Environmental Studies

COURSE CODE: B21ES01AC

ABILITY ENHANCEMENT COMPULSORY COURSE FOR ALL UG PROGRAMMES

SELF LEARNING MATERIAL

SREENARAYANAGURU
OPEN UNIVERSITY

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The State University for Education, Training and Research in Blended Format, Kerala

SREENARAYANAGURU OPEN UNIVERSITY

Vision

To increase access of potential learners of all categories to higher education, research and training, and ensure equity through delivery of high quality processes and outcomes fostering inclusive educational empowerment for social advancement.

Mission

To be benchmarked as a model for conservation and dissemination of knowledge and skill on blended and virtual mode in education, training and research for normal, continuing, and adult learners.

Pathway

Access and Quality define Equity.

Environmental Studies

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Semester - I

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MESSAGE FROM VICE CHANCELLOR

Dear
I greet all of you with deep delight and great excitement. I welcome you to the Sreenarayanaguru Open University.

Sreenarayanaguru Open University was established in September 2020 as a state initiative for fostering higher education in open and distance mode. We shaped our dreams through a pathway defined by a dictum 'access and quality define equity'. It provides all reasons to us for the celebration of quality in the process of education. I am overwhelmed to let you know that we have resolved not to become ourselves a reason or cause a reason for the dissemination of inferior education. It sets the pace as well as the destination. The name of the University centres around the aura of Sreenarayanaguru, the great renaissance thinker of modern India. His name is a reminder for us to ensure quality in the delivery of all academic endeavours.

Sreenarayanaguru Open University rests on the practical framework of the popularly known "blended format". Learner on distance mode obviously has limitations in getting exposed to the full potential of classroom learning experience. Our pedagogical basket has three entities viz Self Learning Material, Classroom Counselling and Virtual modes. This combination is expected to provide high voltage in learning as well as teaching experiences. Care has been taken to ensure quality endeavours across all the entities.

The University is committed to provide you stimulating learning experience. The Ability Enhancement Compulsory Course, Environmental Studies is included in all UG Programmes. Environmental studies tries to grapple with developing sustainable strategies to safeguard the ecosystem. An awareness of the subject helps us make sense of our environment and confront threats to nature and eventually to human life in general. We assure you that the university student support services will closely stay with you for the redressal of your grievances during your studentship.

Feel free to write to us about anything that you feel relevant regarding the academic programme.

Wish you the best

Regards
Dr. PM Mubarak Pasha 21.11.2022

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SREENARAYANAGURU OPEN UNIVERSITY

BLOCK - 01

Environment and Natural Resources

Unit 1
Environmental Segments

Learning Outcomes

- Imbibes scientific knowledge about the environment
- Learns more about the lithosphere, hydrosphere, biosphere and atmosphere
- Understands the hydrological cycles clearly
- Learns to distinguish between the weather and climate

Prerequisites

We are all aware how different natural disasters like Tsunami, Okhi, floods, land-slides and heavy waves have affected our lives. Have you ever thought about the reason behind repeated catastrophes?

We cannot imagine a life without nature. But human greed has brought untold destruction of nature. There is enough for man's needs but not for his greed. This destruction of nature has resulted in repeated disasters.

What we have to understand is that both nature and man are interrelated and interconnected. Man is not above nature, and human beings are only a part of nature. We should know about nature in order to live happily.

Keywords

Lithosphere, Hydrosphere, Biosphere, Climate, Weather

Discussion

As we all know, the earth is the only planet which has life. Life sustaining elements such as land, water and air are present on the earth. Environmental studies is a multidisciplinary academic field of study which deals with the environment and its functions. The environment is the biotic and abiotic surroundings of an organism or population, and consequently includes the factors that have an influence in their survival, development and evolution. The environment can vary in scale from microscopic to global in extent. Examples include the marine environment, atmospheric environment and the terrestrial environment. The surroundings of a living organism, including natural forces and other living things, provide conditions for development and growth as well as of danger and damage.

This branch of study uses principles from the physical sciences, commerce/economics, the humanities, and social sciences to address

complex contemporary environmental issues. Basic principles of subjects such as ethics, geography, anthropology, education, politics, law, economics, philosophy, sociology, pollution control and natural resource management have a vital role in environmental studies.

1.1.1 Environmental Segments

Do you know about the environmental segments controlling life and environmental processes? There are four environmental segments which include

1. Atmosphere
2. Hydrosphere
3. Lithosphere
4. Biosphere

The mutual interactions of these segments are responsible for the dynamic changes and the resultant impacts over the globe.

Any change imposed or occurred in one segment will affect the nature and functioning of the others as well. Elements from each segment are subjected to these dynamic processes and all are inevitable for life.

1.1.1.1 Atmosphere

Atmosphere is the layer of gases surrounding the Earth. This layer is retained over the globe, by the action of earth's gravity. It contains about 5000 million tons of gases. Among these, there are primary gases present in the atmosphere such as Nitrogen which amounts to 78%, oxygen to 21%, carbon dioxide to 0.33% and argon to 0.93%. The other gases present in the atmosphere are helium, methane, ozone, neon, xenon and many trace gases. Do you think that the above-mentioned gases are present everywhere? Above a height of 50 km from the earth's surface, atmosphere contains only oxygen, ozone, helium and hydrogen. Atmosphere contains water vapour and the amount of vapour in atmosphere varies with seasons.

The Earth's atmosphere has evolved into the present condition over a period of geological time and phases. Experts have studied about the evolution of the earth's atmosphere. The history of the Earth's atmosphere prior to the past one billion years is poorly understood. Atmosphere had two different compositions earlier. The original atmosphere primarily contained helium and hydrogen. Heat waves which emanated from the molten mass of the earth's interior and the sun dissipated into this atmosphere. The earth, with all its volcanic eruptions, released steam, carbon dioxide, and ammonia. This created the "second atmosphere". In this phase, the atmosphere had carbon dioxide and water vapour, with some nitrogen, but virtually no oxygen. This second atmosphere had about 100 times as much gas as the current atmosphere. During the next few billion years, water vapour condensed to form rain and oceans, which began to dissolve carbon dioxide. This was the first aquatic environment which favoured the origin of life. Due to the evolution of life, the levels of oxygen increased significantly, lowering the levels of carbon dioxide. With the appearance of an ozone layer (ozone is an allotrope of oxygen) life forms were protected from the ultraviolet radiation of the sun. This oxygen-nitrogen atmosphere is considered to be the "third atmosphere".

Atmosphere is responsible for:

a) the unequal heating of the earth's surface by insolation,

b) different heat zones,

c) variation in temperature,

d) changes in atmospheric pressure,

e) origin of winds,

f) formation of clouds, rain fall and snow fall

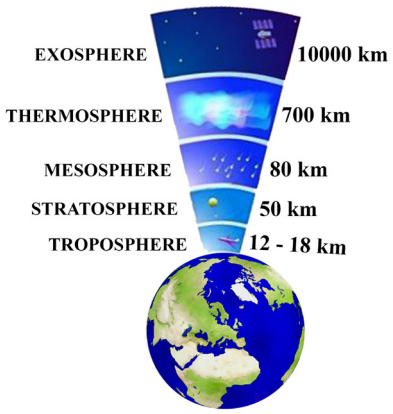

Fig1.1.1Layers of atmosphere

Atmosphere is stratified in the form of layers and is divided into three major layers such as Troposphere, Stratosphere and Ionosphere.

The characteristics of these layers vary in relation to their composition, temperature and impacts of radiation.

Troposphere

The Troposphere is the layer lying just above the surface of the earth. It contains 70% of the mass of the atmosphere. It extends up to 8-18 km. The air in this sphere contains 1% water vapour and more CO_2. It is a dusty layer. The fall of temperature in this zone is 1 deg. C per km. The temperature ranges from 15^0C to –56 ^{0}C. The Troposphere is the zone of turbulence, climate and weather. It ends at a zone named tropopause which separates the stratosphere from the troposphere. Hence, most of the pollutants stay in troposphere. Some extremely stable compounds like chlorofluorocarbons (CFCs) do cross into the next layer.

Stratosphere

The Stratosphere is the second layer of the atmosphere. It extends up to 80 km. In this zone, meteors will be visible. In the stratosphere, there is 1000 times less water vapour and 1000 times more ozone than the troposphere. This layer is free from clouds. Most of the aircrafts, go above the clouds and fly through the stratosphere, as there is little turbulence for flying. Hence, this zone is called as the zone of jet planes. In this layer the temperature increases with increase in altitude. from –52^0C to –2^0C. This layer ends at a region called stratopause, separating the next higher layer, ie the Ionosphere. The Stratosphere contains ozone layer which protects the life on Earth from the Sun's ultra violet radiation. Ozone is formed by UV radiation or lightning interaction with O_2 molecules. Ozone itself is very harmful to living cells. The Ozone layer depletes due to the emission of chlorofluorocarbons and other harmful gases. Depletion of ozone is the principal cause for sunburn, skin and eye cancers and cataracts.

Mesosphere

Mesosphere zone extends upto 80 km above the stratosphere. The temperature decreases uniformly with height, and it may reach as low as -1000C at places. The pressure is also very low at this zone.

Thermosphere

Above the mesosphere, to a height of 700 km is the thermosphere, where the atmosphere density is extremely low with the temperature increasing rapidly. The temperature at 350 km is 1200^0C. The inversion of temperature at this height is due to energy extracted from sunlight at wavelengths below 200 nm. This region is characterised by the dissociation of oxygen molecule, ionisation of oxygen atom, oxygen molecule, nitrogen molecule. Due to photoionisation reactions, this region is rich in electrically charged particles and electrons, and hence is also called ionosphere.

Exosphere

The region above the thermosphere upto 10,000 km is termed exosphere. It has only atoms of hydrogen and helium. It has very high temperature due to solar radiation.

1.1.1.2 Hydrosphere

Can we think of life without water? It is said that water is life. Water is an essential component of all life forms that exist over the surface of the earth. More than 71 per cent of the earth is covered with water. The hydrosphere is a collective term given to all different forms of water. Which are the water resources you have come across? It includes all types of water resources such as oceans, seas, rivers, lakes, streams, reservoirs, glaciers and ground water. Hydrosphere is the total amount of water on a planet. It includes water that is on the surface of the planet, underground and in the air. A planet's hydrosphere can be liquid, vapour or ice. On the Earth, liquid water exists on the surface in the form of oceans, lakes and rivers. It also exists below ground—as groundwater in wells and aquifers. Water vapour is most visible as clouds and fog. The frozen part of the Earth's hydrosphere is made of ice: glaciers, ice caps and icebergs. The frozen part of the hydrosphere has its own name, the cryosphere. Water moves through the hydrosphere in a cycle. Water collects in clouds and then falls to the Earth in the form of rain or snow. This water collects in rivers, lakes and oceans. Then it evaporates into the atmosphere to start the cycle all over again. This is called the hydrological cycle. Our earth is called 'blue planet' due to the presence of water.

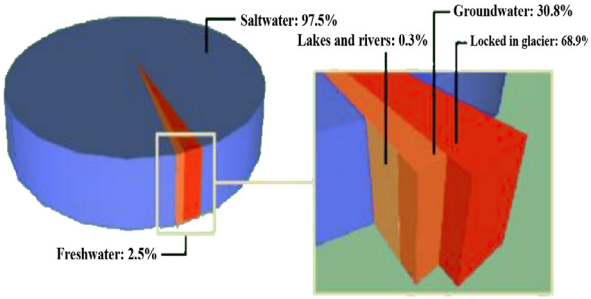

Fig 1.1.2 Global distribution of water

Hydrological Cycle

The hydrological cycle involves a continuous exchange of water between sea, atmosphere, land and living animals through massive evaporation of water from the ocean, cloud formation and precipitation. The land surface and water surfaces on earth lose water by evaporation and by solar energy. Evaporation of water from the ocean exceeds precipitation by rain into the seas by 10%. This 10% excess which precipitates on land balances the hydrological cycle. Some of the precipitated rain seeps into the soil as ground water. Ground water moves up by capillary action and thereby maintains a continuous supply of water to the surface layer of soil. The water from the surface layer of the soil is absorbed by plants, which in turn is returned to atmosphere through transpiration. Surface water or runoff flows into streams, rivers, lakes and catchment areas or reservoirs. Animals also take water which is also returned to the atmosphere through evaporation. Thus there is always a balanced continuous cycling of water between the earth's surface and atmosphere.

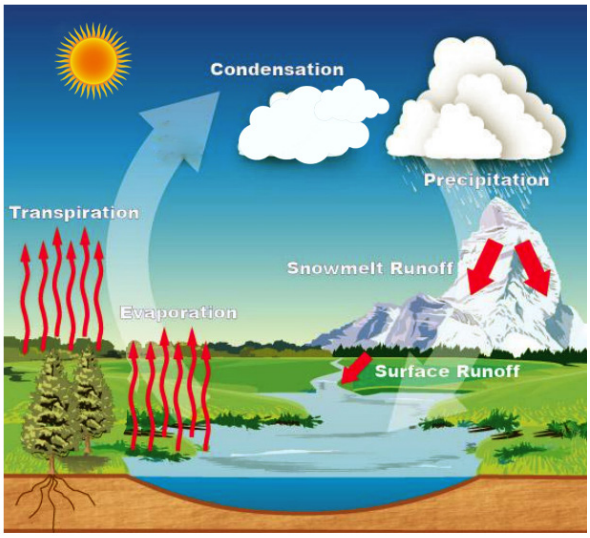

Fig1.1.3 Hydrological cycle

1.1.1.3 Lithosphere

Apart from air and water, what are the other major segments? The lithosphere is the solid, outer part of the Earth. It comprises the rocks of the earth's crust and the thin layers of soil that contain nutrient elements which sustain organisms. The lithosphere includes the brittle upper portion of the mantle and the crust, the outermost layers of the Earth's structure. It is the most rigid of the Earth's layers. Although the rocks of the lithosphere are still considered elastic, they are not viscous. The lithosphere is also the coolest of the Earth's layers.

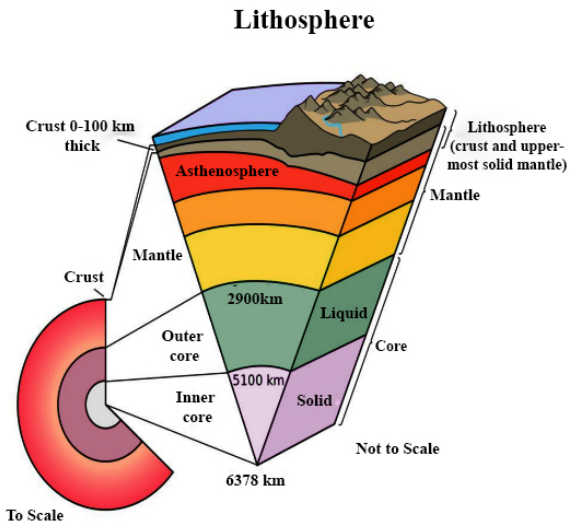

Fig 1.1.4 Composition of Earth

1.1.1.4 Biosphere

The biosphere refers to the realm of living organisms and their interactions with the environment (viz: atmosphere, hydrosphere and lithosphere). It is very large and complex and is divided into smaller units called ecosystems. The complex of living organisms, their physical environment, and all their inter relationships in a particular unit of space is called the ecosystem. Within each ecosystem there are dynamic inter relationships between living forms and their physical environment. Within the ecosystem, organisms interact with one another and with their physical environment in various ways.

On the basis of this interaction the biotic community can be grouped into the following: -

a) Producers: They are green plants which absorb carbon dioxide, mineral nutrients and water and release oxygen required for other living things on the earth.

b) Consumers: Producers are consumed by herbivorous animals that in turn are consumed by carnivorous animals or the secondary consumers. This establishes a chain known as the food chain.

c) Decomposers: The fecal matter, excreta of animals, plants, humans and other dead organisms are decomposed by the activity of bacterial fungi and other small organism which thrive on decaying organic matter. The decomposers are important because they bring the constituent elements of plants and animal bodies back to the surrounding medium or soil.

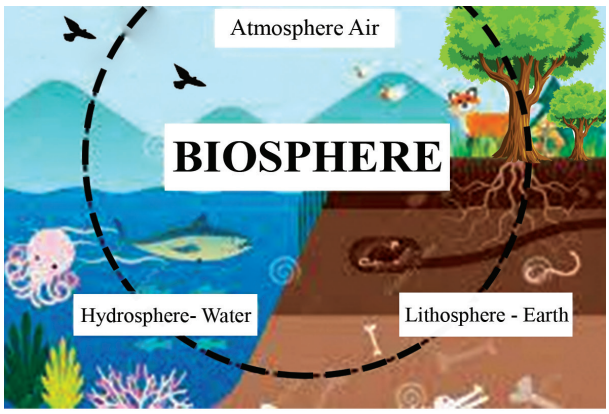

Fig 1.1.5. Interactions of Biosphere

Concepts of Climate and Weather

There are many components to weather. Weather includes sunshine, rain, cloud cover, winds, hail, snow, sleet, freezing rain, flood-

ing, blizzards, ice storms, thunderstorms, steady rains from a cold front or warm front, excessive heat, heat waves and more.

Weather can change dramatically from day to day. However, the average weather condition of a place for a longer period of time represents the climate.

Do you know the exact difference between weather and climate? The difference between weather and climate is that weather consists of the short-term (minutes to months) changes in the atmosphere. In most places, weather can change from minute-to-minute, hour-to-hour, day-to-day, and season-to-season.

However, climate is the average weather for a particular region and time period, usually taken over 30-years. An easy way to remember the difference is that climate is what you expect, like a very hot summer, and weather is what you get, like a hot day with pop-up thunderstorms. When scientists talk about climate, they are looking at averages of precipitation, temperature, humidity, sunshine, wind velocity, and phenomena such as fog, frost, hail storms, and other measures of the weather that occur over a long period in a particular place. It is relevant to study about climate and climate changes, as they affect people around the world

Table 1.1.1 The differences between weather and climate

Weather	Climate
(1) Weather is the study of atmospheric conditions for short duration of a limited area.	(1) Climate is the study of the average weather conditions observed over a long period of time for a larger area.
(2) Weather is influenced by anyone of its predominant elements i.e., temperature or humidity.	(2) Climate is the collective effect of all its elements.
(3) The weather changes very often.	(3) It is more or less permanent.
(4) It is experienced over small areas of a country.	(4) It is experienced over large area of the continent.
(5) A place can experience different types of weather conditions in a year.	(5) A place can experience only one type of climate.

Recap

- Environmental studies is a multidisciplinary approach in studying the human interactions with the environment.
- Atmosphere, hydrosphere, lithosphere and biosphere are inter-linked and control the life of the Earth.
- Weather: atmospheric conditions for a short period and limited area.
- Climate: Average weather conditions for a long period and large area.
- Composition of the earth: Crust, Mantle, Outer Core and Inner Core.

- Rocks and soil constitute the lithosphere.
- Soil is formed by the weathering process.
- Weathering is the breaking down or dissolving of rocks and minerals on Earth's surface.
- Ecosystem needs energy from chemicals or sunlight.
- Biosphere consists of all types of living organisms and their interactions with each other.
- Producers, consumers and decomposers are the integral part of biosphere.

Objective Type Questions

1. Why is the Earth called the blue planet?
2. Which is the outermost layer of atmosphere?
3. Which layer of the atmosphere constitutes a major part of ozone?
4. What is the process of warming of the Earth's surface by absorbing solar radiations that are not reflected back into space called?
5. What is the average weather conditions observed over a long period of time for a larger area called?
6. What is the frozen part of hydrosphere called?
7. What is another name for water cycle?
8. Which layer constitutes the solid outer part of the Earth?
9. What is the smallest unit of biosphere termed?

Answers to Objective Type Questions

1. 71% of the Earth contains water and appears to be blue from outer space.
2. Exosphere
3. Stratosphere
4. Greenhouse effect
5. Climate
6. Cryosphere
7. Hydrologic Cycle
8. Lithosphere
9. Ecosystems

Self Assessment Questions

1. Percentage of CO_2 in the atmosphere is …… .
2. What are the functions of atmosphere?
3. Explain the structure of atmosphere with well labelled diagram.
4. What is the average thickness of lithosphere?
5. Define biosphere.
6. Differentiate weather and climate.
7. Average weather for a particular region and time period, usually taken over 30-years is called …… .
8. Earth is called ……. because of the presence of water.

Assignment

1. Explain the various spheres of atmosphere and add required diagrams wherever needed.

Suggested Reading

1. https://www.researchgate.net/publication/310021347_Atmosphere-_Documentary
2. https://www.nios.ac.in/media/documents/316courseE/ch13.pdf
3. https://www.sathyabama.ac.in/sites/default/files/course-material/2020-10/UNIT-I_15.pdf

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Unit 2
Natural Resources

Learning Outcomes

- Learns to distinguish between renewable and non-renewable resources
- Gains knowledge about natural resources
- Gets an awareness about major types of natural resources

Prerequisites

Human beings cannot live without air, water and food. We all know that all our necessities, comforts and luxuries are provided to us by Nature. It is the natural resources that make our lives a reality.

We can never imagine a world without air or water. While some of these resources are renewable, others are not. Petroleum, fossil fuels and minerals are limited and non-renewable.

It is a matter of concern that human beings are reckless in using the resources. Over-population, exploitation of resources, environmental pollution and climate change are going to affect mankind. These activities are perilous to nature and mankind.

Keywords

Resources, Renewable, Non-renewable

Discussion

1.2.1 Concepts and major types of natural resources

You pay for everything purchased from the market. What are the things that you get from nature without paying? They are natural products. Common examples of natural resources include air, sunlight, water, soil, stone, plants, animals and fossil fuels.

