Committee (ESC) Chaired by the Secretary (EF&CC) which is supported by two Standing Committees viz. Technology and Finance Standing Committee (TFSC) and Standing Committee on Monitoring. The ESC is responsible for overall implementation of the Montreal Protocol provisions, review of various policy and implementation options, project approval and monitoring.

The Project Management Unit (PMU) was set up in 2002 to implement the National ODS Phase-out Plans.

17.10. Role of private sector in climate change efforts

- **Mobilize financial resources:** The **private sector has a critical role in generating new finance** to help fill the massive deficit in available funds for the same.
- **Leverage the efforts of governments:** Private entities dominate many investments that are critical to adaptation, such as the location and design of buildings, roads and other infrastructure investments, agricultural research (e.g., to develop more drought-resistant seeds); water management infrastructure and technologies.
- **Develop innovative climate services and adaptation technologies:** Private-sector corporations develop – and often dominate – the design and delivery of many adaptation services such as weather observation technology and early warning systems. This **will enable lower cost and accelerate the replication of climate-resilient technologies**.

Barriers to Increasing Private Sector Efforts in climate action

- **Limited** government incentives to attract private investment.
- **Limited or no access to information or tools** to assess risks and opportunities related to climate change and identify potential adaptation measures to be taken.
- Lack of availability of or access to advanced technologies and issues with IP rights and technology transfer.
- **Lack of demand in the market** due to low awareness leads to high cost of production of innovative climate resilient products and technologies.

Enablers for the private sector to invest in climate actions

- **Reforming the regulatory framework**
- **Raising awareness**
- **Build the capacity** by providing them with decision support tools to help them.
- **Build a shared vision between the public and private sector**

Steps taken to promote private participation in climate change

- **UNFCCC's Adaptation Private Sector Initiative (PSI)**
- **Green Climate Fund's Private Sector Facility**.
- In India:
  - The **India Climate Collaborative (ICC)** (formed by over ten of the country's foremost philanthropies)
  - **Inclusion of Renewable energy sector in the PSL norms**
  - Policies related to implementation of the **coal cess**, market mechanisms including perform achieve and trade **(PAT),** renewable energy certificates **(REC)** and a regulatory regime of renewable purchase obligation **(RPO)** have arguably led to an indirect carbon pricing by private sector.
  - **The National Solar Mission (NSM)** aims to achieve grid parity for solar electricity through research & development, domestic production, large scale deployment, and long term and predictable policy that encourages private sector participation in the solar business.

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Best practices

- **Internal Carbon Pricing:** Companies like Mahindra & Mahindra, Infosys Limited have implemented internal carbon pricing (ICP) in some form or the other. For instance, Mahindra & Mahindra has adopted an ICP of $10 per tonne of carbon emitted.
- **The International Union of Railways (UIC)** has undertaken an extensive feasibility study analyzing the impacts of climate change on rail transportation infrastructure and taking stock of ongoing and planned work on climate change adaptation in European, Canadian, Australian and Indian railway companies.

17.11. Effects Of COVID-19 On Climate Change Efforts

COVID-19 may result in an approximately **five to eight percent reduction in average global emissions** for the year, and while this is a small amount in the context of the whole system, it offers a rare opportunity to see how Earth responds to cuts on carbon emissions.

COVID-19 is also resulting in **changes in individual behaviour** and **social attitudes**, and in **responses by governments** that will have impacts on the environment and on our ability to combat climate change. Many of these will make matters worse, while others could make them better. Some of the adverse impacts of COVID-19 are listed below.