Natural resources can be defined as the resources that exist (on the planet) independent of human actions. The five most important natural resources are:

1. Air: Clean air is important for all the plants, animals and humans to survive on this planet.

2. Water: 71% of the Earth is covered in water and only 2 % of that is fresh water.

3. Soil: Soil is composed of various particles and nutrients. It helps plants to grow.

4. Iron: It is made from ores and is used to build strong weapons, instruments and buildings

5. Forests: Forests provide clean air and preserve the ecology of the world.

Based on the availability, there are two types of natural resources:

Renewable Resources: Resources that are available in infinite quantity and can be used repeatedly are called renewable resources. Example: Forest, wind, water etc.

Non-Renewable Resources: Do you think that petroleum will remain as a renewable source forever? It gets exhausted. Resources that are limited in abundance due to their non-renewable nature and whose availability may run out in the future are called non-renewable resources. Examples include fossil fuels, minerals etc.

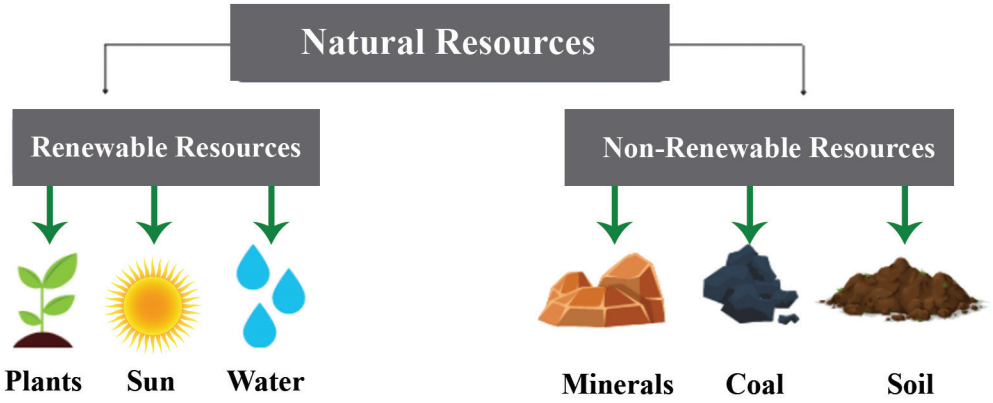

Fig 1.2.1 Renewable and Non-Renewable Resources

Fig 1.2.2 Different types of Natural Resources

1.2.2 Importance of Natural Resources

Natural resources are very important for the survival and development of mankind on this Earth. The importance of natural resources in human life is mentioned below:

1. They provide us with air to breathe.
2. Land for cultivation and growing food products.
3. Sunlight gives us solar energy, which is an important alternative source of energy.
4. Oil and natural gas give us fuel which are used in many industries and vehicles.
5. Minerals which are used as fuel and raw materials, like coal, iron ore, etc.
6. Valuable materials like gold and diamonds which are used for the jewellery industry and in many mechanical equipment.
7. Forest provides us with food, timber, fuel, and it is a shelter for many living organisms.
8. Natural resources help in industrialization and urbanization.
9. Dams which are built on rivers prevent flood, provide proper irrigation, development of fishing industry and electricity generation.

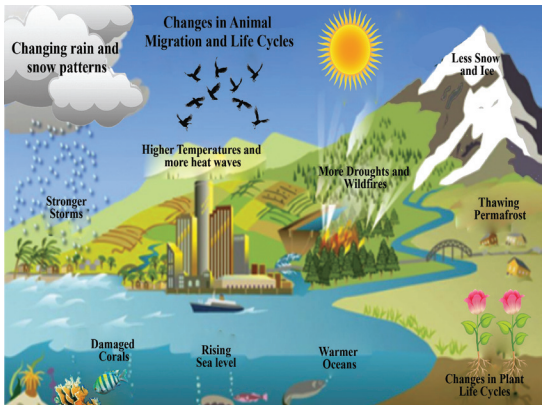

Fig 1.2.3 Threats to natural resources

1.2.3 Threats to Natural Resources

The major threats to natural resources are:

1. Overpopulation
2. Over exploitation
3. Climate change
4. Environmental Pollution

1.2.4 Conservation of Natural Resources

Conservation of natural resources is a procedure of protection and skilful management to preserve the resources provided by nature. The methods that can be used to conserve the natural resources are mentioned below:

1. Reduce, reuse and recycle. The 3R should always be followed
2. We should take part as volunteers in cleaning up our community.
3. Water should not be wasted, and rainwater should be harvested for future use.
4. Ponds and lakes should be kept clean, and digging should be done more often.
5. Dams and water reservoirs should be built.
6. Deforestation should be stopped.
7. Natural resources should be used more efficiently.
8. Public awareness of the importance of natural resource conservation should be developed.
9. Use of alternative forms of energy should be developed.
10. Plantation of trees should be practiced.
11. Pollution should be controlled by using electric vehicles and alternative forms of energy.
12. Laws on the preservation of natural resources should be strictly implemented.

Recap

- Natural resources are resources that exist independent of human actions.
- Examples of natural resources include air, sunlight, water, soil, stone, plants, animals and fossil fuels.
- Resources that are available in infinite quantity and can be used repeatedly are called renewable resources. Example: Forest, wind, water etc.
- Resources that are limited in abundance due to their non-renewable nature and whose availability may run out in the future are called non-renewable resources. Examples include fossil fuels, minerals etc.
- Over population, over exploitation, climate change and environmental pollution are major threats to natural resources.

Objective Type Questions

1. What are the two forms of oxygen found in the atmosphere?
2. What will happen, if all the oxygen present in the environment is converted to ozone?
3. What is meant by 'Ozone-hole'?
4. Give 3 examples of non-polluting renewable type of energy.
5. Which among the natural sources of energy is sustainable?
6. Which source of energy causes pollution?
7. Which type of energy is sustainable in nature?
8. Give an example for exhaustible energy source?

Answers to Objective Type Questions

1. Ozone and oxygen
2. It will become poisonous and kill living forms
3. Thinning of the ozone layer.
4. Tidal, wind, solar
5. Renewable
6. Non-renewable
7. Solar energy, Tidal energy, Wind energy
8. Coal

Self Assessment Questions

1. Differentiate between renewable and non-renewable resources.
2. Explain the significance of natural resources.
3. What are the threats faced by natural resources?
4. Describe the techniques which can be used to conserve natural resources.
5. List out some natural resources.
6. Reflect on why we need resources.
7. Coal is a …… natural resource.
8. Why certain natural resources are said to be non-renewable?

Suggested Reading

1. https://eartheclipse.com/environment/types-and-threats-to-natural-resources.html
2. https://www.adda247.com/school/natural-resources/
3. https://courses.lumenlearning.com/boundless-economics/chapter/introduction-to-natural-resource-economics/

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Unit 3
Forest Resources

Learning Outcomes

- Learns about types and classification of forests in India
- Learns about the threats to forest ecosystem
- Knows more about the conservation strategies for forest resources

Prerequisites

Have you ever heard that there are nearly 16 types of forests in India covering approximately 24.16% of the total area and more than 1550 large dams in India? India is rich in flora and fauna.

The forests in India are full of different types of plants, animals and birds. A safari through the forests can be an unforgettable and enriching experience.

Unfortunately, an average of 26000 sq. km. of forests is converted into agricultural land all over India. Deforestation and timber extraction have exceeded the limits causing threats to the entire ecosystem. The government and Non Governmental Organisations have worked out different strategies for maintaining the forests.

Keywords

Forest, Ecosystem, Deforestation, Afforestation, Reforestation, Social forestry, Agroforestry

Discussion

1.3.1 Types and classification of forests in India

Forests are important renewable resources. The Forest varies in composition and diversity and can contribute substantially to the economic development of any country. Forests in India are very diverse in their composition with a long evolutionary and geological history, occurring under diverse climatic and edaphic conditions. The forest types of India were classified for the first time in 1936 by Sir HG Champion and compiled his monumental work *Preliminary Survey of Forest Type of India and Burma*. Champion and Seth classified India's forests into 16 major types and about 221 sub-type groups which are published in *A Revised Survey of the Forest type of Indian 1968*. The detailed classification of forest types in India is based on climate, physiognomy, species composition, phenology, topography, soil factors, altitude, aspect, and biotic factors. The forests have been classified into six "major groups", ranging from tropical to alpine. These six major groups have been further classified into 16 sub-groups on the basis of temperature and moisture regimes.

Table 1.3.1 The major forest types of India (based on Champion and Seth, 1968)

Major Forest Groups	Sub Groups
I. Moist Tropical forests	Group1: Tropical Wet Evergreen Forests
	Group 2: Tropical Semi-evergreen Forests
	Group 3: Tropical Moist Deciduous Forests
	Group 4: Littoral and Swamp Forests
II. Dry Tropical forests	Group 5: Tropical dry deciduous forests
	Group 6: Tropical thorn forests
	Group 7: Tropical dry evergreen forests
III. Montane Subtropical Forests	Group 8: Subtropical broad-leaved hill forests
	Group 9: Subtropical pine forests
	Group 10: Subtropical dry evergreen forests
IV. Montane Temperate Forests	Group 11: Montane wet temperate forests
	Group 12: Himalayan moist temperate forests
	Group 13: Himalayan dry temperate forests
V. Sub alpine forests	Group 14 Sub alpine forests
VI. Alpine Forests	Group 15: Moist-Alpine Scrub
	Group 16: Dry-Alpine Scrub

1.3.1.1 Moist Tropical Forest

Fig 1.3.1 Moist Tropical Forest

Group 1: Tropical Wet Evergreen Forests

These forests are dense and show 30-45m tall canopy structure with four or five strata, generally found in regions having rainfall in the range of 2000 to > 3000 mm per year. The diversity of tree species is high in these forests. The forests are discontinuously distributed mainly along the Western Ghats, north-eastern India and Andaman and Nicobar.

Group 2: Tropical Semi-Evergreen Forest

These forests occur in areas adjoining tropical wet evergreen, and form a transition between the evergreen and moist deciduous forests. Lower canopy is evergreen, whereas canopy species are deciduous for short periods during the dry seasons. Tropical Semi-evergreen Forest type comprises 13.79% of the Indian forest types. These are dense, multi-strata, 24-36m in height. Rainfall rang-

es from 1500-2500mm per year. The canopies are not continuous and species richness is lower as compared to evergreen forests.

Group 3: Tropical Moist Deciduous Forests

These forests are common in areas where rainfall is 1000 to 2000 mm with a dry season of three to four months. Dominant trees are deciduous, lower story trees are usually evergreen. The trees shed their leaves in winter months, again become flushed in March-April. These forests comprise 19.73% of India's forest types (FSI 2011). These forests are widely distributed covering both southern and northern states including Tamil Nadu, Arunachal Pradesh, Assam, Meghalaya, Mizoram, Bihar, West Bengal, Odisha, and Uttarakhand. These forests are usually 2 to 3 strata with a much lower number of species as compared with the tropical evergreen and semi evergreen forests. The canopy trees are light demanding, middle ones are shade tolerant species of shrubs and young trees, and on ground floor are herbs and saplings. Climbers are abundant.

Group 4: Littoral and Swamp Forests

These forests consist of evergreen species of varying densities and height, usually associated with mesic habitats. These forests are mostly in their developmental stage and are serial in nature.

i. The littoral forests occur along the coast in the Andaman and Nicobar, Andhra Pradesh, Odisha, and Tamil Nadu. The most characteristic species is the tall and evergreen Casuarina on sandy beaches and dunes along the sea face. In Andaman, the forests are dominated by Manilkara littoralis.

ii. The tidal and swamp forests (mangrove scrub) are dominated by several evergreen and semi evergreen species in deltas of the Ganga and the Brahmaputra rivers.

iii. Mangroves are found along the east and west coasts of India, the Andaman and Nicobar Islands, the Gulf of Kachchh and Khambat (Gujarat). Sundarban (40% in West Bengal) is the largest mangrove in the world. Mangrove forests are generally dominated by trees of the genera – Rhizophora, Avicennia, Sonneratia, Bruguiera, and Ceriops, along with some genera like Heritiera and Xylocarpus. On the drier areas within the salt water mangrove scrub/ forests are found palm swamp.

iv. Tropical fresh water swamps such as Myristica swamp forest are found in Travancore, Kerala, and contain species such as Myristica spp., Lagerstroemia speciosa and the like.

v. The species like Baringtonia spp, and Syzygium cumini are found in swamp forests of UP and West Bengal.

1.3.1.2 Dry Tropical Forests

Fig 1.3.2 Dry Tropical Forest

Group 5: Tropical Dry Deciduous Forests

These are the largest forest type of India covering about 38.2% of the forest area of the country. Tropical dry forests occur in climates exhibiting a marked seasonality in rainfall and prolonged drought period over the annual cycle. These forests consist of trees less than 25m high, with a light demanding canopy consisting of deciduous trees, from Kanyakumari to the foothills of the Himalaya in low rainfall areas of 800 to 1200mm; large areas of these forests are suitable habitats for wildlife. Dry teak and dry sal communities predominate in the southern and northern regions, respectively.

Group 6: Tropical Thorn Forests

These forests are found in low rainfall areas (200 to 800mm) of northern India, peninsular India and central India. Moisture availability is limited for plant growth. The trees experience prolonged dry periods. The tree height ranges from six to nine meters. Southern Tropical Thorn Forests Occur in Maharashtra, Tamil Nadu and A. P. In south India, important species are Acacia chundra, Acacia planifrons and Acacia catechu. Northern Tropical Thorn Forests occur in semiarid regions of Rajasthan, Punjab, Haryana, northern Gujarat, M. P., U. P., and Delhi.

1. These forests are open, consisting of short trees, generally belonging to thorny tree species. The desert thorn type consists of Acacia senegal, Prosopis spicigera, Prosopis cineraria, Acacia leucophloea, Acacia nilotica, Ziziphus spp, and Salvadora spp. Acacia tortilis and Prosopis chilensis have been widely planted in this region.

2. The desert dune scrub are very open, irregular formations of stunted trees and bushes, are sparse and thorny. The main species are Acacia senegal, Prosopis spicigera, Acacia Arabica, Tamarix aphylla, Salvadora oleoides.

Group 7: Tropical Dry Evergreen Forests

The forests are restricted in distribution to Karnataka coast, and also reported from the east coast in A. P.. These are low growing forests; trees are of 9-12 m height, and form a complete canopy. Most conspicuous trees are Manilkara hexandra, Memecylon edule along with Diaspyros, Eugenia, Chloroxylon, Albizzia amara. There is a high diversity of trees, shrubs and herbs in these forests.

1.3.1.3 Montane Subtropical Forests

Fig 1.3.3 Montane Subtropical Forests

Group 8: Subtropical Broad Leaved Hill Forests

These forests are of the following types:

i. Southern Subtropical Broad Leaved Hill Forests in south India are found in the hill slopes and tops at about 1000 to 1700m height in Nilgiris, Palani, Tirunelveli, and Mercara hills. Main trees are Calophyllum elatum, Eugenia spp., Dalbergia latifolia, Anogeissus latifolia, Emblica officinalis, Olea dioca, and Phoenix humilis.

ii. Central Indian Subtropical Hill Forests: Hill top forests occur above 1200m in Madhya Pradesh (Pachmarhi), Bihar and Odisha. In Pachmarhi hills, Manilkara hexandra, Mangifera, Syzygium cumini are conspicuous trees.

iii. Northern Subtropical Broad Leaved Hill Forests: Occur in Arunachal Pradesh, Manipur, Mizoram, Meghalaya, Nagaland Sikkim, and west Bengal represented by east Himalayan subtropical wet hill forests. At altitude 1000-to 2000m, they occur in Khasi, Jainti and adjacent hills, dense evergreen forests, rarely exceeding 20m height. Important tree species are Quercus, Castanopsis, Alnus, Prunus, Betula and Schima. There is heavy growth of epiphytic mosses, ferns and phanerogams. Subtropical broad leaved hill forest dominated by Quercus serrata, Eugenia praecox, Schima wallichii,Rhus succidanea are located at Imphal, Manipur.

Group 9: Sub-Tropical Pine Forests

Sub-tropical chir pine (Pinus roxburghii) forests occur throughout the central and western Himalaya between 1000 to 1800m; distributed in Haryana, Himachal Pradesh, Jammu and Kashmir, Punjab and Uttarakhand. Pinus roxburghii along with broad leaved species is the main characteristic of these forests. Climbers and bamboos are absent.

Group 10: Sub-Tropical Dry Evergreen Forests

These forests are distributed in Bhabar tract, Shiwalik hills, and the foothills of western Himalaya. In Punjab, Uttarakhand, and Himachal Pradesh, Olea cuspidata is found on alluvial ground of wider valleys. In Jammu and Kashmir, the dominant species of these scrub forests are Olea cuspidate, Acacia modesta, and Dodonaea viscosa

1.3.1.4 Montane Temperate Forest

Fig 1.3.4 Montane Temperate Forest

Group 11: Montane Wet Temperate Forest

The southern Montane wet temperate forests are closed evergreen forests, trees here are mostly short boled (not exceeding 6m), and highly branched. The branches are clothed with mosses, ferns and other epiphytes and woody climbers are common. The northern Montane wet temperate forests are a characteristic feature of the eastern Himalaya and are found between 1800 m and 3000 m elevation in high rainfall areas (>2000mm rainfall).

Group 12: Himalayan Moist Temperate Forests

These forests extend to the whole length of the Himalayan region between the sub-tropical pine forests and sub-alpine forests. Altitude ranges from 1500m to 3300m. These are concentrated in the central and western Himalaya, except in areas where rainfall is below 1000 mm. They are distributed in Kashmir, Himachal Pradesh, Punjab, Uttarakhand, Darjeeling and some districts of West Bengal, Assam, and Sikkim.

i. Several species of oak predominate in the temperate forests including Quercus leucotrichophora, Quercus. Floribunda, Quercus incana, Quercus semecarpifolia, Quercus dilatate and Qlarginosa. All oak species in the Himalayan region are evergreen showing leaf fall in summer, but are never leafless. There are four strata, 25-30m height, tree canopy is dense, herbaceous layer not well developed, grasses generally lacking, and rich in epiphytes.

ii. Most Cedrus deodara forests form pure stands, canopy is fairly complete, boles are straight and tall (30-40m). There are scattered oaks and Rhododendron under the conifers. The evergreen Cedrus deodara forest surrounding the Khajjiar lake located at 1920 m above mean sea level in Khajjair, Chamba district, Himachal Pradesh in western Himalaya.

iii. As the altitude increases, the upper form consisting of Abies pindrow, Picea smithiana, and Quercus semecarpifolia become dominant.

iv. The eastern Himalayan hills are occupied by Quercus lineata, Quercus lamellosa, Quercus pachyphylla, Rhododendron spp., Tsuga dumosa, Picea spinulosa and Abies densa.

v. Cupressus torulosa is a conspicuous species found on limestone rocks from Chamba (Himachal Pradesh) to the Aka hills at 1800 to 2800 m.

Group 13: Himalayan Dry Temperate Forests

Conifers predominate, distributed on 1700 to 3000m altitude, in the inner ranges of the Himalayas, Rainfall is usually less than 1000mm, mostly received as snow in winter months. They are distributed in Kashmir, Ladakh, Lahaul, Chamba, inner Garhwal, and Sikkim.

i. Coniferous forests are tall (30-35m) and have evergreen canopy.

ii. These forests consist of both coniferous and broad-leaved species. In the western Himalayas, the characteristic species are Pinus gerardiana, Cedrus deodara and Juniperus. At higher elevation, Abies pindrow, and Pinus wallichiana are found.

iii. In the eastern Himalaya, the common species are from Abies and Picea. In higher hills, Juniperus wallichiana is common.

iv. Locally, between 2500 and 4000 m elevation, a few other species like Larix griffithiana, Populus eupheretica, Salix spp., Hippophoe spp. and Myricaria spp. also occur.

1.3.1.5 Sub-Alpine Forests

Group 14: Sub-Alpine Forests

The subalpine forests occur throughout the

Himalaya above 3000 m elevation up to the tree limit., rainfall 83-600mm. The forests are mainly evergreen Rhododendron. Tall trees are conifers; Betula utilis is present as the largest deciduous tree and associated with genera like Quercus semecarpifolia, Sorbus, and Rhododendron sp.

i. Western Himalaya sub-alpine forests are reported in Jammu and Kashmir, Himachal Pradesh, and Uttarakhand. In the western Himalaya, there are two types of forests (i) Abies spectabilis and Betula utilis, (ii) west Himalayan sub-alpine birch/fir forest.

ii. In the eastern Himalayas, these forests occur above 3000m and are distributed in Arunachal Pradesh, Sikkim, and West Bengal. There is a predominance of Abies densa and Betula utilis, and Rhododendron spp. These are climax formations, self-generating with marked resilience.

1.3.1.6 Alpine Forest

Fig 1.3.5 Alpine Forests

Group 15: Moist- Alpine Scrub

Moist Alpine Scrub occurs throughout the Himalayas, above timber line to 5,500m altitude, composed entirely of species of Rhododendron with some birch (Betula) and other deciduous trees. The tree trunks are short and highly branched, moss and ferns cover the ground. A thick layer of humus is present and soil is generally wet.

i. In Kumaun, Uttrakhand, Betula utilis and Rhododendron campanulatum scrub forest occur. Rhododendron- Lonicera association occurs in Uttrakhand, in the inner Himalayas.

ii. In eastern Himalayas, dense Rhododendron thickets occur at 3350-4600m altitude. These forests are reported in Arunachal Pradesh, Sikkim and west Bengal.

Group 16: Dry- Alpine Scrub

It is a xerophytic formation, having predominance of dwarf shrubs; rainfall < 370mm per year. Characteristic plants are Juniperus wallichiana, Lonicera spp and Potentilla spp. Vegetation along the streams is composed of Salix, Myricaria, and Hippophae rhamnoides. These scrub forests are distributed in Jammu and Kashmir, Himachal Pradesh, Uttrakhand, and Arunachal Pradesh. In the eastern Himalayas, Juniperus recurva and Juniperus wallichiana occur at an altitude ranging from 3000 to 4600m.

1.3.2 New Classification of Forest Types of India

Recently, a new classification of forest types has been proposed, reflecting the present ecological, climatic, bio-geographic and edaphic influences on the vegetation composition and stand formation. (CFRE 2013; Bahuguna et al. 2016). India's forest types are very diverse in their compositions with a long evolutionary and geological history, occurring under many

climatic and edaphic conditions. They have been undergoing significant changes in the composition of forests since the forest types were revised by Champion and Seth (1968). The revised classification of forests has been based on the field survey covering more than 200 forest types and subtypes representing very diverse climatic and edaphic conditions throughout the country. Data were collected from the field surveys in terms of forest types, basal area, importance value index, stem density and diversity indexes including similarity indexes. Impact of climate change on the vegetation has been critically examined. In the proposed new classification, 10 major groups and 48 sub-groups have been identified. The study has reported many changes occurring at species and forest subtypes levels. There are some positive and negative changes in different forest types. Some trends in the new classification of forest types are summarized as follows:

1. The species level changes were observed largely in Shorea robusta (Sal), Tectona grandis (Teak) and Bamboo forests with regard to their distribution and species density. The study has revealed that teak is found absent in very moist areas.
2. In central India, the decline of Shorea robusta (Sal) and occurrence of dry deciduous species, fragmentation and changes in the species composition due to anthropogenic and climate changes were noticed.
3. The vegetation composition, particularly on the alpine flora is experiencing the effect of climate change.
4. There are changes in species composition of Shola forests and evergreen forests.
5. The forests in Andhra Pradesh, Karnataka and Gujarat have shown positive changes in the forest composition and density.
6. Analysis based on national level data showing change in temperature and rainfall patterns reveal that many forests are moving towards drier conditions, particularly the temperate forests. There are changes in the pattern of distributions of Oaks and Conifers.
7. The blue pine (Pinus wallichiana) found in the higher elevations up to 1700 m is now found in still higher elevations up to 2700 m showing the shift in the tree lines towards higher elevations.

At the beginning of the 20th century about 30% of land in India was covered with forests. But by the year 2015 the forest cover has been reduced to 21.34%. In 2015, of the existing forests, about 2.61% were very dense forests (canopy cover 70% or more), 9.59% moderately dense forests (canopy cover 40% or more but less than 70%), 9.14% open forests (canopy cover 10% or more but less than 40%), and 1.26% scrub forests (canopy cover less than 10%) (FSI 2015). Mizoram, with 88.93 % of forest cover has the highest forest cover in percentage terms, followed by Lakshadweep (84.56%). Madhya Pradesh has the largest total forest cover (77, 462 km^2) in India, followed by Arunachal Pradesh (67,248 km2) and Chhattisgarh (55,586 km^2).

Threats to forest ecosystem

Forests are among the most biodiverse and valuable terrestrial ecosystems on the planet. However, maintaining forests and their biodiversity is both complex and sensitive, and natural and human impacts on forest ecosystems is making this increasingly difficult.

Over exploitation

Over 72% of species are threatened by over-exploitation and 62% by agriculture out of the 9,000 species listed on the International Union for the Conservation of Nature's Red

List of Threatened Species. Overexploitation of the unsustainable harvest of species from the wildis putting more species on an extinction pathway than any other threat. The expansion and intensification of agriculture (the production of food, fodder, fibre and fuel crops; livestock; aquaculture; and the cultivation of trees) is the second-largest driver of biodiversity loss. Hunting is a threat to more than 1,600 species, including many large carnivores such as tigers and snow leopards. Unsustainable logging is driving the decline of more than 4,000 species, such as Australia's Leadbeater's possu, while more than 1,000 species, including southern bluefin tuna, are losing out to excessive fishing pressure. Land change for crop farming and timber plantations imperils more than 5,300 species, such as the far eastern curlew, while the northern hairy-nosed wombat is one of more than 2,400 species affected by livestock farming and aquaculture.

Timber extraction

There has been unlimited exploitation of timber for commercial use due to increased industrial demand. Timber extraction has significant effect on forest and tribal people.

Deforestation

Deforestation is a serious form of environmental degradation. It is a global phenomenon and the global assault on forest continues to be present.

The forest occupies more than a quarter of the world land. They are not just the source of timber wood but they also perform social and ecological functions. They have the wealth of lands and animals of various kind; they utilize and accumulate carbon and thus stabilize the global climate. Deforestation means clearance of forest by human activities which take place in the following manner:

1. By reckless and ruthless cutting of trees on the forest areas.
2. By forest fires set by farmers for plantation purpose in forest areas.
3. Air pollution.

Thus it is because of human activities that forests are exploited and damaged.

1.3.3 Mining

Major effects of mining operations on forests:

- Mining from shallow deposits is done by surface mining while that from deep deposits is done by sub-surface mining. It leads to degradation of lands and loss of top soil. It is estimated that about eighty-thousand-hectares of land is under stress of mining activities in India
- Mining leads to drying up perennial water sources like springs and streams in mountainous areas.
- Mining and other associated activities remove vegetation along with underlying soil mantle, which results in destruction of topography and landscape in the area. Large scale deforestation has been reported in Mussorie and Dehradun valleys due to indiscriminate mining.
- The forest area has declined at an average rate of 33% and the increase in non-forest area due to mining activities has resulted in relatively unstable zones leading to landslides.
- Indiscriminate mining in forests of Goa since 1961 has destroyed more than 50000 ha. of forest land. Coal mining in Jharia, Raniganj and Singrauli areas has

caused extensive deforestation in Jharkhand.

- Mining of magnetite and soapstone has destroyed 14 ha. of forest in hilly slopes of Khirakot, Kosi valley and Almora.
- Mining of radioactive minerals in Kerala, Tamil Nadu and Karnataka are posing similar threats of deforestation.
- The rich forests of Western Ghats are also facing the same threat due to mining projects for excavation of copper, chromites, bauxite and magnetite.

Effects of dams on forests and tribal people

Pandit Jawaharlal Nehru referred to dam and valley projects as "Temples of modern India". These big dams and river valley projects have multi-purpose uses. However, these dams are also responsible for the destruction of forests. They are responsible for degradation of catchment areas, loss of flora and fauna, increase of water borne diseases, disturbance in forest ecosystems, rehabilitation and resettlement of tribal peoples. India has more than 1550 large dams, the maximum being in the state of Maharashtra (more than 600), followed by Gujarat (more than 250) and Madhya Pradesh (130).

1.3.4 Environmental Impact of Large Dams

Large dams have led to extensive decimation of forest due to submergence by reservoirs and the dereservation and, clearance of forest lands for the resettlement of osteer. Both forests and good farmland have been appropriated by reservoirs, canals, and other infrastructure connected with river valley projects. Rivers and the ecosystems they support are unique. Irreparable environmental damage is caused by the construction of large-scale dams. Some of these are considered here.

1. Change in downstream morphology and water quality

a) Rivers provide energy for a number of vital processes such as transport of nitrogen, organic matter and nutrient rich silt, oxygen enrichment, and entertainment of nutrients in bottom pediments in downstream entries, deltasand coastal areas, upon which the health of the fishes is dependent. Any water management scheme that reduces runoff by more than 25% will result in negative effects on coastal and estuarine fisheries and subsequent depletion of fish catches.

b) Dams trap the sediment eroded from soils and rocks by the river. Clear water below the dam then seeks to recapture its lost sediment and erodes the soil on the bed and banks downstream from the dam. Loss of sediment is particularly important on the delta of the river as it leads to further eroding of the coast. Increased sediment flow also adversely affects the dam's capacity for hydro power generation.

c) Flowing water undergoes rapid thermal, chemical and physical changes. Deterioration of water quality is said to increase with retention time due to loss of dissolved oxygen.

2. Loss of forest and biodiversity

The most dramatic ecological effect of a dam project is the flooding of vast areas of forest wetlands, cultivated land and wildlife. It is estimated that approximately 40,000 sq.km. have been flooded by such dams world wide..

Good forest cover is essential for curbing soil erosion, yet catchment areas of reservoirs usually experience rapid deforestation, leading to landslides, heavier water flow into the reservoirs, and eventually, siltation processes which ironically threaten the viability of riv-

er valley projects themselves. High siltation rates have dramatically reduced the life expectancy to be unsuitable for agriculture.

3. Salinity and pollution

Dams cause massive evaporation loss, resulting in increasing salinity to dangerous levels. Reduction in the flow of water and silt caused by dams has a negative impact on downstream ecosystems and it also adversely affects the fertility of agricultural land. Delta areas suffer from ingress of sea water. Reduced flow of water in many rivers also has increased the level of pollution, making river water unusable for humans and animals.

4. Earthquakes

Large dams built along fault lines or in geologically unstable regions can trigger earthquakes due to the pressure exerted by the weight of water in reservoir and the dam itself, which in turn can destroy the dam leading to widespread flooding. This danger was evidenced by devastating earthquake at Koyanagar near the Koyna dam reservoir in Maharashtra in 1967. Although India has already experienced dam induced earthquakes, the government is pushing ahead with its plans to build the Tehu dam in a seismically sensitive region, the Garhwal Himalayas in the face of opposition by experts and local people and despite the warning sign of a major earthquake in the region in 1992.

5. Design / Construction problems

Dams may burst even in the absence of tremor due to poor construction, as in the case of the Machu dam (Gujarat) which bust in 1979 leading to widespread destruction and death caused by flooding. Large dams and their reservoir disrupt local ecosystem in multiple ways and those effects cannot be easily measured in terms of economic costs and benefits. As in the case of forests, loss of biodiversity is not factored into cost benefit analyses.

6. Resettlement

People who lose their homes and lands because of large scale development projects are called environmental refugees. Displacement takes place very easily because it involves largely tribals. These tribal are mostly uneducated and are unaware of their rights. They are forced to moved around without considering the economic and psychological impacts of such action on them. Hence displacement takes place without the knowledge of the affected population, who do not have any sense of participation in the project nor do they get any share of the benefits. This problem of displacement is compounded by the fact that even land records of the displaced population are not up to date and hence there is no guarantee that the benefits will reach the right person.

1.3.5 Conservation strategies

Conservation is the preservation and protection of natural assets for the future generations. It incorporates keeping up with variety of species, qualities, and biological systems, as well as elements of the climate, like nutrient cycling. Some of the conservation measures practiced in India and other parts of the world are as follows:

1. Increase in area of forest plantation: Planting of trees can be made in vacant or unused lands and waste, degraded and marginal lands, especially on road side, along railway tracts, on contours and on land not suited for agricultural production. Planting trees outside forest areas will reduce pressure on forests for timber, fodder and fuel wood. Apart from this, the deforested areas need to be reforested.

2. Developing alternative sources and promoting substitutes: It has become necessary to find alternative fuels as well as raw materials to manufacture paper, sports goods, packing cases, furniture and beams used in buildings.

Research is going on to develop alternate sources; in some cases, plastics and composite materials have been successful in replacing the use of timber.

3. Increase the area of forest permanently reserved for timber production: The most serious impediment to sustainable forest management is the lack of dedicated forests specifically set aside for timber production.

4. Developing a reliable mechanism of information base and regular monitoring: Knowledge of how much forest, where it is and what it is comprised of seems to be straightforward. However, surprisingly, this most basic information is not always available. It is not possible to properly manage a forest ecosystem without first understanding it. Remote sensing technologies make it feasible and affordable to identify hotspots of deforestation.

5. Establishing an effective system of fighting forest fires.

6. Strictly enforcing laws to deal with unauthorized cutting of trees.

7. Promoting agro-forestry and social forestry: Agroforestry is the interaction of agriculture and trees, including the agricultural use of trees. This comprises trees on farms and in agricultural landscapes, farming in forests and along forest margins and tree-crop production, including cocoa, coffee, rubber and oil palm. Rural people partly meet their needs for fire wood and small timber by growing fast growing trees planted within the limits of their village, along the footpaths, roadsides, alongside railway tracks, side roads or canals and streams, boundaries of fields and empty spaces. The aim of social forestry is to meet the needs of fuel, fodder, fruits, timber and other requirements of local people.

8. Participatory forest management and rights: All stakeholders with an interest in the fate of the forest should be involved in planning, management and benefit sharing. The balance of rights can be tilted strongly toward society in the form of publicly owned strictly protected areas. As of now much of the world's tropical forests are state owned but community participation in forest ownership and management needs to be encouraged. Moreover, the rights of indigenous forest dwellers and others who depend on intact forests must be upheld by recognition of traditional laws of the indigenous peoples as indigenous rights. This will address the conflicts between customary and statutory laws and regulations related to forest ownership and use of natural resources while ensuring conservation of forest resources. Keeping this in view various state governments in India have been implementing Joint Forest Management Program after successful implementation in West Bengal and Haryana in 1970's.

Reforestation

The Intergovernmental Panel for Climate Change (IPCC) defines reforestation as an establishment of a forest cover in a location where the forests have been cleared in the recent past, usually to use the land for activities like agriculture or mining. Reforestation is also important for a number of other reasons including the fact that 1.6 billion people worldwide rely on forests for their livelihoods. Additionally, forests have been shown to have benefits related to anti-erosion, flood control, water security, soil protection/production and the maintenance of biodiversity.

Afforestation

Afforestation stands for the establishment of forests where previously there have been none, or where forests have been missing for a long time. The IPCC Guidelines define afforestation as the "planting of new forests on lands which, historically, have not contained forests."

Fig 1.3.6 Kerala Man M. R. Hari Grows 400-Tree Forest in 3 Cents of Land

Table 1.3.2 Difference between afforestation and reforestation

Afforestation	Reforestation
Afforestation is the construction of a completely new forest in unused land, where no forest existed.	Reforestation is the reestablishment of a forest by planting trees in existing forest land.
Afforestation is meant for growing trees in new areas.	Reforestation is done in an area where a forest was destroyed.
Here, only one sapling is needed to plant for a single tree.	Here, two saplings are planted to eliminate each chopped down tree.
It is done to increase forest areas and to eliminate the effects of deforestation.	It is done to eradicate the negative impacts of burning forests for cultivation.
Afforestation may lead to the destruction of the grassland ecosystem.	Reforestation needs more labour and, thus, is found to be costly.

1.3.6 Social Forestry

Social forestry is forestry outside conventional forests, which primarily aims at providing continuous flow of goods and services for the needs of local people. Social forestry was first recognized as an important component of forestry development in the Interim Report of the National Commission on Agriculture 1976 and later in National Forest Policy 1988. The objective is to organize local communities in their struggle for socio-economic development and to integrate economic gains in the distribution of their benefits to the rural society. It includes raising wind breaks on dry farm lands, planting trees along roadsides, planting in village common lands and waste lands, along railway lines and canal banks, on common community lands like religious places, educational areas and panchayat lands etc.

Benefits of social forestry:

- Fuel, fodder, timber, supplemen-

tary food and income from surplus forest products and tree derived resources for rural people.
- It can form villagers into a well-knit community and increase social cohesion
- Reclamation of waste lands and degraded lands along with soil conservation and green cover.
- Protection of agricultural fields from winds and dust storms.
- Check desertification.

1.3.7 Agroforestry

Agroforestry is the management and integration of trees, crops and/or livestock on the same plot of land. It combines agriculture and forestry by planting viable tree shelter belts along agricultural lands. It is a dynamic, ecologically based, natural resource management system that diversifies and sustains production in order to increase social, economic and environmental benefits for land users. Agroforestry is derived from the concept of ecology and places an emphasis on interaction between different plant species. It results in higher overall yields and reduced operational costs.

Benefits of agroforestry:

- Maintains soil organic matter and biological activity at levels satisfactory for soil fertility.
- Controls runoff and soil erosion and maintains required soil moisture.
- Maintains more favourable soil physical properties than agriculture, through organic matter maintenance and the effects of tree roots.
- Promotes more closed nutrient cycling than agriculture and hence to more efficient use of nutrients.
- Nitrogen-fixing trees and shrubs can substantially increase nitrogen inputs to agroforestry systems.
- Decomposition of trees and pruning can substantially contribute to maintenance of soil fertility.
- Helps in income diversification thereby reducing agricultural dependency of farmers.

Table 1.3.3 Distinction between Social Forestry and Agroforestry

Social Forestry	Agroforestry
1. Social forestry is a plantation made on lands outside conventional forest areas for the benefit of rural and urban communities, with objectives to supply fuel wood, to divert cow dung from village hearths to village fields, small timber for housing and agricultural implements and fodder for cattle of the rural population, protection of agriculture by creation of diverse ecosystem and arresting wind and water erosion, provide raw material for village cottage industries and improve scenic value in rural and urban areas.	1. Agroforestry is a sustainable land management system that increases the overall production, combines agricultural crops, tree crops and forest plants and/or animals simultaneously or sequentially, and applies management practices that are compatible with the cultural patterns of the local population.

Social Forestry	Agroforestry
2. It is the forestry of the people, by the people and for the people.	2. It is a system which is rather localized in its concept for managing the unit of land for maximising production of agricultural crop and forest trees complimentary with each other.
3. Planting of trees on massive scales is done on vacant land, community land, roadside, railway track and even degraded reserve forests. Helps to eradicate poverty especially among landless and marginal rural people by providing them job potential.	3. Agroforestry is practiced mostly in farmers' field/own land.
4. Mainly trees and shrubs are to be used to harvest multiple products.	4. It involves integration of two or more than two components in the same unit of land.
5. Social forestry is primarily a government-based programme that aims at increasing the forest area by rehabilitating wastelands while producing biomass both for industrial and local uses.	5. Agroforestry involves the rural awakening towards self-sufficiency by producing maximum biomass per unit area, fulfilling needs of food, fodder, fuel wood etc..

Recap

- Forest is an important renewable resource.
- Over exploitation, timber extraction, deforestation are the threats to forest ecosystem.
- Afforestation is the construction of a completely new forest in unused land, having no forest formerly.
- Reforestation is the reestablishment of a forest by planting trees in existing forest land.
- Deforestation refers to the destruction of forests for agriculture, industrialization, and urbanization.
- Social forestry is forestry outside conventional forests, which primarily aims at providing continuous flow of goods and services for the needs of local people
- Agroforestry is the management and integration of trees, crops and/or livestock on the same plot of land.

Objective Type Questions

1. Why should we conserve forest and wild life?
2. What are reserved and protected forests also referred to as?
3. Who started the Chipko Movement in the Himalayas to protect the forest?
4. What percent of land in India is covered with forest and trees?
5. What types of land all over India, measuring over 26,000 sq km of forest area have been converted into, according to Forest Survey of India
6. What is the name given to forests exclusively used for the conservation of forest and wildlife resources?
7. What is the approximate percentage of total forests in India declared as protected forest by the department of forest?
8. Which forests are also called Monsoon Forests?

Answers to Objective Type Questions

1. To maintain ecosystem
2. Permanent Forest estate
3. Sunder Lal Bahuguna
4. 24.16%
5. Agricultural land
6. Reserved Forest
7. 33%
8. Tropical deciduous forest

Self assessment Questions

1. Forests are …….. resources
2. List out the major groups of soil
3. Describe tropical wet evergreen forests.
4. Differentiate evergreen and deciduous forests.
5. Explain the features of tropical thorn forests.
6. Coniferous trees are found in …… .
7. Comment on the new forest classification in India.
8. Write an essay on the threats to forests.

Suggested Reading

1. https://www.ceeindia.org/CEE-Academy-resouce/PDF/Forest%20ecosystem%20Forest%20Types%20of%20India.pdf
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Unit 4
Water Resources

Learning Outcomes

- Gains knowledge about global distribution of water
- Learns about different water resource types
- Learns about threats to water resources and conservation methods

Prerequisites

We are already familiar with the saying "Water, Water, everywhere but not a drop to drink". Do you know that water is almost everywhere? It is in the air, clouds, rivers, oceans, plants and living organisms.

We have to understand that over 96% of world's supply of water is saline and not fit for drinking. And fascinatingly, over 68% of fresh water is locked up in ice and glaciers. Life is impossible without water.

Water is used for several purposes – drinking, domestic, industrial, agricultural uses etc. Can you imagine a day when the world is short of potable water? Potable water is nothing but drinking water.

If we continue the style and practices of today, that day is not very far for the extinction of all life on earth. The threats to drinking water system are many, including both man-made and natural.

The world has recognised the danger. Several plans and projects are on the anvil to avoid the peril. Water harvesting system, watershed management, ground water re-charging etc. are some of them.

It is strange that though there is very little rain in Tamil Nadu compared to Kerala, the Keralites depend on TN for almost all the vegetables. Tamil Nadu is the only state in India which has made rooftop rainwater harvesting structure compulsory to all the houses.

Keywords

Flood, Drought, Groundwater, Surface water, Rainwater Harvesting, Waste water, Watershed, CRZ

Discussion

1.4.1 Global distribution of water

What is the source of drinking water in your house? Some of you may be using well water, river water, ponds or pipeline. Earth's water is (almost) everywhere in the air and clouds and in rivers, oceans, ice, plants, and in living organisms. The distribution of water on the Earth's surface is extremely uneven.