- **International negotiations delayed:** 2020 was supposed to be a "a pivotal year" for efforts to address climate change. COP26 of UNFCCC, World Conservation Congress, Convention on Biological Diversity and 2020 UN Ocean Conference etc. all are postponed.
- **Weakening of climate policies:** For instance, European Union has come under pressure to shelve crucial climate initiatives, with Poland calling for a carbon trading program to be put on hold and the Czech Republic urging that the EU's landmark climate bill be abandoned. Airline companies have pressed regulators to delay emissions-cutting policies.
- **Less money for climate resilience and renewable energy:** The need for **more emergency services** coupled with a **reduction in tax revenue** has taken an economic toll on governments' efforts. As a result, some have had to delay and divert funding away from climate resilience projects and renewable energy.
- **Scientific research disrupted:** Due to lockdowns and travel bans, scientists have been unable to travel to do their fieldwork, and there's a limit to how much some can accomplish with data and computers alone.
- **Increased waste and More plastic:** COVID-19 has vastly increased our use of plastic: gloves and masks and PPE kits, and disposable shopping bags etc. Ordering all sorts of items online has also resulted in more packaging materials, increasing the carbon footprint of e-commerce.
- **Deforestation in the Amazon:** As Brazil, hard hit by COVID-19, is focused on controlling the virus, **illegal loggers and miners** are taking advantage of the situation to cut down large swaths of the Amazon. Between January and April, 464 square miles of the rainforest were razed, **55% more area than was destroyed** in the same period in 2019.

However, efforts to combat COVID-19 pandemic also offer valuable lessons for combating climate change.

- **Put science and scientists first:** The collaborative networks of scientists beyond political lines and national borders in finding a cure to COVID-19, offers a lesson for global response to climate emergency, where there is a need to keep science at the forefront of climate negotiations with unimpeded transparency and scientific cooperation.
- **Adopt a "whatever money it takes" approach:** Governments have quickly mobilized financial support to back businesses and expand welfare benefits in response to the COVID-19 pandemic; and this is the right thing to be done. An urgent fund mobilization is needed to avoid a climate catastrophe.

- **Protect and improve common goods:** Over-exploitation of common goods, without consideration for the long-term needs of our next generations, has resulted in the **"tragedy of the commons",** with big environmental impacts, including the zoonotic origins of the COVID-19 pandemic.
- **Focus on those already left behind:** The COVID-19 pandemic struck fast and affected those most vulnerable, those who had little means and access to health-care services, and those in nursing homes and homes for persons with disabilities. Climate mitigation and adaptation activities should put these and other vulnerable groups at the center of attention and response.
- **Make the global value chains climate resilient:** The COVID-19 driven disruption in sectors like transport, medicine and tourism was immediate and hard. The **climate crisis with its low on-set characteristics** will drive at least similar if not larger implications in the value chains of main sectors. There is an opportunity to develop systems able to increase the resilience of value chains in climate sensitive sectors.
- **Fix and make sustainable the food systems:** The FAO has started documenting the negative impacts of COVID-19 on food security. The impacts of climate change on agriculture have also been extensively documented by the IPCC and **food supply chain** has emerged as the **most crucial global value chain** to be secured against the climate emergency.
- **Ensure credible information and not fake news leads the public discussion:** Since the causes and risks of climate change are already well examined, documented and vetted, scientific facts and solutions need to be brought widely to the attention of the public to avoid speculations and misconstrued theories, which only cause anxiety and panic, as is happening around this novel disease.
- **Institutionalise behaviour change:** The lockdown has enabled new behaviours and habits, especially among the corporate workforce, with remote work becoming normalised. Institutionalising these changes after the lockdown is eased or lifted can go a long way in lowering vehicular emissions, reducing air travel, and reducing the carbon footprints of people and products.