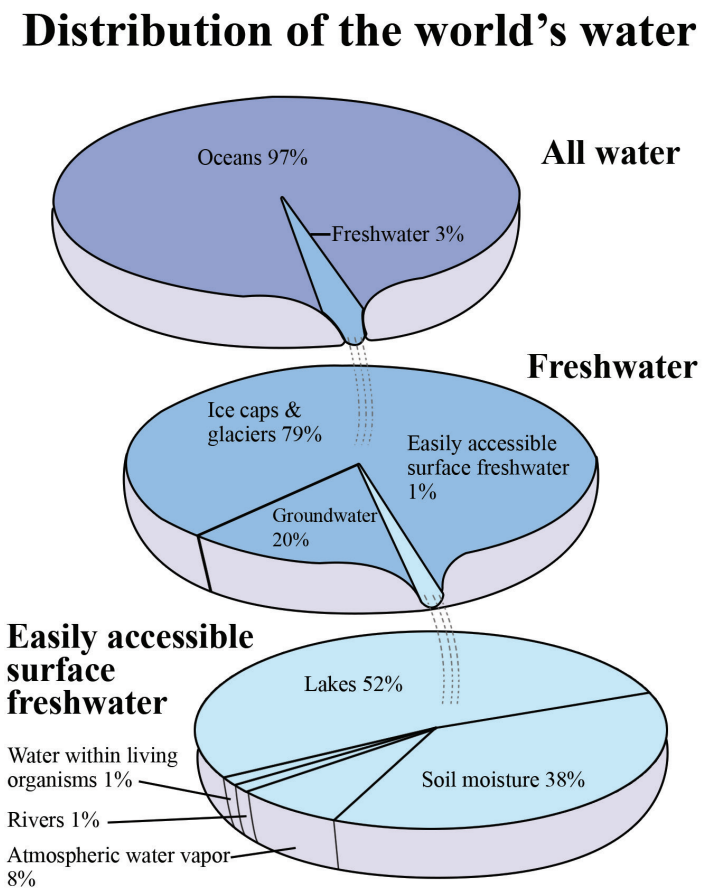

Fig 1.4.1 Global distribution of water

Table 1.4.1 Global distribution of water

Distribution	Abundance in Percentage
Oceans and Seas	97.4
Ice Caps and Glaciers	1.98
Groundwater and Soil water	0.599
Lakes	0.007
Atmosphere	0.001
Rivers	0.0001

Of the world's total water supply of about 332.5 million cubic miles of water on earth, over 97% is saline water and is confined in the open ocean and seas. The remainder 3% is fresh water on the land, and the major chunk of fresh water is held up in the snow covered continents and mountain regions in the form of ice caps and glaciers. The remaining fresh water on land, like groundwater (0.6%), lakes (0.007), water vapour in atmosphere (0.001) and river water (0.0001%) is very small in abundance compared to the total water on earth.

If we consider the freshwater on land alone, of the total freshwater, over 79% is locked up in the ice and glaciers. Another 20% of freshwater is groundwater occurring within the earth. However, the easily accessible surface freshwater constitute only 1%.

Among the easily accessible fresh water on land, major portion is in lakes (52%), followed by soil moisture (38%), water vapour in atmosphere (8%), living organism (1%) and river (1%). The important thing to be realised is that the volume of water in river is very small (0.0001%) compared to the total volume of water on globe, and hence river water has to be used very judiciously when we plan for sustainable river water management projects.

1.4.2 Water resource types

The world's water exists in nature in different forms and locations: in the air, on the surface, below the ground and in the oceans.

Saltwater– 97%

As you are aware, the majority of water on the Earth is salty! Chloride and sodium are the most abundant ions found in salt water. Other ions or elements, particularly in the oceans, include magnesium, sulphur, calcium, potassium, and many more. These ions form salt, giving oceans, seas, and some lakes their salty or saline characteristics. Humans cannot use saltwater directly. Before humans can use saltwater for drinking or farmland irrigation, it must be treated to remove the salts, through a process called desalinization. Desalinization is costly and requires a lot of energy, but for places that are extremely dry this process can provide people with much needed freshwater.

Surface water

Surface water is water in a river, lake, pond or fresh water wetland. It is naturally replenished by precipitation and naturally lost through discharge to the oceans, evaporation, evapotranspiration natural input to any surface water system is precipitation within its watershed, the total quantity of water in that system at any given time is also dependent on many other factors. These factors include storage capacity in lakes, wetlands and artificial reservoirs, the permeability of the soil beneath these storage bodies, the runoff characteristics of the land in the watershed, the timing of the precipitation and local evaporation rates. All of these factors also affect the proportions of water loss.

Lakes

Lakes constitute a type of surface water that is easily accessible and visible on the surface of the Earth. Lakes form where water runoff from rain and snow accumulates. In some places, lakes form in areas where groundwater seeps up to the surface. Lakes come in a variety of shapes and sizes, and can contain salty or fresh water. The Earth's oldest and largest lake, Lake Baikal in Siberia, has a depth of over 1,500 m. or 1 mile! Freshwater lakes are highly valued as places of recreation and water supply.

Estuary

Estuary is a water body where fresh water

and salt water meet. An estuary is a partially enclosed coastal body of brackish water with one or more rivers or streams flowing into it, and through it, into the open sea. Normally, estuaries form a transition zone between river and marine environments. All estuaries have a free connection, either continuous or intermittent. They tend to be very rich in organisms. Rivers, before they are diluted by the enormous body of ocean water, have generally high concentrations of many chemical elements needed by plants and animals to build their tissues.

Rivers

Rivers form where water flows downhill, due to gravity, making a journey from the tops of mountains to the sea. Many different plant and animal species can be found along rivers. Although rivers make up a small proportion of the Earth's water resources, they have and continue to be, an important resource for humans, serving as transit systems for exploration and transport of goods, power generation, recreation, and a source of freshwater.

Groundwater

Groundwater is fresh water located in the subsurface pore space of soil and rocks. It is also water that is flowing within aquifers below the water table. Sometimes it is useful to make a distinction between groundwater that is closely associated with surface water and deep groundwater in an aquifer (sometimes called "fossil water"). The natural input to groundwater is seepage from surface water. The natural outputs from groundwater are springs and seepage to the oceans. Water from rain trickles downward through the soil until it reaches material that is already saturated with water. Depending on the depth of this area and the how fast the water has filtered through the soil, groundwater can be days to thousands of years old. Places where groundwater collects in water wells are called aquifers. Aquifers can be quite large – the Great Artesian Basin in Australia is one of the deepest and largest in the world, covering 1.7 million square kilometres (660,000 square miles) or 23% of the Australian Continent. Humans rely heavily on groundwater for drinking, farming, and other uses; but over-use, pollution, and sea level rise threaten this precious resource.

Frozen water

Frozen water is found as a persistent body of dense ice in water bodies, otherwise called as glaciers. Glacier runoff is considered to be surface water and glacial ice is the largest reservoir of fresh water. The Himalayas, which are often called "The Roof of the World", contain some of the most extensive and rough high-altitude areas on the Earth as well as the greatest area of glaciers and permafrost outside of the poles. Ten of Asia's largest rivers flow from there, and more than a billion people's livelihoods depend on them. To complicate matters, temperatures there are rising more rapidly than the global average.

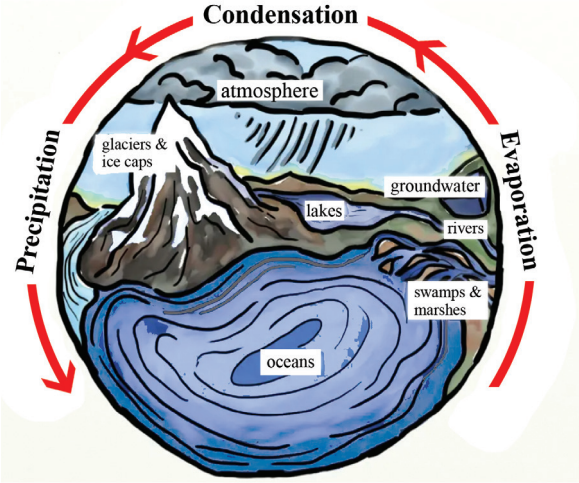

Fig 1.4.2 Water moves between these reservoirs through processes that transfer energy across the globe.

Ice

Most of the freshwater on the Earth is frozen. So much of our water is frozen, that if all of it melted at once, the sea would rise about 6 meters (20 feet)! Ice is made of freshwater, even ice floating in oceans and seas. This is because saltwater freezes at much lower temperatures than freshwater and very cold saltwater is so dense it sinks away from the surface where freezing takes place. Ice is found at the north and south poles as ice caps, as glaciers on high mountains and at high latitudes, and in regions with permanent snow and permafrost (frozen soils). Approximately 90% the Earth's ice is in Antarctica.

1.4.3 Water availability and water uses

1. Drinking water and domestic use (household)

It is estimated that 8% of world water use is for domestic purposes. These include drinking water, bathing, cooking, toilet flushing, cleaning, laundry and gardening. Drinking water is water that is of sufficiently high quality so that it can be consumed without risk of immediate or long-term harm. Such water is commonly called potable water.

2. Agriculture

It is estimated that 70% of world water is used for irrigation, with 15–35% of irrigation withdrawals being unsustainable. To avoid a global water crisis, farmers will have to strive to increase productivity to meet growing demands for food, while industry and cities find ways to use water more efficiently. Changing landscape for the use of agriculture has a great effect on the flow of fresh water.

3. Industries

It is estimated that 22% of world water is used in industry. Major industrial users include hydroelectric dams, thermoelectric power plants, which use water for cooling, ore and oil refineries, which use water in chemical processes, and manufacturing plants, which use water as a solvent. Water withdrawal can be very high for certain industries, but consumption is generally much lower than that of agriculture.

4. Environment

Water usage of environment is also very small but there is a growth in the percentage of total water use. Environmental water usage includes watering of natural or artificial wetlands, artificial lakes intended to create wildlife habitat, fish ladders, and water releases from reservoirs timed to help fish spawn, or to restore more natural flow regimes. Environmental usage is non-consumptive but may reduce the availability of water for other users at specific times and places.

5. Recreation

Recreational water use is mostly tied to lakes, dams, rivers or oceans. If a water reservoir is kept fuller than it would otherwise be for recreation, the water retained could be categorized as recreational usage. Examples are anglers, water skiers, nature enthusiasts and swimmers. Recreational usage is usually non-consumptive. However, recreational usage may reduce the availability of water for other users at specific times and places.

Water scarcity

You might have seen people in search of water in drought prone areas. Water scarcity or water shortage is the lack of fresh water resources to meet the standard water demand. Two types of water scarcity have been defined: physical and economic water scarcity. Physical water scarcity is where there is not enough water to meet all demands, including that needed for ecosystems to function effectively. Arid areas (for example Central and West Asia, and

North Africa) often suffer from physical water scarcity. On the other hand, economic water scarcity is caused by a lack of investment in infrastructure or technology to draw water from rivers, aquifers, or other water sources, or insufficient human capacity to satisfy the demand for water. Much of Sub-Saharan Africa is characterized by economic water scarcity.

Climate change, such as altered weather-patterns (including droughts or floods), deforestation, increased water pollution and wasteful use of water can also cause insufficient water supply. Scarcity varies over time as a result of natural hydrological variability, but varies even more so as a function of prevailing economi policy, planning and management approaches. Scarcity can be expected to intensify with most forms of economic development, but, if correctly identified, many of its causes can be predicted, avoided or mitigated.

1.4.4 Threats to water sources

Threats are those conditions that would affect people's health if the water is used for drinking, cooking, or general hygiene purposes; and could be either a quality issue or quantity issue. Threats to your drinking water system may be either man made or naturally occurring. Threats to our drinking water sources can be considered as groundwater threats or surface water threats.

1.4.4.1 Groundwater Threats

Threats arise through man made sources and by natural contamination

Man made Threats

Many human activities can negatively affect groundwater quality as well as quantity. Those activities that can have a negative impact on groundwater can be categorized into four groups: waste disposal, resource extraction, agricultural practices, and urbanization.

Waste Disposal

The best-known source of groundwater contamination is waste disposal sites (landfills). Septic systems are another potential source of groundwater contamination. If septic systems are improperly installed or maintained, bacteria, viruses, nitrate, phosphorus, chlorides, and the organic solvents that are found in many household cleaners as well as products sold to "clean" septic systems can all make their way into groundwater.

Resource Extraction

As mines intersect aquifers and collect water, they interfere with groundwater storage and can lead to lowered water levels in wells. Drainage from mining degrades water quality as it infiltrates aquifers or discharges into streams. Increased concentrations of iron, manganese, sulphate, and dissolved solids in well water can result in severe health problems.

Agriculture

Common agricultural practices such as fertilizing and applying pesticides are coming under increased scrutiny because groundwater samples have revealed nitrates and, in some cases, pesticides. The most prevalent problem is the presence of high levels of nitrate from over application of manure and fertilizer. Nitrate is especially harmful to babies, interfering with the blood's ability to transport oxygen, which causes the baby to suffocate ("blue baby" disease).

Urbanization

Many human activities and land use practices, which proliferate with urbanization, can negatively affect groundwater. Even cemeteries, for example, can contaminate groundwater.

Soils that have been covered with impervious surfaces-roofs, parking lots, or streets obvi-

ously cannot absorb precipitation. As a result, much of the water from rain and snowmelt goes directly into streams and is never available to recharge groundwater. Large concentrations of people can also lead to over pumping of aquifers. This can result in significant aquifer draw down, which in turn reduces the quantity of stream flow. Intensive pumping in coastal areas can cause salt water to be drawn into aquifers and wells. With increased population comes industrialization and an increase in the amount and variety of industrial activities, many of which can potentially contaminate groundwater.

Natural Contamination

The natural constituents of water that may affect its suitability for drinking and other purposes most commonly found in groundwater are dissolved solids, calcium carbonate, and iron. Concentrations of chlorides and nitrates can also restrict use of water. These constituents enter water by leaching from rocks as water moves through them. Hardness is a property of water, usually measured by the concentration of calcium carbonate, which increases the amount of soap needed to produce lather. Corrosive groundwater is common. Corrodibility involves many factors including high acidity and low concentrations of calcium carbonate.

1.4.4.2 Surface Water Threats

Because surface water (rivers, streams, ponds, lakes, reservoirs, and springs) is by its nature more "visible," most people have more experience with this water source. Surface waters are often areas of recreation that provide us with opportunities for swimming, boating, fishing, and camping. Most of us have pleasant memories and experiences related to these water habitats and view them as a wonder of nature, representing crisp, clear, clean water. Surface waters can be contaminated by pollution from point source or non-point source.

Point Source

Contamination originating from a single and identifiable source. For example, permitted discharge from factory or sewage plant.

Nonpoint Sources

Contamination that originates from multiple and unidentifiable sources. For example, fertilizers and herbicides from agriculture lands and sedimentation.

Water Pollution

Water pollution occurs when harmful substances are released into water bodies degrading water quality. This is a serious form of pollution. There are several sources of water pollution:

a) Domestic sewage - it consists of sewage water from homes and business concerns which pollutes water.

b) Industrial waste in fresh water - large quantities of water pollutants are released into water sources due to different types of industrial activities.

c) Agricultural pollution - this includes sediments fertilizers, pesticides and animal wastes.

Effects

1) Water pollution is mainly responsible for more human illnesses than any other environmental factor. Three of the common diseases, Cholera, Jaundice and Typhoid, are transmitted through water.

2) Water pollution has a deadly effect on aquatic life, such as fishes, planktons and sea birds.

3) Artificial eutrophication - a lake, canal usually supports a rich variety of plant and animal life. But if it receives large quantities of phosphates and nitrates, very little oxygen is

available and eutrophication takes place.

Solutions

1) Primary treatment - this a mechanical process, it simply removes solid waste from polluted water.

2) Secondary treatment - this is a biological process; it consists of the removal of impurities by the digestive action of bacteria.

3) Tertiary treatment - it involves advanced biological, chemical and physical processes.

An innovative afforestation scheme "Smriti Van" was started by a voluntary organization Nisarga Sevak at Poona. According to this scheme a new sapling was to be planted in a memory of any pleasant or painful event.

1.4.5 Water logging

Water logging is the saturation of soil with water. Soil may be regarded as waterlogged when it is nearly saturated with water much of the time such that its air phase is restricted and anaerobic conditions prevail. In extreme cases of prolonged water logging, anaerobiosis occurs, the roots of mesophytes suffer, and the subsurface reducing atmosphere leads to such processes as denitrification, methanogenesis, and the reduction of iron and manganese oxides. In agriculture, various crops need air(specifically, oxygen) to a greater or lesser depth in the soil. Water logging of the soil stops air getting in.

Water logging in agricultural lands can be of various types and are categorized,

a) Based on causes:

(i) Natural, e.g., natural swamps and valley bottoms.

(ii) Human-induced water logging, e.g., through agricultural and other activities.

b) Based on permanence.

(i) Temporary- whereby water logging lasts a few days to several months.

(ii) Permanent water logging– which occurs throughout the year.

c) Based on source of water.

(i) Rainfed- mostly source of excess water is direct rainfall.

(ii) Irrigated agriculture– water logging caused by water supplied for irrigation.

d) Based on location

(i) Agricultural lands– including cultivated lands.

(ii) Other utility lands e.g., built up areas, urban areas.

1.4.6 Floods

A flood is a natural event that can have far reaching effects on people and the environment. A flood is caused by a combination of heavy rainfall causing river / oceans to over flow their banks, and can happen at any time of the year. However, they can happen very quickly when lot of heavy rain falls over a short period of time. These 'flash floods' occur with little or no warning and cause the biggest loss of human life compared to any other type of flooding. The worst cases of flooding may occur if there is a combination of storms, spring tides and low atmospheric pressure.

Floodwater can seriously disrupt public and personal transport by cutting off roads and railway lines, as well as communication links when telephone lines are damaged. Floods disrupt normal drainage systems in cities, and sewage spills are common, which represents a serious health hazard, along with standing water and wet materials in the home. Bacteria, mould and viruses cause diseases, trigger allergic reactions, and continue to damage materials long after a flood. Floods can distribute large amounts of water and suspended sediment over vast areas, restocking valuable

soil nutrients to agricultural lands. In contrast, soil can be eroded by large amounts of fast flowing water, ruining crops, destroying agricultural land / buildings and drowning farm animals.

The major types of floods are:
a)Flash Floods
b) Single event floods
c) Multiple event floods
d) Seasonal floods
e) Coastal floods
f) Estuarine floods
g) Floods caused by Dam failures
h) Floods due to sudden melting of snow and glacier

Fig 1.4.3 July, 2021 Maharashtra flooding

Fig 1.4.4 August 2021 Flooding in West Bengal

Flash floods are frequently associated with violent, convectional storms of short duration. They are floods of great volume and short duration. These result from cloud burst on relatively small and widely-dispersed streams. These unpredictable Heavy rainfall or slow-moving thunderstorms may create flash floods.

Single event flood is the most common type of flooding. It is caused by widespread heavy rains of longer duration of 2 to 3 days. These are associated with cyclonic disturbances like storms and depressions.

Multiple event floods are caused by successive weather disturbances. Floods in Indo-Gangetic plains are of this type.

Seasonal floods are floods occurring during different seasons. Floods in some parts occur during summer monsoons and in some other parts during winter monsoon. The southern half of the Indian Peninsula experiences floods mostly during winter seasons.

Coastal floods come due to the action of high tides and waves. Storm surges can create extensive floods along a coast. Hurricanes and tropical storms can produce heavy rains or drive ocean water onto the land. Beaches and

coastal houses can be swept away by the water. Coastal flooding can also be produced by killer sea waves called tsunamis.

1.4.7 Drought

A drought is a period of time when an area or region experiences below-normal precipitation. The lack of adequate precipitation, either rain or snow, can cause reduced soil moisture or groundwater, diminished stream flow, crop damage, and a general water shortage. Droughts are the second-most costly weather events after hurricanes.

A drought is an event of prolonged shortages in the water supply, whether atmospheric (below-average precipitation), surface water or ground water. A drought can last for months or years, or sometimes it can be declared as drought after as few as 15 days. It can have a substantial impact on the ecosystem and agriculture of the affected region and harm the local econom. Annual dry seasons in the tropis significantly increase the chances of a drought developing and subsequent bush fires. Periods of heat can significantly worsen drought conditions by hastening evaporation of water vapour.

Types of droughts

1. Meteorological drought occurs when there is a prolonged time with less than average precipitation. Meteorological drought usually precedes the other kinds of drought.

2. Agricultural droughts affect crop production or the ecology of the rang. This condition can also arise independently from any change in precipitation levels when either increased irrigation or soil conditions and erosion triggered by poorly planned agricultural endeavors cause a shortfall in water available to the crops.

3. Hydrologicl drought is brought about when the water reserves available in sources such as aquifers, lakes and reservoirs fall below a local significant threshold. Hydrological drought tends to show up more slowly because it involves stored water that is used but not replenished.

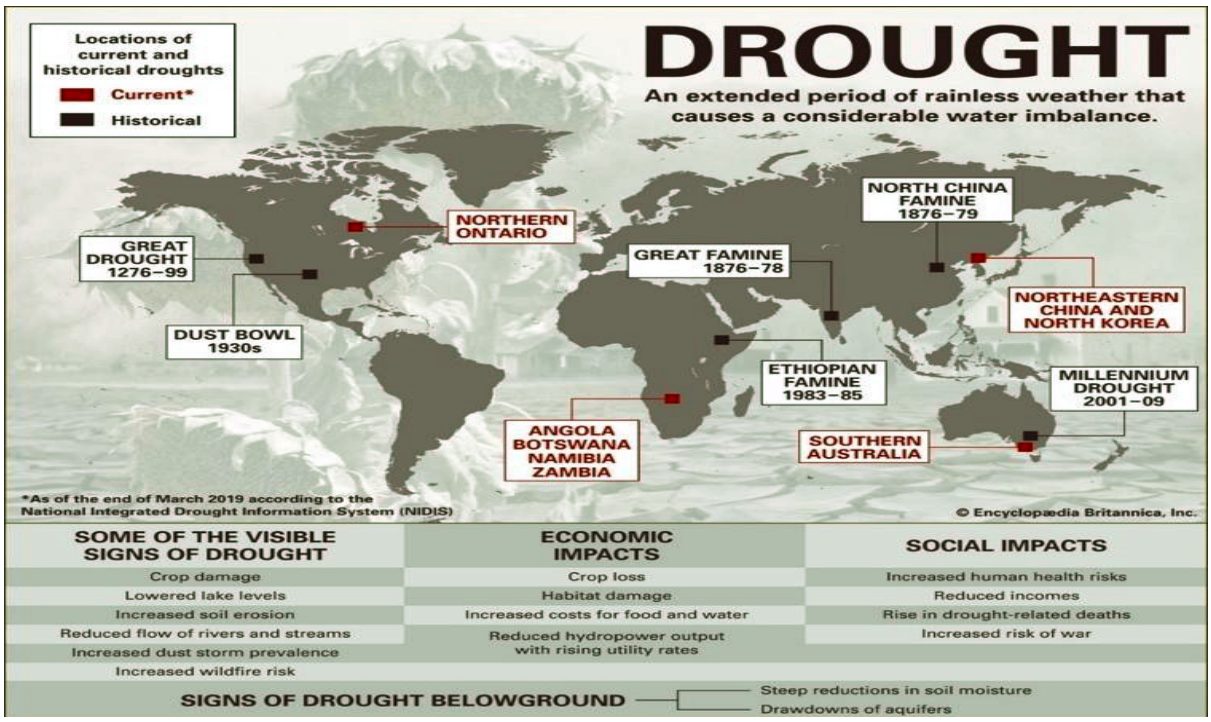

Fig 1.4.5 Major Droughts

Fig 1.4.6 A refugee camp in Kenya

1.4.8 Conservation and management of water resources

Water conservation and management encompass the policies, strategies and activities made to manage water as a sustainable resource, to protect the water environment, and to meet current and future human demand. Population, household size, growth and affluence all affect how much water is used. Though blessed with large rivers like the Ganga, Yamuna, Godavari, Narmada, and others, India's socio-economic development has a lot to contribute to the decreasing water resources. Rising population, industrialization, urbanization and modernization of agriculture are some of the main reasons for water shortages in many parts of the country. As a result, most of our prominent rivers, especially the smaller ones, have become toxic with waste products and pollution. The supply of water is fixed by nature. But the consumption of water has increased to a great extent. This, has led to a scarcity of water which is especially felt in the poorest countries. Therefore, rational use of water is essential.

Various methods of water conservation need to be adopted:

1) Traditional water harvesting system- traditional systems are usually suited to the local conditions. Different areas have their own systems of collecting and sharing water. Pat, Johad, Saza Kuva, Talab and Paar systems are some examples of Indian traditional water harvesting systems.

2) Watershed management- Watershed is a land area which shed water into a particular region. It is the study of the relevant characteristics of a watershed aimed at the sustainable distribution of its resources and the process of creating and implementing plans, programs and projects to sustain and enhance watershed functions that affect the plant, animal, and human communities within the watershed boundary. Features of watershed that agencies seek to manage include water supply, water quality, drainage, storm water runoff, water rights and the overall planning and utilization of watersheds.

3) Pani Panchayat- It is a voluntary activity of farmers which regulates the adequate supply of water from river to the crop fields to ensure its optimum use.

4) Percolation Ponds- They help in reducing water shortage. They use check dams and tap rain water.

5) Trapping spring water- This is a new solution to conserve and harvest water.

6) Roof- top rainwater harvesting. In this system the rain water falling on a building roof or terrace is to be collected into a well or tank below.

7) Reclamation of waste water– Waste water reclamation involves the treatment or processing of wastewater to a quality level acceptable for reuse. Wastewater reuse may be direct or indirect. Direct wastewater reuse involves a direct link between reclamation and processing. Indirect reuse occurs when reclaimed water is discharged to a stream, impoundment, or

aquifer where it is diluted by and mixed with freshwater prior to reuse.

8) Groundwater recharging- Artificial recharge can be done through injection of water through wells. This method often is applied to recharge deep aquifers where application of water to the land surface is not effective at recharging these aquifers.

1.4.9 Coastal Regulation Zone(CRZ)

Under the section 3 of Environment Protection Act, 1986 of India, Coastal Regulation Zone (CRZ) notification was issued in February 1991 for the first time, for the regulation of activities in the coastal area by the Ministry of Environment and Forests (MoEF).

As per the 1991 notification, the coastal land up to 500m from the High Tide Line (HTL) and a stage of 100m along banks of creeks, lagoons, estuaries, backwater and rivers subject to tidal fluctuations, is called the Coastal Regulation Zone (CRZ). The above notification includes only the inter-tidal zone and land part of the coastal area and does not include the ocean part. The notification-imposed restriction on the setting up and expansion of industries in the said CRZ. The CRZ along the country has been placed in four categories, viz., CRZ-I, CRZ-II, CRZ-III and CRZ-IV.

Amendments were made to the 1991 notification in 2003, 2011 and 2019.

Under the 1991 Notification, the coastal area has been classified as CRZ-1, CRZ-2, CRZ-3, CRZ-4. The same were retained for CRZ in 2003 notifications as well.

- CRZ-1: These are ecologically sensitive areas essential in maintaining the ecosystem of the coast. They lie between low and high tide line. Exploration of natural gas and extraction of salt are permitted in CRZ-1
- CRZ-2: These areas are urban areas located in the coastal areas. Under Coastal Zone Regulation (CRZ) Notification 2019, the floor space index norms has been de-freezed.
- CRZ-3: Rural and urban localities which fall outside the 1 and 2. Only certain activities related to agriculture and some public facilities are allowed in this zone
- CRZ-4: This lies in the aquatic area up to territorial limits. Fishing and allied activities are permitted in this zone. No Solid waste should be let off in this zone. This zone has was changed from 1991 notification, which covered coastal stretches in islands of Andaman & Nicobar and Lakshadweep.

Coastal regulation zone notification - 2019

The CRZ notification 2019 was issued to replace the 2011 notification and develop the coastal region of the country in a sustainable manner on scientific principles, keeping in view current global problems of climate change and sea level rise.

One of the important developments was the division of CRZ-I into I A and I B. The CRZ-I A covers eleven ecologically sensitive areas like mangroves, corals and coral reefs, sand dunes, salt marshes, national parks, sea grass beds etc. The CRZ-I B covers the intertidal zone. i.e. the area between Low Tide Line and High Tide Line.

CRZ-II shall constitute the developed land areas (urban areas) upto or close to the shoreline, within the existing municipal limits or in other existing legally designated urban areas, which are substantially built-up with a ratio of built-up plots to that of total plots being more than 50 per cent and have been provided with drainage and approach roads and other infrastructural facilities, such as water supply, sewerage mains, etc.

CRZ-III: Land areas that are relatively undisturbed (i.e., rural areas) and those which do not fall under CRZ-II, shall constitute CRZ–III. This shall be further classified into following categories:

CRZ-III A: densely populated areas, where the population density is more than 2161 per square kilometre as per 2011 census base shall be designated as CRZ–III A and in this, area upto 50 meters from the HTL on the landward side shall be earmarked as the 'No Development Zone (NDZ), provided the CZMP as per this notification, framed with due consultative process, have been approved, failing which, a NDZ of 200 meters shall continue to apply.

CRZ-III B: All other CRZ-III areas with population density of less than 2161 per square kilometre, as per 2011 census base, shall be designated as CRZ-III B and in this, the area up to 200 meters from the HTL on the landward side shall be earmarked as the 'No Development Zone (NDZ)'. Land area up to 50 meters from the HTL, or width of the creek whichever is less, along the tidal influenced water bodies in the CRZ III, shall also be earmarked as the NDZ in CRZ III.

CRZ- IV shall constitute the water area and shall be further classified as CRZ- IVA: The water area and the sea bed area between the Low Tide Line upto 12 nautical miles on the seaward side shall constitute CRZ-IV A. The CRZ- IVB shall include the water area and the bed area between LTL at the bank of the tidal influenced water body to the LTL on the opposite side of the bank, extending from the mouth of the water body at the sea up to the influence of tide, i.e., salinity of five parts per thousand (ppt) during the driest season of the year.

The notification of 2019 also promotes the development of tourism infrastructure in the coastal areas. One of the important features of 2019 notifications is the streamlining of the coastal regulation zone clearing procedure. The Ministry of Environment, Forest and Climate Change will oversee the matter of CRZ clearance only for CRZ-I; i.e., the ecologically vulnerable areas and CRZ IV (area between low tide line and 12 nautical miles seaward) areas, while for the other two categories namely CRZ-III and CRZ-II (urban areas), the power of clearance has been designated at State level. The notification also proposes a no development zone of 20 meters for all islands. The ecologically vulnerable areas identified on the basis of Environment Protection Act, 1986 are to be managed in partnership with coastal communities and fisher folks. For the purpose of pollution abatement in coastal areas, the development of treatment facilities is proposed under the regulation in CRZ-IB areas.

Recap

- Water uses include drinking and domestic use, industrial, agricultural, recreational.
- Water logging is the saturation of soil with water.
- Threats to drinking water system may be either man made or natural.
- Water scarcity (closely related to water stress or water crisis) is the lack of fresh water resources to meet the standard water demand.
- A flood is caused by a combination of heavy rainfall causing river / oceans to over flow their banks, and can happen at any time of the year.
- A drought is a period of time when an area or region experiences below-normal precipitation.
- Traditional water harvesting system, watershed management, groundwater recharging etc. are some important water conservation methods.
- Coastal Regulation Zone notification was issued in February 1991 for the first time, for regulation of activities in the coastal area by the Ministry of Environment and Forests (MoEF).

Objective Type Questions

1. Mention the only State which has made rooftop rainwater harvesting structure compulsory to all the houses
2. What is the major source of fresh water in India?
3. What is the main purpose of rain water harvesting?
4. How much of earth's surface is covered with water?
5. What percentage of the total volume of world's water is estimated to exist as oceans?
6. What is the rank of India in the world countries in terms of water availability per person per annum?
7. What is Potable water?

Answers to Objective Type Questions

1. Tamil Nadu
2. Groundwater
3. Ground water recharging
4. Three-fourth
5. 96.5%
6. 133 rd
7. Safe drinking water

Self Assessment Questions

1. Describe the global distribution of water.
2. Explain the different types of water resources.
3. What is water scarcity?
4. What are the types of water scarcity?
5. What are the threats faced by ground water resources?
6. Differentiate point and non-point sources of pollution.
7. Define water logging.
8. Explain Coastal Zone Regulation.
9. Write an essay on surface and ground water resources.

Assignment

Give a detailed account of contamination of surface water keeping the current observation in mind.

Suggested Reading

1. https://www.academia.edu/36575424/Learning_to_live_with_FLOODS_Natural_Hazards_and_Disasters
2. http://gpambala.ac.in/wp-content/uploads/2020/04/Water-Logging-1.pd

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Unit 5
Land and Mineral Resources

Learning Outcomes

- Learns about land resources and its degradation
- Learns about man induced landslides, soil erosion and desertification
- Knows more about environmental effects of extracting mineral resources

Prerequisites

Have you heard the famous saying of Arthur Young: "God sleeps in the minerals, awakens in plants, walks in animals, and thinks in man"? Land is a primary ecosystem visible in the forms of hills, plains, river basins, deserts, wetlands and valleys.

Over the years, humans have brought unlimited degradation to the land. Deforestation, cultivation, construction, blasting, mining, earthwork etc have been responsible for degradation.

And what is the consequence? Landslides, soil erosion, desertification, ozone depletion, natural hazards, tsunamis, cyclones, floods etc. have become common. These and other various natural disasters have a heavy toll upon mankind and other living beings. Let us be aware of these facts lest we perish.

Keywords

Soil erosion, Desertification, Mineral Resources, Landslides

Discussion

1.5.1 Land resources

Land forms such as hills, valleys, plains, river basins and wetlands include different resource generating areas that the people living in them depend on. It is an essential natural resource, both for the survival and prosperity of humanity, and for the maintenance of all terrestrial ecosystems. Land is a major resource for agricultural development worldwide. Over millennia, people have become progressively more expert in exploiting land resources for their own ends. The limits on these resources are finite while human demands on them are not. Increased demand, or pressure on land resources, shows up as declining crop production, degradation of land quality and quantity, and competition for land. Attention should now be focused on the role of humankind as stewards rather than exploiters, charged with the responsibility of safeguarding the rights of unborn generations and of conserving land as the basis of the global ecosystem.

1.5.2 Land degradation

Have anybody thought of how land degradation happens? Land degradation is a process in which the value of the biophysical environmt is affected by a combination of human-induced processes acting upon the land. It is viewed as any change or disturbance to the land perceived to be undesirable. Natural hazards are excluded as a cause; however human activities can indirectly affect phenomena such as floods and bush fires. This is considered to be an important topic of the 21st century due to the implications land degradation has upon agricultural productivity, the environment, and its effects on food security. It is estimated that up to 4% of the world's agricultural land is seriously degraded.

According to the Special Report on Climate Change and Land of the Intergovernmental Panel on Climate Change, "About a quarter of the Earth's ice-free land area is subject to human-induced degradation (medium confidence). Soil erosion from agricultural fields is estimated to be currently 10 to 20 times (no tillage) to more than 100 times (conventional tillage) higher than the soil formation rate (medium confidence)." The United Nations estimate that about 30% of land is degraded worldwide and about 12 million hectares of productive land– which roughly equals the size of Greece– is degraded every year. This happens because people exploit the land without protecting it. The United Nations Sustainable Development Goal 15 has a target to restore degraded land and soil and achieve a land degradation-neutral world by 2030.

The usage of agriculture, deforestation, and climate change are the main causes of land degradation, which is a global issue. Land clearing, including clear-cutting and deforestation, agricultural soil nutrient depletion due to inefficient farming methods, livestock overgrazing and overdrafting, inappropriate irrigation, urban sprawl, commercial development, vehicle off-roading, quarrying for stone, sand, ore, and minerals, increase in field size due to economies of scale, and reduced shelter for wildlife, such as hedgerows and corpses, are some of the causes.

1.5.3 Man induced landslides

Human-induced landslides (HIL) refer to landslide events that are directly triggered or partially aggravated by anthropogenic factors such as modification of the topography, change of the water circulations, land use changes, ageing of infrastructure, etc. Human-induced landslides usually occur on cut slopes due to excavation, which can cause many fatalities and severe destruction.

Landslides are aggravated by human activities, such as:

- Deforestation, cultivation and construction.
- Vibrations from machinery or traffic.
- Blasting and mining.
- Earthwork (e.g., by altering the shape of a slope, or imposing new loads);in shallow soils, the removal of deep-rooted vegetation that binds colluvium to bedrock.
- Logging, and urbanization, which change the amount of water infiltrating the soil.
- Temporal variation in land use and land cover (LU/LC): It includes the human abandonment of farming areas, e.g. due to the economic and social transformations which occurred in Europe after the Second World War. Land degradation and extreme rainfall can increase the frequency of erosion and landslide phenomena.

Fig 1.5.1 August 2020 Landslide in Idukki, Kerala

1.5.4 Soil erosion

What is soil erosion? When will it happen? Soil erosion is a major worldwide threat to agro-ecosystem sustainability and land productivity. More than 36 billion tons of fertile soil is lost from world agricultural systems each year through soil erosion. Erosion is a serious problem for productive agricultural land and for water quality concerns. Controlling the sediment must be an integral part of any soil management system to improve water and soil quality. Eroded topsoil can be transported by wind or water into streams and other waterways. Sediment is a product of land erosion and derives largely from sheet and rill erosion from upland areas, and to a lesser degree, from cyclic erosion activity in gullies and drainage ways.

Types of Erosion

- Sheet erosion (water) is almost invisible. Lighter colored soils are a sign that over the years erosion has taken its toll.
- Wind erosion is highly visible. Although it is a problem, water erosion is generally much more severe.
- Rill erosion occurs during heavy rains, when small rills form over an entire hillside, making farming difficult.
- Gully erosion makes gullies, some of them huge, impossible to cross with farm machinery.
- Ephemeral erosion occurs in natural depressions. It differs from gully erosion in that the area can be crossed by farm equipment.

1.5.5 Desertification

Do you know what Desertification is? Desertification basically implies degradation, deterioration and impoverishment of the world dryland regions. It can be defined as the reduction or destruction of the biological-potential of land resulting in the appearance of desert conditions. In other words, it refers to a loss of productivity of the land. This however does not mean that there is an expansion of deserts. In this context it is necessary to focus on the fact that desertification is essentially adverse in nature. The problem is global in scale affecting nearly one fourth of the world's land area. It can take place anywhere; however the fertile land near the existing deserts usually becomes victims to the process of desertification very easily. Desertification essentially is the result of human activities rather than by natural factors.

Causes of desertification

1) Over cultivation- most countries need to cultivate commercial or cash crops. This displaces traditional agriculture to marginal lands. The marginal lands which were previously not used either decline in productivity or remain stagnant at the basic production level. Natural events such as droughts and famines lead to the process of deterioration and degradation.

2) Over grazing- low livestock prices tempt producers to rear as many as possible. The cattle over graze the green land. This leads to removal of vegetation cover and its nutrients. The loose soil particles, which basically contain the fertile characteristics, are blown away by the wind. This makes the land look like a desert. In other words, over-grazing over a period of time lead to desert like conditions.

3) Over irrigation- The irrigation schemes meant for the supply of water are important and hence they require adequate planning. Inefficient land irrigation schemes result in water logging of crops and consequent salination of soil. The saline soil brings up the salts to the surface and continued evaporation makes the soil unfit for cultivation.Subsequently, this causes desertification.

4) Deforestation- This is one of the significant causes of desertification. Forests are removed and cleared for various resources and for cultivation of cash crops, human settlement, creating space for increasing cattle etc. This process is called deforestation. Due to this the top-quality soil or fertile soil gets exposed to the forces of nature. Subsequently, it gets washed away. Thus, deforestation results in desertification.

5) Mining operation- Mining operations result in the disposal of rejects in fertile land. These mining rejects lead to total erosion of soil, further resulting in the desert like conditions,

6) Growth of population - large increase in population is taking place in many parts of the world. This causes severe pressure on land, subsequently causing desertification. In other words, land encroachment by human beings will lead to desertification.

Consequences of desertification

What are the consequences of desertification? Desertification is a severe problem as it causes exploitation of land which is one of most important natural resources. This problem is especially grave in the developing countries. Moreover, the seriousness of the problem increases because the negative consequences are irreversible.

1) Productivity of the land is almost eliminated or it reaches the lowest level.

2) The productivity of land is vital for the survival of mankind. If a particular area of land becomes dry land, the living conditions of the people in this affected area become miserable.

3) Once a land becomes a dry land or has desert like condition the result is loss of productivity or a loss of important means of survival. It means the drylands are incapable of producing food resources.

4) Desertification also leads to drying up of the water resources; it causes destruction of the natural resources of the environment.

5) There is also an adverse effect on the biotic and abiotic components of the environment.

6) The desert like conditions created due to desertification affects human being in a serious manner. It leads to less productive or relatively infertile land. All these factors basically create miserable living conditions or poverty for the people. Desertification is a serious problem because the consequences cannot reversed.

1.5.6 Mineral resources

Use of Minerals

The earth's resources have been used by all cultures throughout history. The earliest uses of the earth's resources involved water, salt and simple tools made from rocks. The quantities of various mineral resources used by particular societies vary widely but generally correspond per capita to the nation's degree of development and standard of living.

The use of minerals depends upon its deposits. Some countries are rich in mineral deposits, while others have no deposits. The greatest use of minerals depends on its properties. Minerals are used in almost all industries. Gold, silver and platinum are used in the jewellery industry. Copper is used in coin industry and for making pipes and wire. Silicon obtained from quartz is used in the computer industry. Aluminium is light, strong and durable in nature, so it is used for aircraft, shipping and car industries.

Exploitation of Mineral Resources

Exploitation of minerals refers to the use of mineral resources for economic growth. Exploitation of mineral resources at a mindless speed to meet the growing needs of modern civilization has resulted in many environmental problems. Although the exploitation of minerals began at a slow pace during the industrial revolution in Western countries, during the 20th century, the exploitation of some minerals, especially the fossil fuels, increased exponentially to meet the growing energy needs. Today about 80% of the world's energy consumption is sustained by the extraction of fossil fuels, which consists of oil, coal, and gas.

Environmental effects of extracting Mineral Extraction

Extracting and use of mineral resources can affect the environment adversely. Environmental effects may depend on factors such as mining procedures, ore quality, climate, size of operation, topography, etc. Some of the major environmental impacts of mining and processing operations are as under:

1. Degradation of land.
2. Pollution of surfaces and ground water resources.
3. Effect on growth of vegetation due to leaching out effect of minerals.
4. Surface water pollution and groundwater contamination lead to occupational health hazards etc.
5. Air pollution due to emission of gases.
6. Deforestation affects flora and fauna.
7. Rehabilitation of affected population.
8. Rapid depletion of high-grade minerals
9. Forced migration
10. Wastage of upper soil layer and vegetation
11. Soil erosion and oil depletion
12. Ozone depletion
13. Environmental pollution
14. Natural hazards

Recap

- Land resources are all those features and processes of the land, which can, in some way, be used to fulfil certain human needs.
- Land degradation is a process in which the value of the biophysical environment is affected by a combination of human-induced processes acting upon the land.
- Human-induced landslides (HIL) refer to landslide events that are directly triggered or partially aggravated by anthropogenic factors such as modification of the topography, change of the water circulations, land use changes, ageing of infrastructure, etc.
- A mineral is a natural substance of organic or inorganic origin with definite chemical and physical properties.
- Environmental effects of extracting minerals depend on factors such as mining procedures, ore quality, climate, size of operation, topography, etc.
- Desertification is defined as the reduction or destruction of lands biological-potential resulting in the appearance of desert conditions.
- Causes of desertification include over cultivation, over grazing, over irrigation, deforestation, mining operation, and growth of population.

Objective Type Questions

1. What is soil conservation?
2. What is the most abundant element on the Earth crust?
3. Which element is used extensively in making coins, electric wires and pipes?
4. Name any mineral source from which silicon is obtained.
5. The process of taking out minerals from rocks buried under the surface of the earth is named as?
6. Which central government agency is responsible for the mapping and exploration of minerals?
7. What are the causes of soil erosion?
8. What is soil erosion?