17.12. UPSC Previous Years Prelims Questions

1. Regarding "carbon credits", which one of the following statements is not correct? (2011)
(a) The carbon credit system was ratified in conjunction with the Kyoto Protocol
(b) Carbon credits are awarded to countries or groups that have reduced greenhouse gases below their emission quota
(c) The goal of the carbon credit system is to limit the increase of carbon dioxide emission
(d) Carbon credits are traded at a price fixed from time to time by the United Nations Environment Programme

Answer- d

2. With reference to 'Global Environment Facility', which of the following statements is/are correct? (2014)
(a) It serves as financial mechanism for 'Convention on Biological Diversity' and 'United Nations Framework Convention on Climate Change'
(b) It undertakes scientific research on environmental issues at global level
(c) It is an agency under OECD to facilitate the transfer of technology and funds to underdeveloped countries with specific aim to protect their environment
(d) Both (a) and (b)

Answer- a

3. Which of the following statements regarding 'Green Climate Fund' is/are correct? (2015)
1. It is intended to assist the developing countries in adaptation and mitigation practices to counter climate change.
2. It is founded under the aegis of UNEP, OECD, Asian Development Bank and World Bank.

Student Notes:

Select the correct answer using the code given below.
(a) 1 only
(b) 2 only
(c) Both 1 and 2
(d) Neither 1 nor 2

Answer- a

4. With reference to the Agreement at the UNFCCC Meeting in Paris in 2015, which of the following statements is/are correct? (2016)
1. The Agreement was signed by all the member countries of the UN and it will go into effect in 2017.
2. The Agreement aims to limit the greenhouse gas emissions so that the rise in average global temperature by the end of this century does not exceed 2 °C or even 1.5 °C above pre-industrial levels.
3. Developed countries acknowledged their historical responsibility in global warming and committed to donate $ 1000 billion a year from 2020 to help developing countries to cope with climate change.

Select the correct answer using the code given below.
(a) 1 and 3 only
(b) 2 only
(c) 2 and 3 only
(d) 1, 2 and 3

Answer- b

5. Which of the following best describes/describe the aim of 'Green India Mission' of the Government of India? (2016)
1. Incorporating environmental benefits and costs into the Union and State Budgets thereby implementing the 'green accounting'
2. Launching the second green revolution to enhance agricultural output so as to ensure food security to one and all in the future
3. Restoring and enhancing forest cover and responding to climate change by a combination of adaptation and mitigation measures

Select the correct answer using the code given below.
(a) 1 only
(b) 2 and 3 only
(c) 3 only
(d) 1, 2 and 3

Answer- c

6. The term 'Intended Nationally Determined Contributions' is sometimes seen in the news in the context of (2016)
(a) pledges made by the European countries to rehabilitate refugees from the war-affected Middle East
(b) plan of action outlined by the countries of the world to combat climate change
(c) capital contributed by the member countries in the establishment of Asian Infrastructure Investment Bank
(d) plan of action outlined by the countries of the world regarding Sustainable Development Goals

Answer- b

7. In the context of which of the following do some scientists suggest the use of cirrus cloud thinning technique and the injection of sulphate aerosol into stratosphere? (2020)
(a) Creating the artificial rains in some regions
(b) Reducing the frequency and intensity of tropical cyclones
(c) Reducing the adverse effects of the solar wind on the earth
(d) Reducing the global warming

Answer- d

Student Notes:

17.13. UPSC Previous Years Mains Questions

1. Assess the impact of global warming on the coral life system with examples.- 2019
2. Should the pursuit of carbon credits and clean development mechanisms set up under UNFCCC be maintained even though there has been a massive slide in the value of a carbon credit? Discuss with respect to India's energy needs for economic growth. (2014)
3. Explain briefly the "Clean Development Mechanism" as provided under the United Nations Framework Convention on Climate Change (UNFCCC). (2012)
4. In the context of the United Nations Framework Convention on Climate Change (UNFCCC), distinguish between 'Annex I' and 'Annex II' countries. (2010)

17.14. Vision IAS Previous Years Test Series Questions

1. ***In the context of India taking greater responsibility in management of the global commons, there has been a shift in India's climate change negotiation stance. In this context, analyze the evolution of India's climate policy.***

Approach:

- Introduce by highlighting India's greater focus on climate change negotiations.
- Analyze how India's climate policy has evolved over the years from 1970 conference to the recent Paris climate meet.
- Conclude by briefly emphasizing the reason for such shift in India's climate policy.