Answers to Objective Type Questions

1. Soil is protected against loss
2. Oxygen
3. Copper
4. Quartz
5. Mining
6. Geological Survey of India
7. Rapid urbanization, cutting of trees, over grazing by animals.
8. Destruction of soil cover or removal of topsoil

Self assessment Questions

1. What do you mean by land degradation?
2. Describe the causes of land degradation.
3. Comment on man-induced landslides.
4. More than …….. billion tons of fertile soil is lost from world agricultural systems each year through soil erosion.
5. Define desertification. What are the causes and consequences of desertification.
6. Comment on the effect of mineral extraction.
7. …… obtained from quartz is used in the computer industry.
8. What are the various types of erosion?

Assignment

Prepare a detailed report of the problems associated with the exploitation of land resources.

Suggested Reading

1. https://archive.mu.ac.in/myweb_test/M.A.Part%20-%20II%20-%20Paper%20VII.pdf
2. https://www.ipcc.ch/site/assets/uploads/2019/08/2e.-Chapter-4_FINAL.pdf

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Unit 6
Energy Resources

Learning Outcomes

- Identify the functions of energy resources
- Understand the types and classifications of energy resources
- Know the advantages and disadvantages of some energy resources
- Learn about the production and process of energy resources

Prerequisites

All of us speak about energy. We have learned in our primary classes about energy. Energy is the capacity to perform work.
The total quantity of usable energy available to people is called as Energy supply.
Energy comes from either Renewable sources or Non-renewable sources.
The world is trying to find new sources of energy. We know that we are running short of petroleum and coal.
We are now tapping different sources of energy and now speak of CNG, Fossil fuel, wind energy, biogas, electric energy and Geothermal Energy.

Keywords

Energy, Resources, Biofuels, Future fuels, Clean energy, Hydrogen energy

Discussion

1.6.1 Energy Resources

We all know that planet earth has enormous amounts of energy resources. The use of energy by human beings dates back to several centuries. Energy is the capacity to perform work. We use various forms of energy to do work. The total quantity of usable energy available to people is called as Energy Supply.

Energy is of many kinds electrical energy, kinetic energy, mechanical energy and chemical energy. Electrical energy operates on several appliances like pump sets, fans, grinders, vacuum cleaners, washing machines and other industrial equipment. Heat energy is used to cook food on stoves, shape metals, make bricks and for several industrial processes requiring heat as a major factor or as a catalytic factor. Similarly, mechanical energy is used for many activities like moving vehicles, lifting and breaking materials, handling and aligning objects. Energy may be obtained directly from an energy source or it may be obtained indirectly. Energy is derived from one or more than one source.

The chief sources of energy are

a) Fossil fuels

b) Flowing water

c) Biomass and

d) Atomic minerals

In addition, solar energy, wind power, tidal energy, chemical and geothermal power also provide some amounts of energy. The sources and use of energy by the population differ from a developed country to a developing country. It depends on the energy resources available with them.

Sources of energy are classified into two major groups as renewable and non-renewable energy sources.

1. Renewable sources are those which will be available for our human consumption again and again. The energy derived from water as hydro-electric power, Sun as solar energy and wind energy are renewable energy resources.

2. Non-renewable energy sources are those which are permanently consumed for generating the energy and needs further supply. Fossil fuels like coal, oil and gas, fissionable materials for nuclear power generation and geothermal sources come under this category.

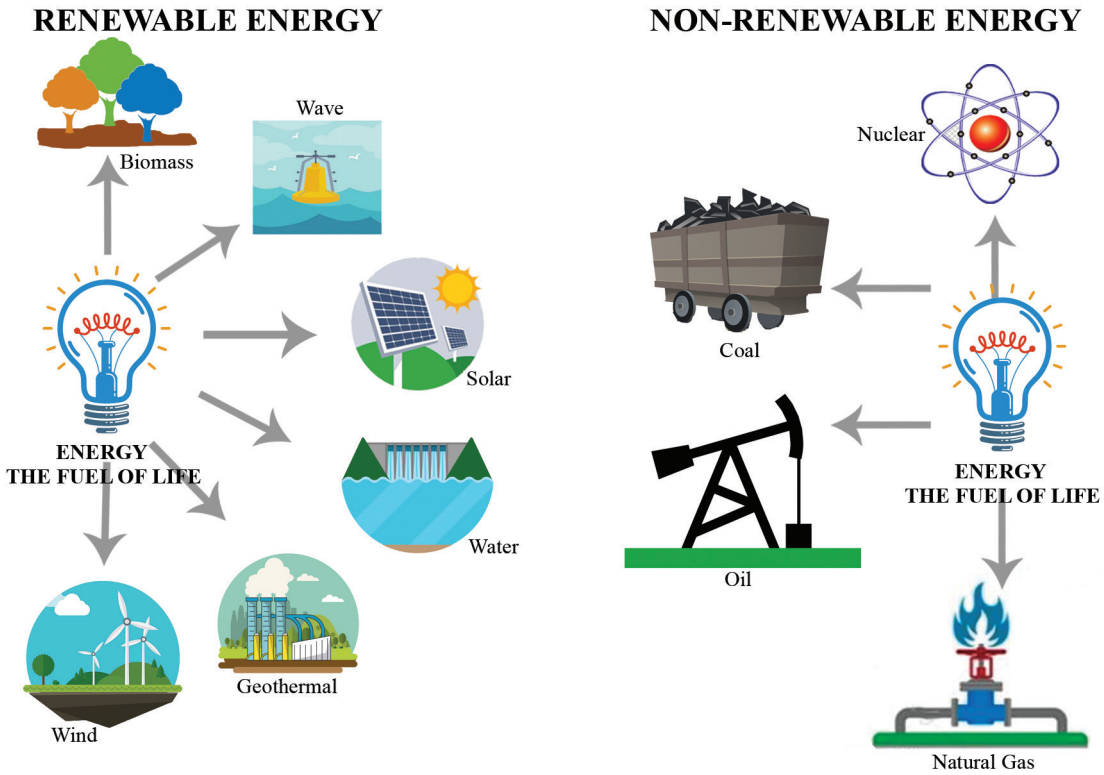

Fig 1.6.1 Energy Sources

1.6.2 Types and classification

1.6.2.1 Energy from Fossil Fuels

About 85 per cent of the world's commercial energy comes from coal, oil, and natural gas. These are called fossil fuels since they have formed from the fossilized remains of prehistoric plants and animals.

The use of these sources depends on their availability in a country .

Coal is made up of organic material which has escaped from oxidation in the carbon cycle. It is an altered residue of plants and trees of older forests, which have been buried under sediments, and they were subjected to a set of geological processes and transformations.

Coal is burned to create heat to turn water into steam. The steam is then used to rotate turbines which will rotate the dynamos to generate electricity. It is also converted into another useable form called coke. It is a charcoal– like solid which is an essential raw material used in the production of iron and steel.

Coal occurs in sedimentary basins as coal seams or layers. There are four types of coal occurring in the order of decreasing carbon content, volatiles and moisture, as

a. Anthracite

b. Bituminous coal

c. Sub-bituminous coal and

d. Lignite.

Peat is partially decayed plant matter found in recent swamp deposits. Peat and wood are the basic materials before the formation of lignite. Anthracite is a rare form but is the hardest variety of coal. It also contains more carbon and produces more heat than the other varieties. Bituminous coal is the most commonly used coal by industries. It contains more carbon and produces more heat than either lignite or sub-bituminous coal. It is also suitable for making coke.

Coal contains some sulphur compounds. The sulphur content may be very low (< 1%) or medium (1-3%) and high (> 3 %).

Coal is mainly used in thermal power plants. While using it, the one having low sulphur will cause less air pollution. The production of thermal power depends on the ash-content of the coal used. The higher the ash content, the lower the efficiency of the boiler and furnaces.

Use of coal also generates solid wastes and ashes. For every megawatt of energy produced by a thermal plant, about one acre of land is needed to dump the wastes (ash).

Coal-based thermal planst pollute the atmosphere by gaseous emissions of sulphur-di-oxide and nitrogen oxide, and produce tremendous amount of solid wastes, fly ash and bottom ash.

Coal mining, transport, washing, processing, shipping, combustion and final disposal of ash may lead to potentially adverse environmental effects like aesthetic degradation, noise pollution, dust pollution and the release of trace elements into water, soil and air. Coal is a non-renewable form of energy, the use of which is to be done very economically.

Oil

The next major source of energy comes from oil. The oil that is derived from rocks is called Petroleum. (Petro means rock, oleum means oil). Petroleum furnishes about 40 per cent of the commercial energy used in the world. It provides most of the energy used for transportation and other activities of the population.

In general, Petroleum and natural gas (methane) are hydrocarbons. They are fossil fuels formed from organic material, free from complete decomposition after burial. Petroleum is a complex mixture of hydrocarbons containing N, S and O.

The major source for oil and gas is the fine grained, organic rich sediments that are buried to a depth of 500 m or below stagnant oceanic waters. These might have experienced a thrust due to an increase in pressure and heat. The water is deficient in oxygen. Various geological and biological (bacteria) processes have promoted the chemical transformation of these organic materials into hydrocarbons. They tend to migrate through the porous sediments called reservoir rocks.

Like coal, oil also contains some impurities that can cause air pollution. But refineries can remove many of these pollutants when they process the petroleum.

Natural gas is the most convenient fossil fuel. It causes little or no air pollution. Natural gas is a clean source of energy because it is refined naturally during its formation within the earth and does not require further refining. In addition, it can be compressed into a liquid and transported long distances through pipelines.

Natural gas accounts for about 21 per cent of the commercial energy used in the world. Millions of people use natural gas to heat their homes, cook their meals, and dry their laundry.

Typical gas consists of hydrocarbons, having a very low boiling point. Methane, the first member of the paraffin series makes up 85 % of the typical gas.

Clean Energy Sources

Clean energy is energy derived from renewable, zero-emissions sources ("renewables"), as well as energy saved through energy efficiency ("EE") measures. Renewable power is booming, as innovations bring down costs and starts to deliver on the promise of a clean energy future. This means that renewables are increasingly displacing "dirty" fossil fuels in the power sector, offering the benefit of lower emissions of carbon and other types of pollutants. But not all sources of energy marketed as "renewable" are beneficial to the environment. Biomass and large hydroelectric dams create difficult tradeoffs when considering the impact on wildlife, climate change, and other issues.

1.6.2.2 Solar and Wind Energy

The energy received from the sun's electromagnetic radiation is called solar energy. It is also used to produce electric power. This is a non-conventional and renewable energy source.

Do you know the two methods through which sunlight can be converted into electric power?

They are:

(1) photovoltaic conversion, and

(2) solar thermal conversion

It is reported that the solar energy falling on the earth every 29 seconds is equivalent to the human energy requirement of a day.

It comes from the Sun and is plentiful. The distribution is sparse. It must be collected and concentrated to produce usable power. This requires some special devices. Hence, harnessing of solar energy is an expensive affair.

A typical solar water heater consists of a coil of copper pipe brazed to a blackened metal base. This assembly is covered by a transparent glass plate or a plastic sheet. The water which is passed through coil gets heated up by the radiation. Very high amount of heat is trapped in this process during summer months.

Solar energy is also caught to provide power using solar cells. Solar cells are the devices made from crystals of silicon to produce electricity from sunlight. They are the Photovoltaic cells. Research continues on the applications of solar energy for pumping up water, refrigeration, solar ponds and temperature control in buildings.

Fig 1.6.2 Solar Energy

Fig 1.6.3 Wind Energy

Advantages of consumption by Solar energy

1. Unlimited supply,
2. Does not produce air, water, thermal, and noise pollution,
3. No danger of large-scale disasters,
4. Conserves earth's resources and
5. Technology is available for immediate use.

Disadvantages

Solar cells are more expensive. They cannot completely replace the conventional fuels.

Wind Energy

The rapid depletion of fossil fuels and the increase in environmental pollution call for an efficient use of other energy sources and to identify alternate sources also.

Wind is a powerful agent for providing power. It is the best renewable energy source available on earth.

Wind energy can be harnessed very easily. The blow of wind is allowed to rotate the blades of a windmill, coupled to a turbine. This drives a power generator.

Merits and demerits of Wind Energy

1. The generation period is low (5 months). This is because of the seasonal availability of a reasonably useful wind.
2. Power generation starts immediately after commissioning the plant.
3. Power is cost free; generation is cheaper and recurring cost is less.
4. Installation cost is heavy, and the maintenance of machinery is also expensive.
5. This is a pollution free and environment friendly generation of power.

A wind power plant is also a source of income. A wind power generator of 200 kw/250 kw, generates at an average of six to seven lakh units every year.

1.6.2.3 Energy from Biogas

Biogas is the methane gas produced or released from the organic wastes like sewage, garbage, manure or crop residues. These are decomposed substances in the absence of air. This is similar to the natural gas in origin.

Biogas can be collected using a container filled with the wastes and closed at the top

with a tap for trapping the gas. The wastes are mostly animal excreta or dungs which are allowed to decay and decompose naturally inside the container. After producing the gas, the used-up materials can be used as a high-quality organic manure in crop lands.

Community biogas plants, industrial biogas plants, night soil biogas plants, family size biogas plants and improved chulhas are some of the bio-energy sources employed and are under operational conditions in several parts of the world.

Tidal Power

Tides and Waves can generate enormous energy for consumption. The tides, which are dashing against the shores continuously, can generate the tidal power. This can be obtained by using a tidal dam built with a turbine. This is more expensive when compared to the hydroelectric power installations.

In high tide zones such provisions help in harnessing this power. There is also a limitation that it can produce electricity only at certain times of a year.

1.6.2.4 Energy from Nuclear and other Sources

Many of the environmentally conscious countries in the world depend on nuclear power for their electricity generation. At present about 17 % of the world's electricity is generated through nuclear sources.

Nuclear source is clean, compact and concentrated. Nuclear power plants are similar to coal plants in that heat is used to produce steam to drive a turbine. But the basic difference between them is the atomic fission instead of chemical combustion.

A nuclear reactor requires a fuel substance whose nuclei can undergo fission. Such substances are called fissionable substances. Uranium-235 and plutonium-239 are the most widely used fuels. In addition to the fuel, reactors require neutrons. These are the stimulators for chain reaction. The safety, design and operation of reactors depend on the way the neutrons are managed.

Nuclear reactors are classified based on the fuel, coolant and moderator used to support the nuclear chain reaction.

The natural concentration of uranium in the earth's crust is about 2 ppm. Uranium originates in magma. It is concentrated to about 4ppm in granitic rocks, pegmatites, etc. They occur in a large number of minerals. They are called rare-earth minerals (or) radio-active minerals. They contain Uranium or Thorium as an essential part of their chemical composition. Some of them are Oxides and complex oxides.

The disposal of nuclear wastes, some radio-active liquids, and gases will affect the environment severely. Sources are available in the form of fuel bundles, which were once loaded in to the reactor core can provide energy for 1 to 2 years at a stretch before discharge. One kg of Uranium gives an energy equivalent to 25,000 kg of coal.

Geothermal Energy

This refers to the heat energy emanating from the earth's interior which could be used for heating or for generating electricity. The production of geothermal energy can occur only in areas where hot rocks lie near the earth's surface.

Iceland, Italy, Japan, the Philippines, New Zealand, and the United States have developed geothermal power plants. The method is simple. Pipes are intalled into the wells drilled over the regions of geothermal sources and connected to a turbine.

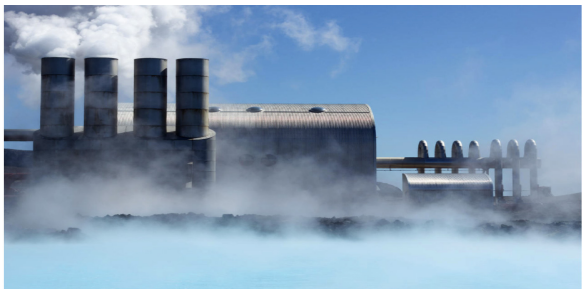

Fig 1.6.4 GeothermalEnergy

Nuclear energy

Nuclear energy is a form of energy which is released from the nucleus of an atom. It is delivered in huge amounts in processes that influence atomic nuclei made-up of protons and neutrons, the thick centres of atoms. It is particular from the energy of another atomic phenomenon. One technique for delivering nuclear energy is by controlled atomic splitting in gadgets called reactors, which presently work in many areas of the planet for the creation of power. Nuclear energy has been released violently by both nuclear fusions, where nuclei fuse together and nuclear fission, where nuclei split apart.

Hydrogen: Fuel of The Future

Hydrogen is an energy carrier that can transform our fossil-fuel dependent economy into a hydrogen economy, which can provide an emissions-free transportation fuel. An alternative fuel must be technically feasible, economically viable, easily convertable to another energy form when combusted, be safe to use, and be harmless to the environment. Hydrogen is the most abundant element on earth. Although hydrogen does not exist freely in nature, it can be produced from a variety of sources such as steam, reformation of natural gas, gasification of coal, and electrolysis of water. Hydrogen gas can used in traditional gasoline-powered internal combustion engines (ICE) with minimal conversions. However, vehicles with polymer electrolyte membrane (PEM) fuel cells provide a greater efficiency. Hydrogen gas combusts with oxygen to produce water vapor. Even the production of hydrogen gas can be emissions-free with the use of renewable energy sources. The current price of hydrogen is about $4 per kg, which is about the equivalent of a gallon of gasoline. However, in fuel cell vehicles, such as the 2009 Honda FCX Clarity, 1 kg provides about 68 miles of travel. Ofcourse, the price range is currently very high. Ongoing research and implementation toward a hydrogen economy is required to make this fuel economically feasible.

The current focus is directed toward hydrogen being a clean alternative fuel that produces insignificant greenhouse gas emissions. If hydrogen is the next transportation fuel, the primary energy source used to produce the vast amounts of hydrogen will not necessarily be a renewable, clean source. The U.S. Department of Energy has recently funded a research project to produce hydrogen from coal at large-scale facilities, with carbon sequestration in mind. Is this the wrong approach? Should there be more focus on other forms of energy that produce no greenhouse gas emissions? If the damage to the environment is interpreted into a monetary cost, the promotion of energy sources such as wind and solar may prove to be a more economical approach. The possibility of a hydrogen economy that incorporates the use of hydrogen into every aspect of transportation requires much further research and development. The most economical and major source of hydrogen in the US is steam reformation of natural gas, a nonrenewable resource and a producer of greenhouse gases. The electrolysis of water is a potentially sustainable method of producing hydrogen, but only if renewable energy sources are used for the electricity.

Today, less than 5% of our electricity comes

from renewable sources such as solar, wind, and hydro. Nuclear power may be considered as a renewable resource to some, but the waste generated by this energy source becomes a major problem. A rapid shift toward renewable energy sources is required before this proposed hydrogen economy can prove itself. The transport of hydrogen through underground pipes seems to be the most economical when demand grows enough to require a large centralized facility. However, in places of low population density, this method may not be economically feasible. The project mentioned earlier may become an option for individuals to produce their own hydrogen gas at home, with solar panels lining their roof. A drastic change is needed to slow down the effects of our fossil fuel dependent society. Conservation can indeed help, but the lifestyles we are accustomed to require certain energy demands. Transportation is a necessary part of our current world and the switch to a hydrogen economy can provide a sustainable solution.

Recap

- Energy is the capacity to perform work.
- The total quantity of usable energy available to people is called as Energy supply.
- Renewable sources are those which will be available for our human consumption again and again.
- Non-renewable energy sources are those which are permanently consumed for generating the energy and need further supply.
- Hydrogen is an energy carrier that can transform our fossil-fuel dependent economy into a hydrogen economy, which can provide an emissions-free transportation fuel.
- Fossil fuel is a natural fuel such as coal or gas, formed in the geological past from the remains of living organisms
- The energy we get from wind is known as wind energy.
- Biogas is the methane gas produced or released from the organic wastes like sewage, garbage, manure or crop residues.
- Geothermal Energy refers to the heat energy emanating from the earth's interior which could be used for heating or for generating electricity.

Objective Type Questions

1. Name a natural fuel such as coal or gas, formed in the geological past from the remains of living organisms
2. Mention an energy source that cannot be exploited though it can act as a continuous source.
3. What are energy sources that are not regenerated as per consumption?
4. Name the thermal energy produced deep in the earth core.

5. What is Bio-gas?
6. What constitute Bio-gas?
7. The energy we get from wind is known as?
8. Which is the best resource of energy in the form of heat and light?

Answers to Objective Type Questions

1. Fossil fuel
2. Renewable sources
3. Non-renewable sources
4. Geothermal Energy
5. It is the byproduct of aerobic digestion of organic materials which can be used as fuel.
6. Methane and carbon dioxide
7. Wind energy
8. Non-renewable sources

Self Assessment Questions

1. List out the various sources of energy.
2. Comment on the types and classification of energy resources.
3. Which are the various types of coal?
4. …….. is partially decayed plant matter found in recent swamp deposits.
5. Write a short note on natural gas.
6. Explain clean energy sources.
7. What are the advantages of solar energy?
8. Comment on the merits and demerits of wind energy.
9. Describe the non-conventional sources of energy.

Assignment

Do a comparative study on conventional and non-conventional energy sources.

Suggested Reading

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BLOCK - 02

Ecosystems, Biodiversity and Conservation

Unit 1
Concept, Structure and Function of an Ecosystem

Learning Outcomes

- Learns about the ecosystem concept and its structure
- Learns about the ecosystem and its types
- Understands the science of ecology and its types

Prerequisites

Life is impossible without Nature. The living organisms called biotic components are either producers, consumers or decomposers of food. Have you ever thought in which category we are? This leads to the study of ecosystem and its components.

Eco-system is fundamental interactions among organisms and their non-living/physi-co-chemical environment. The ecosystem is largely divided into two components - Abiotic and Biotic. The abiotic components refer to the physical environment or the non-living factors. The biotic components of the ecosystems are the living organisms including plants, animals and microorganisms.

Another important aspect we need to know is about the food chain. It shows how nutrients and energy are transferred from one organism to the other. Several interconnected food chains form a food web. Let us try to see our position in the food web.

Keywords

Ecosystem, Producers, Consumers, Decomposers, Food Web, Ecological Pyramid

Discussion

2.1.1 Concept, structure and function of an ecosystem

The interactions in nature are studied in a branch of science termed as 'Ecology'. Do you know why the plants and animals in a pond differ from an ocean? Why is there a difference in forest types all over the globe?

All these questions find answers in the study of ecology and ecosystems. The term 'Ecology' was first coined by the German biologist Ernst Haeckel in 1869. Haeckel defined ecology as 'the study of natural environment including the relations of organisms to one another and to their surroundings.' It is derived from two Greek words - "oikos" meaning home and "logos" meaning study. Thus literally, ecology is the study of life at home with main emphasis on patterns of relations between organisms and their surrounding environment.

An ecosystem can be visualised as a functional unit of nature, where living organisms interact

among themselves and also with the surrounding physical environment. The ecosystem is largely divided into two components, Abiotic and Biotic. Ecosystem structure is created due to interaction between abiotic and biotic components, varying over space and time.

2.1.1.1 Abiotic Components

The abiotic components of an ecosystem refer to the physical environment or the non-living factors. The organisms cannot live or survive without their abiotic components. They mainly include:

i) inorganic substances required by organisms such as carbon dioxide, water, nitrogen, calcium, phosphorus, etc. that are involved in material cycles. The amount of these inorganic substances present at any given time in ecosystem is called as standing state or standing quality of ecosystem.

ii) Organic compounds like proteins, carbohydrates, amino acids, lipids, humic substances and others are synthesized by the biotic counterpart of an ecosystem. They make the biochemical structure of the ecosystem.

iii)Climatic factors including mainly rain, light, temperature, humidity, wind and air and

iv) Edaphic and other factors such as minerals, soil, topography, pH, etc. greatly determine the functions, distribution, structure, behaviour and inter-relationship of organisms in a habitat.

2.1.1.2 Biotic Components

The biotic components of the ecosystems are the living organisms including plants, animals and microorganisms. Based on their nutritional requirement, i.e. how they get their food, they are categorized into three groups:

i) Producers,

ii) Consumers and

iii) Decomposers

Producers

Producers are mainly the green plants with chlorophyll which gives them the ability to use solar energy to manufacture their own food using simple inorganic abiotic substances, through the process of photosynthesis. They are also called as photoautotrophs (photo = light, auto= self, troph = nutrition). This group is mainly constituted by green plants, herbs, shrubs, trees, phytoplanktons, algae, mosses, etc. This group of organisms uses solar energy (photosynthesis) or more rarely inorganic chemical reactions (chemosynthesis) to create food in the form of energy-rich molecules such as carbohydrates. This process, the synthesis of carbon dioxide into organic compounds, is called primary production and is directly or indirectly connected to the survival of all life on the Earth. Producers form the first link of a food chain. Since they are at the beginning of the food chain, producers are the direct or indirect source of food for other living organisms. There are some chemosynthetic bacteria (sulphur bacteria) beneath in the ocean which can synthesize their food in absence of sunlight, thus known as chemoautotrophs (chemo= chemical, auto= self, troph = nutrition).

Consumers

The next level of organisms that follows the producers are the consumers. Consumers are organisms that cannot prepare their own food and depend on plants and animals for food. Organisms that cannot make their own food are called heterotrophs, because they obtain food from other organisms rather than themselves. Consumers lack chlorophyll, so they depend on producers for food. They are also known as heterotrophs. Consumers include mammals, birds, fish, reptiles, amphibians, insects, fungi and microscopic organisms such as protozoa and some types of bacteria. Depending on how they obtain food, there are

four types of consumers: primary, secondary, tertiary and quaternary consumers. They mainly include herbivorous (feed on plants), carnivorous (feed on other animals), omnivorous (feed on both plants and animals) and detritivore organisms (feed on dead parts, waste, remains, etc. of plants and animals,).

Primary consumers: Feed directly on plants and other producers. Examples of primary consumers are zooplankton, butterflies, rabbits, giraffes, pandas and elephants.

Secondary consumers: Feed on primary consumers, Examples of secondary consumers are earwigs, ants, badgers, snakes, rats, crabs, hedgehogs, blue whales (their diet is primarily composed of phytoplankton-eating krill and zooplankton, and phytoplankton), lions, and humans. Secondary consumers nearly always consume both producers and primary consumers and are therefore usually classed as omnivores.

Tertiary consumers: Feed on secondary consumers.

Quaternary consumers: A quaternary consumer is simply a consumer which preys upon a tertiary consumer. To be classed as a quaternary consumer within a food chain or food web, there must be a tertiary consumer available for the quaternary consumer to prey upon. Examples of quaternary consumers are the white shark, polar bear and alligator.

Decomposers

Decomposers (saprotrophs) are the microorganisms, bacteria and fungi, which break down complex dead organic matter into simple inorganic forms, absorb some of the decomposition products, and release inorganic nutrients that are reused by the producers. All ecosystems have their own set of producers, consumers and decomposers which are specific to that ecosystem.

Decomposers or detrivores are a group of organisms consisting of small animals like worms, insects, bacteria and fungi, which break down dead organic material into smaller particles and finally into simpler substances that are used by plants as nutrition. Thus, decomposers are microorganisms that break down complex organic matter into simple inorganic matter through chemical reactions. All living organisms are made up of complex organic matter such as complex carbohydrates, proteins and fats. When they die, decomposers act on their dead bodies and return their organic matter back to nature in inorganic form. The inorganic matter enters the soil as nutrients that are absorbed by plants. Bacteria, protozoa and earthworms are examples of decomposers. Decomposers are an integral part of a food chain, as they convert organic waste materials into inorganic materials. Decomposers complete a life cycle. They help in recycling the nutrients as they provide nutrients to soil or oceans, that can be utilised by autotrophs or producers, thus, starting a whole new food chain.

2.1.2 Concept and definition of Food Chain

The food chain is a linear sequence of organisms where nutrients and energy are transferred from one organism to the other. This occurs when one organism consumes another organism. It begins with producer organism, follows the chain and ends with decomposer organism. A food chain refers to the order of events in an ecosystem, where one living organism eats another organism, and later that organism is consumed by another larger organism. The flow of nutrients and energy from one organism to another at different trophic levels forms a food chain. The food chain also explains the feeding pattern or relationship between living organisms. Trophic

level refers to the sequential stages in a food chain, starting with producers at the bottom, followed by primary, secondary and tertiary consumers. Every level in a food chain is known as a trophic level.

There are two types of food chains, namely detritus food chain and grazing food chain. Let's look at them more closely:

a) Detritus food chain:

The detritus food chain includes different species of organisms and plants like algae, bacteria, fungi, protozoa, mites, insects, worms and so on. The detritus food chain begins with dead organic material. The food energy passes into decomposers and detritivores, which are further eaten by smaller organisms like carnivores. Carnivores, like maggots, become a meal for bigger carnivores like frogs, snakes and so on. Primary consumers like fungi, bacteria, protozoans, and so on are detritivores which feed on detritus.

b) Grazing food chain:

The grazing food chain is a type of food chain that starts with green plants, passes through herbivores and then to carnivores. In a grazing food chain, energy in the lowest trophic level is acquired from photosynthesis. In this type of food chain, the first energy transfer is from plants to herbivores.

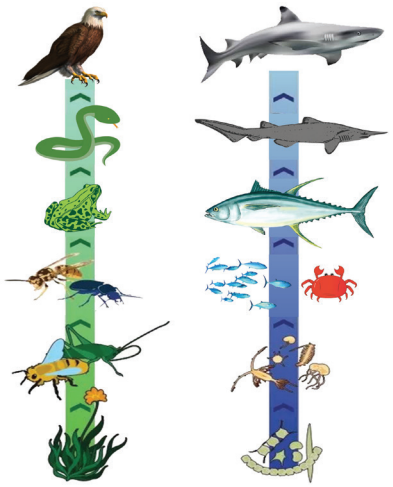

Fig2.1.1.TerrestrialandAquaticFoodChains
(Source -Internet)

This type of food chain depends on the flow of energy from autotrophs to herbivores. As autotrophs are the base for all ecosystems on Earth, the majority of ecosystems in the environment follow this kind of food chain.

2.1.3 Food Web

Several interconnected food chains form a food web. A food web is similar to a food chain but it comparatively larger than a food chain. Occasionally, a single organism is consumed by many predators or it consumes several other organisms. Due to this, many trophic levels get interconnected. The food chain fails to showcase the flow of energy in the right way. But the food web is able to show the proper representation of energy flow, as it displays the interactions between different organisms. When there are more cross interactions between different food chains, the food web gets more complex. This complexity in a food web leads to a more sustainable ecosystem. In a food chain, there is a singular path for energy flow and in a food web, there are different paths for energy flow.

2.1.4 Ecological Pyramid

An ecological pyramid is a graphical representation of the relationship between the different living organisms at different trophic levels. Ecological pyramids were first developed by Charles Elton. Since he first developed the ecological pyramid, it is also known as Eltonian pyramid. An ecological pyramid may be erect or inverted depending on the type of criterion and the ecosystem. It can be observed that these pyramids are in the shape of actual pyramids with the base being the broadest, which is covered by the lowest trophic level, i.e., producers. The next level is occupied by the primary consumers and so on.

2.1.4.1 Types of Ecological Pyramid

Three types of ecological pyramid exist. They are as follows,

a) Pyramid of Numbers

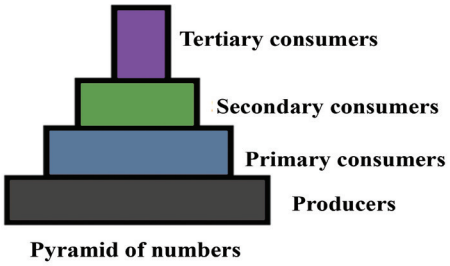

Fig: 2.1.2 Pyramid of Numbers

In this type of ecological pyramid, the number of organisms in each trophic level is considered as a level in the pyramid. The pyramid of numbers is usually upright except for some situations like that of the detritus food chain, where many organisms feed on one dead plant or animal. This shows the number of organisms in each trophic level without any consideration for their size. This type of pyramid can be convenient, as counting is often a simple task and can be done over the years to observe the changes in a particular ecosystem.

b) Pyramid of Biomass

In this particular type of ecological pyramid, each level takes into account the amount of biomass produced by each trophic level. The pyramid of biomass is also upright except for that observed in oceans where large numbers of zooplanktons depend on a relatively smaller number of phytoplanktons. This indicates the total mass of organisms at each trophic level. Usually, this type of pyramid is largest at the bottom and gets smaller going up, but exceptions do exist. The biomass of one trophic level is calculated by multiplying the number of individuals in the trophic level by the average mass of one individual in a particular area. This type of ecological pyramid solves some problems of the pyramid of numbers, as it shows a more accurate representation of the amount of energy contained in each trophic level, but it has its own limitations. For example, the time of year when the data are gathered is very important, since different species have different breeding seasons.

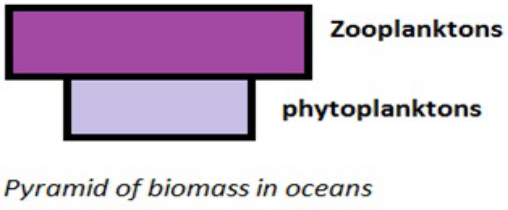

Fig:2.1.3.Pyramid of biomass in oceans

c) Pyramid of Energy

Pyramid of energy is the only type of ecological pyramid, which is always upright as the energy flow in a food chain is always unidirectional. Also, with every increasing trophic level, some energy is lost into the environment. The pyramid of productivity looks at the total amount of energy present at each trophic level, as well as the loss of energy between trophic levels. Since this type of representation takes into account the fact that the majority of the energy present at one trophic level will not be available for the next one, it is more accurate than the other two pyramids. This is based on a law which states that only about 10% of the energy in a trophic level will go towards creating biomass. In other words, only about 10% of the energy will go into making tissue, such as stems, leaves, muscles, etc. in the next trophic level. The rest is used in respiration, hunting, and other activities, or is lost to the surroundings as heat.

The pyramid of energy is the most widely used type of ecological pyramid, and, unlike the two other types, can never be largest at the apex and smallest at the bottom. It's an important type of ecological pyramid because it examines the flow of energy in an ecosystem over time.

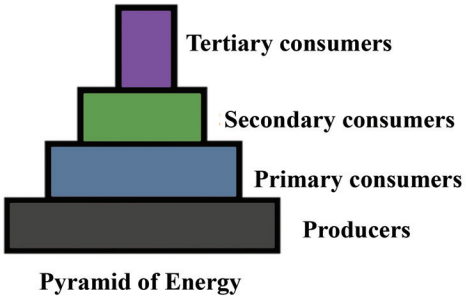

Fig:2.1.4. Pyramid of Energy

Ecological pyramid

The diagram below is an example of a productivity pyramid, otherwise called an energy pyramid. The sun has been included in this diagram, as it is the main source of all energy, as well the decomposers, like bacteria and fungi, which can acquire nutrients and energy from all trophic levels by breaking down dead or decaying organisms. As shown, the nutrients then go back into the soil and are taken up by plants.

The loss of energy to the surroundings is also shown in this diagram, and the total energy transfer has been calculated. We start off with the total amount of energy that the primary producers contain,

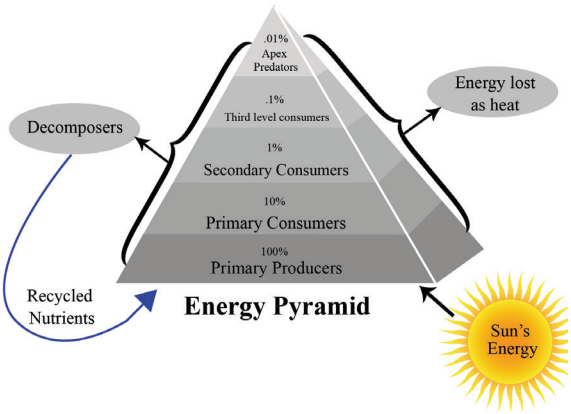

Fig:2.1.5. Ecological pyramid

which is indicated by 100%. As we go up one level, 90% of that energy is used in ways other than to create flesh. What the primary consumers end up with is just 10% of the starting energy, and, 10% of that 10% is lost in the transfer to the next level. That's 1%, and so on. The predators at the apex, then, will only receive 0.01% of the starting energy! This inefficiency in the system is the reason why productivity pyramids are always upright.

Recap

- The fundamental interactions among organisms and their non-living/physico-chemical environment constitute an interrelating and interdependent ever-changing system known as an ecological system or ecosystem. The ecosystem has been considered as the basic functional unit of ecology.
- The ecosystem is largely divided into two components - Abiotic and Biotic
- The abiotic components of an ecosystem refer to the physical environment or the non-living factors.
- The biotic components of the ecosystems are the living organisms including plants, animals and microorganisms.
- The biotic components of the ecosystems are the living organisms including plants, animals and microorganisms Based on their nutritional requirement, i.e. how they get their food, they are categorized into three groups – i) Producers, ii) Consumers and iii) Decomposers

- The food chain is a linear sequence of organisms where nutrients and energy are transferred from one organism to the other.
- Several interconnected food chains form a food web. A food web is similar to a food chain but the food web is comparatively larger than a food chain.
- An ecological pyramid is a graphical representation of the relationship between the different living organisms at different trophic levels.
- Three types of ecological pyramid exist. They are a) Pyramid of Numbers b) Pyramid of Biomass and c) Pyramid of Energy.
- Pyramid of energy is the only type of ecological pyramid, which is always upright as the energy flow in a food chain is always unidirectional. Also, with every increasing trophic level, some energy is lost into the environment.

Objective Type Questions

1. Who coined the term 'Ecology'?
2. Who makes its own energy in food chain?
3. Which is last level of a food chain?
4. Who proposed the term Ecosystem?
5. What is called the natural residence of every organism?
6. What is the variety of living organisms called?
7. Who developed ecological pyramids for the first time?
8. What is producers?

Answers to Objective Type Questions

1. German biologist Ernst Haeckel in 1869.
2. Producer Organisms
3. Decomposers
4. AG Tansley
5. Habitat
6. Biodiversity
7. British Ecologist, Charles Elton (1927)
8. An organism that uses sunlight to make its own food.

Self Assessment Questions

1. Define ecology.
2. The term 'Ecology' was first coined by the German biologist …….. .
3. Describe abiotic components with examples.
4. What do you mean by biotic components of an ecosystem? Give examples.
5. Explain the functions of decomposers in an ecosystem.
6. Differentiate food chain and food web.
7. Describe ecological pyramids and their types.
8. Pyramid of energy is always upright.Do you agree? Explain the reason for your answer.
9. Write an essay on ecological pyramids.

Assignments

1. Construct a pyramid of numbers in a nearby ecosystem
2. List out producers, consumers, and decomposers in an ecosystem

Suggested Reading

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Unit 2
Basic Awareness on Various Ecosystems

Learning Outcomes

- Learns about the concept of different ecosystems
- Understands about terrestrial ecosystems such as forests and deserts.
- Learns about aquatic ecosystem
- Understands about Wetland ecosystem

Prerequisites

Now we are familiar with an ecosystem. An ecosystem can be as small as an oasis in a desert, or as big as an ocean.? Do you know why? Ecosystems can be terrestrial or aquatic. Terrestrial ecosystems are land based while aquatic are water based.

Terrestrial ecosystem can be classified in to three types- forest ecosystem, grassland ecosystem and desert ecosystem.

Global aquatic ecosystem fall in to two categories defined by salinity-Fresh water ecosystems and salt water ecosystems.

The distribution of the ecosystem is influenced by temperature and precipitation.

Keywords

Terrestrial, Aquatic Ecosystem, Freshwater and Marine, Wetland Ecosystem

Discussion

Do you know why an ecosystem can be as small as an oasis in a desert, or as big as an ocean? It is interesting.

An ecosystem consists of all the living and non-living things in a specific natural setting. Plants, animals, insects, microorganisms, rocks, soil, water and sunlight are the major components of many ecosystems. A community of living organisms of a particular region living in conjunction with non-living components is called an ecosystem. Ecosystems vary greatly in size from a small pond to a large forest or a sea. Many ecologists regard the entire biosphere as a global ecosystem, as a composite of all local ecosystems on Earth. Since this system is too big and complex to be studied at one time, it is convenient to divide it into two basic categories, namely the terrestrial and the aquatic. Terrestrial ecosystems are land-based, while aquatic are water-based. The major types of ecosystems are forests, grasslands, deserts, tundra, freshwater and marine. The word “biome” may also be used to describe terrestrial ecosystems which

extend across a large geographic area, such as the tundra. There are different types of terrestrial ecosystems, which are widely distributed around the geological zones.

2.2.1 Terrestrial Ecosystem

The terrestrial ecosystem refers to the ecosystem of different land forms. Terrestrial ecosystems cover approximately 140 to 150 million Km^2, which is about 25 to 30 percent of the total surface area of the earth. They are exclusively land-based ecosystems. There are different types of terrestrial ecosystems distributed around various geological zones. They are as follows:

1. Forest Ecosystems
2. Grassland Ecosystems
3. Tundra Ecosystems
4. Desert Ecosystem

2.2.1.1 Forest Ecosystems

These types of ecosystems include temperate deciduous forest, plantation forests and tropical rain forests. They serve as a natural habitat for a vast range of living species and also comprise the highest species diversity. Forests cover nearly 30 to 35 million square kilometres of the earth's surface.

The Forest ecosystems are classified according to their climate type as tropical, temperate or boreal. In the tropics, rainforest ecosystems contain more diverse flora and fauna than ecosystems in any other region on earth. In these warm, moisture-laden environments, trees grow tall and foliage is lush and dense, with species inhabiting the forest floor all the way up to the canopy. In temperate zones, the forest ecosystems may be deciduous, coniferous or often times a mixture of both, in which some trees shed their leaves each autumn, while others remain evergreen year-round. In the far north, just south of the Arctic, boreal forests– also known as taiga– feature abundant coniferous trees. There are different types of forest ecosystems based on climatic conditions such as tropical, temperate, boreal, etc. In a tropical ecosystem, we can find a large variety of vegetation as compared to another terrestrial ecosystem. This is the reason that you will always find tropical regions loaded with lush green landscapes. Forests are important. On the other hand, in the temperate regions the ecosystem may be coniferous, deciduous, or a combination of both. The forest ecosystem is one of the crucial terrestrial ecosystems that provide shelter to thousands of plant and animal species.

2.2.1.2 Grassland Ecosystem

Grasslands are the most dominant type of vegetation and these types of environments occur naturally in several parts of the world. These types of terrestrial ecosystems serve as a home for a wide diversity of animal species, such as elephants, giraffes, hyenas, jackrabbits, lions, rhinos, warthogs and zebras. Different types of grassland ecosystems can be found in prairies, savannas and steppes. Grassland ecosystems are typically found in tropical or temperate regions, although they can exist in colder areas as well, as is the case with the well-known Siberian steppe. Grasslands share the common climactic characteristic of semi-aridity. Trees are sparse or nonexistent, but flowers may be interspersed with the grasses. Grasslands provide an ideal environment for grazing animals.

Types of grasslands include:

1. Tropical Grasslands and
2. Temperate Grasslands

As the name suggests, the grassland ecosystem mainly contains grasses along with some species of shrubs and trees. Grassland is a perfect region for grazing animals. The atmosphere in the grassland ecosystem is quite pleasant, and the climatic conditions are very similar to

semi-arid regions. Organisms mostly found in the grassland ecosystem are grazing animals, herbivorous, insectivorous, etc. Tropical and temperate are typical regions of the grassland ecosystem.