Answer:

India is taking greater responsibility in the management of the global commons such as sea, air, space, cyberspace etc. by actively voicing its concerns including keeping global commons such as sea open to all, emphatically supporting the comprehensive ban against deployment of weapons in the global commons like Antarctica, sea beds, and outer space etc.

In global climate politics as well, India has progressed from being a protest voice on the fringes of global environmental policy to one that is actively shaping global environmental efforts. This can be highlighted from the greater commitment towards the Intended National Determined Contributions (INDCs) goals as a part of Paris climate conference.

This is also evident from the evolution of India's climate policy

- **1972 United Nations Conference on the Human Environment:** India's focus was on socio-economic development against environmental protection. It held developed countries responsible for causing global environmental problems.
- **UNFCCC negotiation in 1992:** India, along with the group of developing nations, urged developed countries to take action on climate change while arguing that developing nations might only take on voluntary commitments. The concept of Common But Differentiated Responsibility (CBDR) was highlighted. Similar stance was also highlighted during Kyoto Protocol negotiations.
- **COP 13 in Bali in 2007:** India shifted its climate policy and accepted that developing countries should participate in the global mitigation effort, at least on a voluntary basis.
- **COP 19 in Warsaw in 2013:** The idea of INDCs was first mooted and it was agreed by all to contribute. The differentiation between developed and developing nations was left behind.
- **Paris negotiations:** India accepted the 1.5 degrees goal for climate policy. India also quickly ratified the Paris Agreement to help bring it into force.

Thus, India's departure from arguing for strict differentiation between developed and developing countries in the 1990s to leading the negotiations towards a loosely differentiated regime signifies India's increasing role in global common - environment. Although initial Indian government positions served to protect India's sovereignty but with greater development, India is adopting a more pragmatic approach in foreign policy including the climate negotiations.

Student Notes:

2. The potential of technology to aid farmers in increasing productivity as well reducing susceptibility to climate change remains underutilized. Identify the reasons for the same and suggest measures to improve technological penetration in agriculture.

Approach:

- Discuss the potential of technology in raising farm productivity and reducing susceptibility to climate change.
- Discuss the reasons why the use of technology in agriculture remains underutilized.
- Suggest measures to improve technological penetration in agriculture.

Answer:

Technology has a huge role in raising farm productivity and addressing susceptibilities related to climate change. This can be understood from the following:

Raising agricultural productivity

- Digital technology can guide crop and input selection, facilitate credit and insurance, provide weather advisories and disease/pest-related assistance as well as real-time data on domestic and export markets.
- Remote sensing (via satellites), GIS, crop and soil health monitoring and technologies for livestock and farm management have the potential to bring about another agriculture revolution.
- Agricultural conservation principles of minimal soil disturbance, mixed farming, permanent soil cover and crop rotation can be done with enforced soil testing, using computerized testing devices with effective agriculture extension.
- Technologies which enhance the shelf life of agricultural commodities or bio-fortify them have the potential to reduce waste and enhance nutrition.

Tackling vulnerabilities due to climate change:

- With greater investment in research multi-resistant crops can be developed which can withstand weather extremes such as droughts, floods, declining and more variable rainfalls. Similarly indigenous breeds of livestock may be conserved through animal husbandry practices and resistant breeds may be developed through genetic engineering.
- Water efficient drip and sprinkler technologies can minimize usage of water. Similarly, aquaponics and hydroponics offer viable ways to overcome problems of land availability.
- Technologies which disseminate information related to natural disasters can prevent losses due to unforeseen weather change.

Despite these benefits, the potential of technology in agriculture remains unexploited due to following challenges:

- Absence of reliable, up-to-date, location-specific repository for a diverse agricultural sector.
- Low digital literacy rates, Gender divide and lack of investment in education and training in information technology especially in rural areas.

Student Notes:

- Inadequate monitoring of real impact of interventions in agriculture.
- A very low investment in agricultural research compared to countries like China.
- Resistance to genomics technologies; for example, resistance to adopted Bt Brinjal, Bt mustard etc.

Need of the hour

Not only is there underinvestment in research, but agriculture extension systems, such as the Agricultural Technology Management Agency, and the Krishi Vigyan Kendras have delivered limited results. Thus, given the magnitude of the challenges, a coherent, climate-smart, integrated framework is needed at national and state-level, which goes beyond the mission mode approach.

Technology incubation should be undertaken through outcome based technology policy which encourages research, innovation and incubation in the field of agriculture. The vast network of Panchayats and Fair Price Shops should be tapped to undertake awareness and outreach activities in order to achieve productivity. Substantial investment is needed in physical infrastructure, power, broadband, transportation etc. India needs much larger investments in promoting digital literacy, particularly, in poorer regions, and in its poorest people.

3. Livestock farming not only contributes to climate change but is also affected by it. Elaborate the statement and discuss some measures that can be taken to make livestock farming more sustainable as well as resilient.

Approach:

- Briefly comment on the role of livestock in the Indian economy.
- Write the impacts of livestock farming on climate change and vice-versa.
- Suggest measures to make livestock farming sustainable and resilient.

Answer:

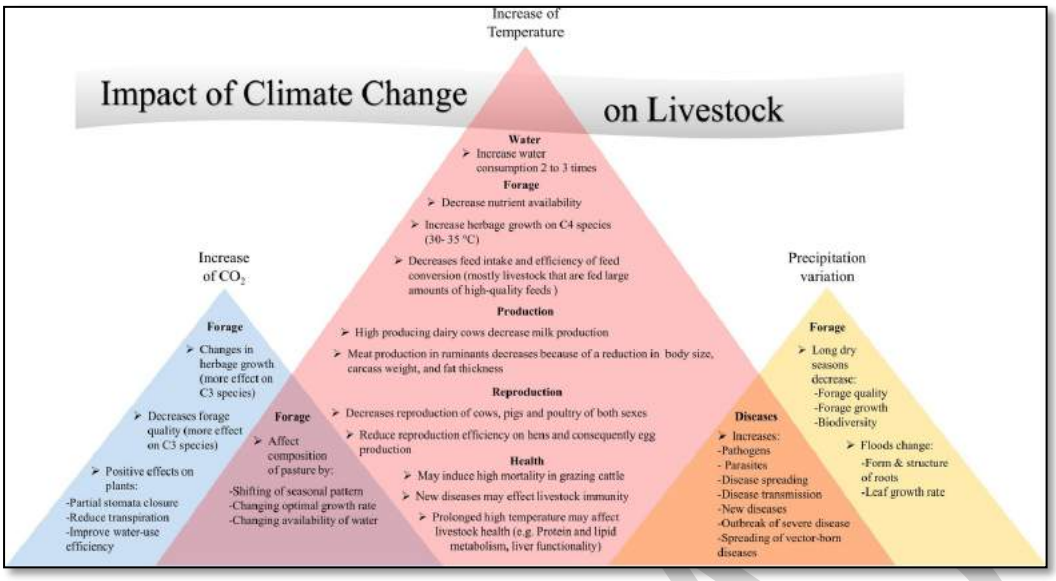
Livestock farming is the rearing of animals such as cattle, chicken, goats, horses etc. for food and for other human uses and contributes significantly to agricultural gross production value.

Livestock farming and climate change

As per the FAO, Livestock supply chain contributes approximately **14.5% of human-induced greenhouse gas (GHG) emissions**. The major emissions include **Methane**, which is mainly produced by enteric fermentation in animals as well as **Nitrous oxide**, arising from manure storage and the use of organic/inorganic fertilizers. Moreover, significant emissions also emanate from resultant land use change during feed production and processing, manufacturing and use of fertilizers and pesticides etc.

On the other hand, livestock farming is also affected due to climate change in several ways:

- Heat stress leads to **reduced milk and meat production**, impairment of embryo development and increase in **embryonic mortality** in cattle.
- Affects **species composition,** which is an important determinant of livestock productivity.
- **Increase in variety of health risks** due to wetter and warmer climate.
- For maintaining their body temperature, animals generally initiate compensatory and adaptive mechanisms, thus possibly impacting their **productive potential**.
- Irregular water availability may impact **forage productivity and quality**.



Measures to make livestock farming sustainable and resilient

- **Undertake well planned breeding programmes and conservation of animal genetic diversity** to improve adaption of livestock to changing environments, resistance to stress or shocks.
- **Adjusting grazing pressure** by balancing spatial and temporal presence of livestock, fertilization and nutrient management, introduction of species such as legumes etc.
- **Better integrating livestock into the circular bio-economy** by recycling and recovering nutrients and energy from animal waste.
- **Increasing productivity and resilience** of existing livestock by improving feed quality and establishing adequate veterinary infrastructure for reducing the incidence and impact of diseases, parasites and insect burdens.
- **Strengthening the knowledge and evidence base** through scientific assessment of the impact of climate change on the livestock sector and developing a nationwide guideline framework for livestock management.

These along with other measures such as training farmers in scientific rearing practices, use of weather information and weather-index based insurance to improve resilience etc. can help improve long-term sustainability and resilience of livestock farming to climate change.

4. The Paris Agreement addresses crucial areas necessary to combat climate change. In this context, identify some of the key aspects of the Agreement.

Approach:

- Give a brief introduction about the Paris Agreement.
- Identify the key aspects of the Agreement while highlighting the crucial areas of climate change addressed by this agreement.
- Conclude accordingly.

Answer:

The Paris Agreement, signed at COP 21 in 2016, is a global agreement under the United Nations Framework Convention on Climate Change (UNFCCC), dealing with greenhouse-gas-emissions mitigation, adaptation, and finance. It calls for 196 member countries to accelerate and intensify the actions and investments needed for a sustainable and low carbon future.

Student Notes:

Crucial areas of climate change	Key aspect of Paris agreement in this regard
Long-Term Temperature	The Paris Agreement's central aim is to strengthen the global response to the threat of climate change by keeping the global temperature rise in this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius.
GHG emissions	To achieve this temperature goal, Parties aim to reach global peaking of greenhouse gas emissions (GHGs) as soon as possible, recognizing peaking will take longer for developing country parties.
Mitigation	The Paris Agreement establishes binding commitments to all parties to prepare, communicate and maintain Nationally Determined Contributions (NDC) and to pursue domestic measures to achieve them.
Adaptation	The Paris Agreement establishes a global goal on adaptation whereby all parties should engage in adaptation planning. The parties are expected to submit and periodically update an adaptation communication on their priorities, implementation and support needs, plans and actions.
Loss and Damage	The Agreement significantly enhances the Warsaw International Mechanism on Loss and Damage, which will develop approaches to help vulnerable countries cope with the adverse effects of climate change, including extreme weather events and slow-onset events such as sea-level rise. It provides a framework for the parties to enhance understanding, action and support with regard to loss and damage.
Finance, technology and capacity-building support	The Paris Agreement reaffirms the obligations of developed countries to support the efforts of developing country parties to build clean, climate-resilient futures, while for the first time encouraging voluntary contributions by other parties.
Assessing progress	A "global stocktake" to take place in 2023 and every 5 years thereafter, will assess collective progress toward meeting the purpose of the Agreement

Paris Climate Agreement is a landmark in fight against climate change; however, still few critical issues need to be resolved like bringing developing and developed countries same table on all aspects as recently USA has withdrawn from the agreement. Apart from it, designing a more suitable mechanism for resolving issues like national interests, technology transfer, funding etc. should be carefully designed.

5. What is carbon pricing? Mention some of the different types of carbon pricing mechanisms. Examine how it can help India in achieving its climate commitments under the Paris Agreement.

Approach:

- Explain carbon pricing.
- Discuss the different types of carbon pricing mechanisms.
- State how it can help India in achieving its climate commitments under the Paris Agreement.
- Conclude the answer accordingly.

Answer:

Student Notes:

Carbon pricing is an instrument that captures the external costs arising from greenhouse gas (GHG) emissions (such as damage to crops, health issues from heatwaves) and ties them to the sources of emissions through a price, usually in the form of a price on the carbon dioxide (CO_2) emitted etc.

Types of carbon pricing mechanisms:

- **Emissions Trading Systems (ETS):** It is a system where emitters can trade emission units to meet their emission targets. By creating supply and demand for emissions units, an ETS establishes a market price for GHG emissions. The two main types of Emission Trading Systems are:
  - **Cap-and-trade systems**, which apply a cap or absolute limit on the emissions within the ETS and emissions allowances are distributed, usually for free or through auctions, for the amount of emissions equivalent to the cap.
  - **Baseline-and-credit systems**, where baseline emissions levels are defined for individual regulated entities and credits are issued to entities that have reduced their emissions below this level. These credits can be sold to other entities exceeding their baseline emission levels.
- **A carbon tax** directly sets a price on carbon by defining a tax rate on GHG emissions or - more commonly - on the carbon content of fossil fuels. For example, the carbon tax on production and import of coal in India.
- **An offset mechanism** designates the GHG emission reductions from project- or programme-based activities, which can be sold either domestically or in other countries. Offset programmes issue carbon credits according to an accounting protocol and have their own registry. These credits can be used to meet compliance under an international agreement, domestic policies or corporate citizenship objectives related to GHG mitigation.
- **Results-Based Climate Finance (RBCF)** is a funding approach where payments are made after pre-defined outputs or outcomes related to managing climate change such as emission reductions, are delivered and verified. Many RBCF programmes aim to purchase verified reductions in GHG emissions while at the same time reduce poverty, improve access to clean energy and offer health and community benefits.
- **Internal carbon pricing** is a tool an organization uses internally to guide its decision-making process in relation to climate change impacts, risks and opportunities.

India, as a party to the **Paris Agreement**, has made commitments which include reduction in the emissions intensity of GDP by 33 to 35 per cent by 2030 and creation of an additional carbon sink of 2.5 to 3 billion tonnes of CO_2 equivalent by 2030. In this backdrop, **carbon pricing** can help India achieve its objectives in the following ways:

- It provides an opportunity to shift the burden on those responsible for it by allowing them to decide to either transform their activities and lower their emissions or continue emitting and paying for their emissions.
- Internalizing the external cost of climate change in the economic decision making would **incentivize businesses to invest in clean technology and market innovation**. It would fuel new, low carbon drivers of economic growth and help India to reduce emission intensity.
- Long-term investors may use carbon pricing to analyze the potential impact of climate change policies on their investment portfolios, allowing them to **reassess investment strategies** and reallocate capital toward low- carbon or climate-resilient activities.
- It would **help to evaluate the impact of mandatory carbon prices on the operations of businesses** and to identify potential climate risks and revenue opportunities.

Overall, these actions would promote the adoption of clean technologies and investment in green projects.

- Considering the developmental needs and economic constraints, if businesses decide to pay for emissions, it would help the government to **mobilize finances** which can be used for adaptation and mitigation measures such as reforestation, energy efficiency, evacuation plans etc.

However, issues such as carbon leakage, policy overlap or inconsistency, ineffective use of revenues etc. need to be addressed to ensure effective utilization of carbon pricing scheme. Also, internationally much would depend on setting rules for carbon markets under Article 6 of the Paris Agreement, the decision for which has been deferred till COP26 in 2020.

Student Notes:

Heartiest Congratulations to all successful candidates

7 IN TOP 10 SELECTIONS IN CSE 2019

FROM VARIOUS PROGRAMS OF VISION IAS

9 IN TOP 10 SELECTION IN CSE 2018