2.2.1.3 Desert Ecosystems

The common defining feature among desert ecosystems is low precipitation, generally less than 25 centimeters, or 10 inches, per year. Not all deserts are hot desert ecosystems; they can exist from the tropics to the arctic, but regardless of latitude, deserts are often windy. Some deserts contain sand dunes, while others feature mostly rock. Vegetation is sparse or nonexistent, and any animal species, such as insects, reptiles and birds, must be highly adapted to the dry conditions. A high amount of flora and fauna are found in this region. The desert ecosystem covers almost 17% of the Earth's surface. Excessive temperature, extreme sunshine, less water availability, etc. do not allow a variety of plants and animals to live in a desert ecosystem. You can find some plants such as cactus in the desert ecosystem. These types of plants can conserve water to a large extent. In this region, we can find animals like camels, reptiles, a few insects, etc.

Depending on the climate and temperature, deserts can be classified into hot deserts and cold deserts. There are many life forms well-adapted to life in the desert. Animals include camels, foxes, hyenas, jackals, scorpions, a few varieties of snakes and lizards. The common plants are acacia, cactus and date palms. Sahara is an example of a hot desert, which is characterised by high temperatures associated with little rainfall and complicated life for both plants and animals. Ladakh is an example of a cold desert, which is found on the eastern side of Jammu and Kashmir near the Great Himalayas.

2.2.1.4 Aquatic Ecosystem

Aquatic ecosystems are ecosystems present in a body of water. These can be further divided into two types, namely:

1. Freshwater Ecosystem
2. Marine Ecosystem

Freshwater Ecosystem

The freshwater ecosystem is an aquatic ecosystem that includes lakes, ponds, rivers, streams, wetlands bogs and freshwater swamps. These have no salt content in contrast with the marine ecosystem. They are subdivided into two classes those in which the water is nearly stationary, such as ponds, and those in which the water flows, such as creeks. Freshwater ecosystems are home to more than just fish: algae, plankton, insects, amphibians and underwater plants also inhabit them. Freshwater covers less area as compared to the marine ecosystem. The freshwater ecosystem covers almost 0.8% of the Earth's surface.

The major kinds of freshwater ecosystems are lentic, lotic, and wetlands. Lentic ecosystem refers to stagnant water bodies such as ponds, lakes, etc. whereas the lotic ecosystem means fast-flowing water bodies such as a river. On the other hand, in wetland areas, the land becomes saturated and remains water logged for a long period. The freshwater ecosystem is a home for various fishes, reptiles, amphibians, etc. The fast-flowing water bodies have more dissolved oxygen as compare to slow-flowing water bodies. Hence, the fast-flowing water bodies support significant diversity of life.

Marine Ecosystems

The Marine ecosystems differ from freshwater ecosystems in that they contain saltwater, which usually supports more different types of species than the fresh water. The Marine ecosystems are the most abundant types of

ecosystems in the world. They encompass not only the ocean floor and surface but also tidal zones, estuaries, salt marshes and saltwater swamps, mangroves and coral reefs. Marine ecosystem covers almost 70% of the area on the Earth's surface; hence it is known as one of the biggest kinds of ecosystems on the Earth. Water is the main component of the marine ecosystem, which contains various minerals and salts dissolved in it. Many organisms such as sharks, cephalopods, brown algae, echinoderm, corals, dinoflagellates, etc .populate the marine ecosystem.

Wetland Ecosystems

Wetlands comprise areas that are transitional between terrestrial (land) areas and aquatic (water) areas. The wetlands ecosystem represents a richly diverse web of plants and animals interacting together. They also exhibit great sensitivity to disturbance from outside influence, particularly by human development and environmental damage. Wetlands ecosystems provide the world with natural storm barriers, environmental cleansers, and food and water resources for many forms of life. The water in wetlands ecosystems can be freshwater, saltwater, brackish water or flowing water. Wetlands contain wet soils and typically anaerobic environments, and rooted plants and other forms of life used to those conditions. While remaining distinct, the characteristics of wetlands may blend both terrestrial and aquatic environments. The characteristics and functions of any given wetland are determined by climate, hydrology, and substrate, as well as by position and dominance in the landscape. In many cases, wetlands occupy a small portion of the total landscape (usually less than 10%), but have extensive boundaries with both terrestrial and aquatic ecosystems. In some cases, they occupy virtually the entire landscape. Despite their great range in size and other features, wetlands share specific characteristics, some of which are structural (water, substrate, biota), while others are functional (nutrient cycling, water balance, organic production).

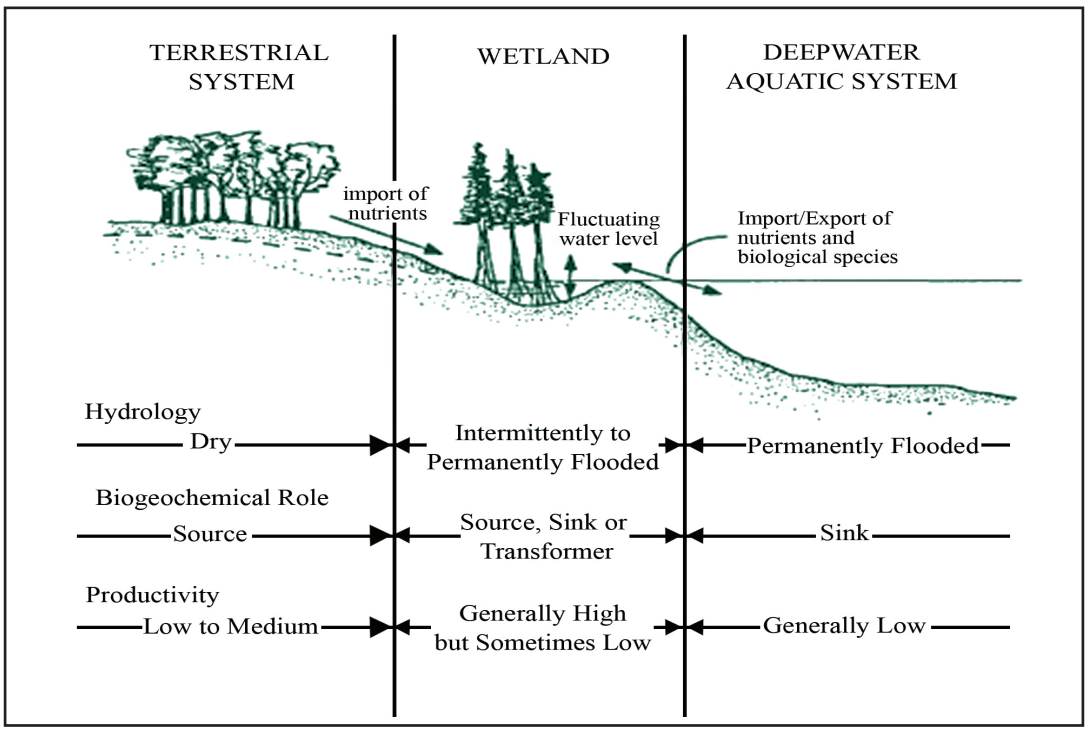

Fig 2.2.1 Wetland Ecosystems

Recap

- All types of ecosystems fall in to two categories, terrestrial, and aquatic.
- Terrestrial ecosystems are land based, while aquatic are water based.
- The distribution of terrestrial ecosystems is primarily related to precipitation and temperature
- Terrestrial ecosystem can be classified in to three types, forest ecosystem, grassland ecosystem and desert ecosystem.
- Grasslands are the most dominant type of vegetation and these types of environments occur naturally in several parts of the world.
- Grasslands are mainly two types: Tropical grasslands and Temperate Grasslands.
- The common defining feature among desert ecosystems is low precipitation, generally less than 25 centimetres, or 10 inches, per year. The desert ecosystem covers almost 17% of the Earth's surface. Excessive temperature, extreme sunshine, less water availability, etc. do not allow a variety of plants & animals to live in a desert ecosystem.
- Global aquatic ecosystems fall in to two categories defined by salinity-Fresh water ecosystems and salt water ecosystems.
- Fresh water ecosystems can be divided in to two group: lentic or standing water habitats and lotic or running water habitats.
- Wetlands comprise areas that are transitional between terrestrial (land) areas and aquatic (water) areas. The wetlands ecosystem represents a richly diverse web of plants and animals interacting together.

Objective Type Questions

1. What are the major types of ecosystems?
2. Which ecosystem is known as Kidneys of the Earth ?
3. Which is the largest ecosystem on the Earth ?
4. Which are the most important organisms of an ecosystem?
5. What is an ecosystem?

Answers to Objective Type Questions

1. Terrestrial and Aquatic
2. Wetlands
3. Biosphere
4. Green plants
5. Ecosystem consists of all the living and non-living things in a specific natural setting.

Self Assessment Questions

1. What are the different types of terrestrial ecosystems?
2. Forests cover nearly ……. million square kilometres of the earth's surface.
3. Describe grasslands.
4. What are the abiotic and biotic characteristics of desert ecosystems?
5. Describe aquatic ecosystems.
6. Define wetlands.
7. Which is the biggest ecosystem on the earth?

Assignments

1. "Wetlands are known as Kidneys of Earth". Find out the reasons.
2. Visit the nearest ecosystem and find out its significance in the Environment

Suggested Reading

1. E-pgpathsal
2. www.Sciencing.co

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Unit 3
Definition and Levels of Biodiversity

Learning Outcomes

- Learns about biodiversity and its levels.
- Learns about the tangible uses (goods) provided by the global biodiversity, including food, drugs, industrial products, genetic resources and so on.
- Learns about intangible values (services) provided by the global biodiversity, including provisional services, regulating services, supporting services and cultural services.

Prerequisites

Our earth has a variety of living creatures. The diverse flora and fauna make the earth a beautiful place. There are several levels of biodiversity, each indicating how different the genes, species and resources are in a region.

Biodiversity is measured by two major components: species richness, and species evenness. Species richness depends on the number of species found in a community. Species Evenness implies the number and the relative abundance of species.

Do you know that even human kind are varied? The Homo sapiens include the Chinese, Indian American, African etc..

The biodiversity impart Consumptive use value, Productive use value , Social values, Ethical and moral values, Aesthetic value, and Option value.

Keywords

Species richness, Species Evenness, Genetic diversity, Aesthetic value, Option value.

Discussion

2.3.1 Biodiversity

Biodiversity describes the richness and variety of life on the earth. It is the most complex and important feature of our planet. Without biodiversity, life would not sustain. The term biodiversity was coined in 1985. It comes from a combination of two words "Bio",means living and diversity means variation. Hence, put simply, variation among the living beings is called biodiversity. It is important in natural as well as artificial ecosystems. It deals with nature's variety, the biosphere. It refers to variabilities among plants, animals and microorganism species. Biodiversity includes the number of different organisms and their

relative frequencies in an ecosystem. It also reflects the organization of organisms at different levels. Biodiversity holds ecological and economic significance. It provides us with nourishment, housing, fuel, clothing and several other resources. It also brings in monetary benefits through tourism. Therefore, it is very important to have a good knowledge of biodiversity for a sustainable livelihood. Biodiversity is the variety of plant and animal life in the world or in a particular habitat. It is a key measure of the health of any ecosystem, and of our entire planet. Every organism in an ecosystem, or biome, relies on other organisms and the physical environment. For example, plant and animal species need each other for food, and depend on the environment for water and shelter. Biodiversity describes how much variety an ecosystem has, in terms of resources and species, and also genetically within species. A more diverse ecosystem will have more resources to help it recover from famine, drought, disease or even the extinction of a species. There are several levels of biodiversity, each indicating how diverse the genes, species and resources are in a region. Biodiversity is measured by two major components: species richness, and species evenness.

Species richness: It is the measure of the number of species found in a community. It takes in to account only the numbers and not the abundance of the species.

The sample forest A has 4 tigers, 5 deer and 6 rabbits and sample forest B has 1 tiger, 6 deer and 8 rabbits. Both samples have the same richness (3 species – species richness) and the same total number of individuals. However, the sample forest A has more evenness than the sample forest B. Low evenness indicates that a few species dominate in the site.

Species Evenness: Species evenness takes into account the number of species and the relative abundance of species in a community. Several indices have been proposed. Two of the commonly used measures of evenness are the

a)Shannon- Weiner- index (H): It quantifies the entropy or degree of surprise

b)Simpson index (D) : It was introduced in 1949 by Edward H Simpson to measure the degree of concentration when individuals are classified in to types.

Alpha diversity: It refers to the diversity within a particular area or ecosystem and is usually expressed by the number of species (i.e., species richness) in that ecosystem.

Beta diversity: It is a comparison of diversity between ecosystems, usually measured as the change in the number of species between the ecosystems.

Gamma diversity: It is a measure of the overall diversity for the different ecosystems within a region.

Genetic diversity: Genetic diversity is the total number of genetic characteristics in the genetic makeup of a species. A single species might show high diversity at the genetic level (e.g. Homo sapiens: Chinese, Indian American, African etc.). Genetic diversity allows species to adapt to changing environments. This diversity aims to ensure that some species survive drastic changes and thus carry on desirable genes. Species that differ from one another in their genetic makeup do not interbreed in nature. Closely-related species have in common much of their hereditary characteristics. For instance, about 98.4 per cent of the genes of humans and chimpanzees are the same. Each member of any animal or plant species differs widely from other individuals in its genetic makeup because of the large number of combinations possible in the genes

that give every individual specific characteristic. Thus, for example, each human being is very different from all others. This genetic variability is essential for a healthy breeding population of a species. If the number of breeding individuals is reduced, the dissimilarity of genetic makeup is reduced and inbreeding occurs. Eventually this can lead to the extinction of the species. The diversity in wild species forms the 'gene pool' from which our crops and domestic animals have developed over thousands of years. Today the variety of nature's bounty is being further harnessed by using wild relatives of crop plants to create new varieties of more productive crops and to breed better domestic animals. Modern biotechnology manipulates genes for developing better types of medicines and a variety of industrial products.

2.3.2 Species diversity

It is the ratio of one species population over the total number of organisms across all species in the given biome. 'Zero' would be infinite diversity, and 'one' represents only one species present. Species diversity is a measure of the diversity within an ecological community that incorporates both species richness (the number of species in a community) and the evenness of species. In general, species diversity decreases as we move away from the equator towards the poles. With very few exceptions, tropics (latitudinal range of 23.5° N to 23.5° S) harbour more species than temperate or polar areas. The number of species of plants and animals that are present in a region constitutes its species diversity. This diversity is seen both in natural ecosystems and in agricultural ecosystems. Some areas are more rich in species than others. Natural undisturbed tropical forests have a much greater species richness than plantations developed by the Forest Department for timber production. At present conservation scientists have been able to identify and categorise about 1.8 million species on earth. However, many new species are being identified, especially in the flowering plants and insects. Areas that are rich in species diversity are called 'hotspots' of diversity. India is among the world's 15 nations that are exceptionally rich in species diversity.

Fig 2.3.1 Species Diversity

2.3.3 Ecosystem Diversity

An ecosystem is referred to as 'natural' when it is relatively undisturbed by human activities, or 'modified' when it is changed to other types of uses, such as farmland or urban areas. Ecosystems are most natural in wilderness areas. If natural ecosystems are overused or misused their productivity eventually decreases and they are then said to be degraded. India is exceptionally rich in its ecosystem diversity. A region may have several ecosystems, or it may have one. Wide expanses of oceans or deserts would be examples of regions with low ecological diversity. A mountain area that has lakes, forests, and grasslands would have

higher biodiversity in this sense. A region with several ecosystems may be able to provide more resources to help native species survive, especially when one ecosystem is threatened by drought or disease. Ecosystem diversity deals with the variations in ecosystems within a geographical location and their overall impact on human existence and the environment. It is a type of biodiversity which refers to variation in species rather than ecosystems.

There are a large variety of different ecosystems on earth, which have their own complement of distinctive inter linked species based on the differences in the habitat. Ecosystem diversity can be described for a specific geographical region, or a political entity such as a country, a State or a taluk. Distinctive ecosystems include landscapes such as forests, grasslands, deserts, mountains, etc., as well as aquatic ecosystems such as rivers, lakes, and the sea. Each region also has man-modified areas such as farmland or grazing pastures. The diversity of life at all three organizational levels, genetic, species and ecosystem, is thus being rapidly modified by modern man. This is a great loss to the future generations who will follow us.

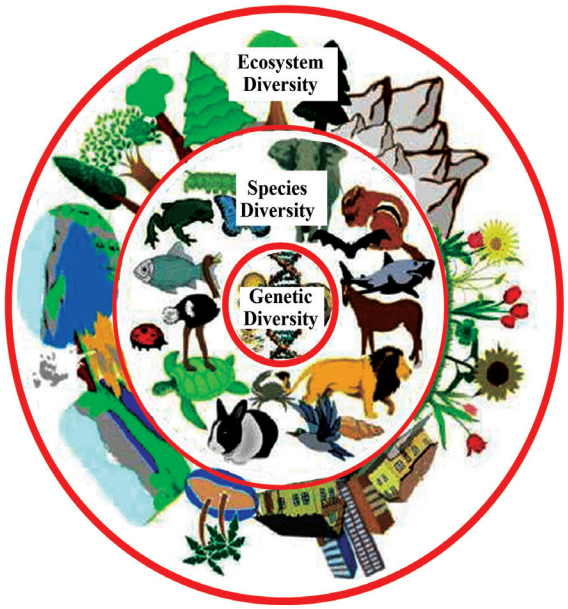

Fig.2.3.2. Biodiversity at different levels

2.3.4 Values of Biodiversity

Biodiversity provides a variety of environmental services from its species and ecosystems that are essential at the global, regional and local levels. Biodiversity is essential for preserving ecological processes, such as fixing and recycling of nutrients, soil formation, circulation and cleansing of air and water, global life support, maintaining the water balance within ecosystems, watershed protection, maintaining stream and river flows throughout the year, and erosion control and local flood reduction. Food, clothing, housing, energy, and medicines are all resources that are directly or indirectly linked to the biological variety present in the biosphere

2.3.4.1 Consumptive use value

A straight consumptive use is the direct utilization of timber, food, fuel wood and fodder by local communities. The diversity of organisms provide food, clothing, shelter, medicines, proteins, enzymes, papers, sports goods, musical instruments, beverages, narcotics, pets, zoo specimens, tourism and raw material for business etc. The direct utilization of timber, food, fuel wood and fodder is done by local communities. The biodiversity held in the ecosystem provides forest dwellers with all their daily needs, food, building material, fodder, medicines and a variety of other products. Fisher folk are highly dependent on fish and know where and how to catch fish and other edible aquatic animals and plants.

2.3.4.2 Productive use value

The biotechnologist uses bio rich areas to 'prospect' and search for potential genetic properties in plants or animals that can be used to develop better varieties of crops that are used in farming and plantation programs or to develop better livestock. To the pharmacist, biological diversity is the raw material from

which new drugs can be identified from plant or animal products. To industrialists, biodiversity is a rich storehouse from which to develop new products. For the agricultural scientist the biodiversity in the wild relatives of crop plants is the basis for developing better crops. Genetic diversity enables scientists and farmers to develop better crops and domestic animals through careful breeding. Originally this was done by selecting or pollinating crops artificially to get a more productive or disease resistant strain. Today this is increasingly being done by genetic engineering, selecting genes from one plant and introducing them into another. New crop varieties (cultivars) are being developed using the genetic material found in wild relatives of crop plants through biotechnology. Even today, new species of plants and animals are being constantly discovered in the wild. Thus these wild species are the building blocks for the betterment of human life and their loss is a great economic loss to mankind. Among the known species, only a tiny fraction has been investigated for their value in terms of food, or their medicinal or industrial potential. Preservation of biodiversity has now become essential for industrial growth and economic development. A variety of industries such as pharmaceuticals are highly dependent on identifying compounds of great economic value from the wide variety of wild species of plants located in undisturbed natural forests. This is called biological prospecting.

2.3.4.3 Social values

While traditional societies which had a small population and required less resources had preserved their biodiversity as a life supporting resource, modern man has rapidly depleted it even to the extent of leading to the irrecoverable loss due to extinction of several species. Thus, apart from the local use or sale of products of biodiversity there is the social aspect in which more and more resources are used by affluent societies. The biodiversity has to a great extent been preserved by traditional societies that valued it as a resource and appreciated that its depletion would be a great loss to their society. The consumptive and productive value of biodiversity is closely linked to social concerns in traditional communities. 'Ecosystem people' value biodiversity as a part of their livelihood as well as through cultural and religious sentiments. A great variety of crops have been cultivated in traditional agricultural systems and this permitted a wide range of produce to be grown and marketed throughout the year and acted as an insurance against the failure of one crop. In recent years farmers have begun to receive economic incentives to grow cash crops for national or international markets, rather than to supply local needs. This has resulted in local food shortages, unemployment (cash crops are usually mechanized), landlessness and increased vulnerability to drought and floods.

2.3.4.4 Ethical and moral values

Ethical values related to biodiversity conservation are based on the importance of protecting all forms of life. All forms of life have the right to exist on earth. Man is only a small part of the Earth's great family of species. We do not know if life as we know it exists else- where in the universe. Apart from the economic importance of conserving biodiversity, there are several cultural, moral and ethical values which are associated with the sanctity of all forms of life. Indian civilization has over several generations preserved nature through local traditions. This has been an important part of the ancient philosophy of many cultures. India has a large number of sacred groves or 'deorais' preserved by tribal people in several states. These sacred groves around ancient sacred sites and temples act as gene banks of wild plants.

2.3.4.5 Aesthetic value

Knowledge and an appreciation of the presence of biodiversity for its own sake is another reason to preserve it. Quite apart from killing wildlife for food, it is important as a tourist attraction. Biodiversity is a beautiful and wonderful aspect of nature. Sit in a forest and listen to the birds. Watch a spider weave its complex web. Observe a fish feeding. These are magnificent and fascinating. Symbols from wild species such as the lion of Hinduism, the elephant of Buddhism, the eagles and foxes of Egyptian, Roman and Greek civilizations,have been venerated for thousands of years.

2.3.4.6 Option value

Keeping future possibilities open for their use is called option value. It is impossible to predict which of our species or traditional varieties of crops and domestic animals will be of great use in the future. To continue to improve cultivars and domestic livestock, we need to return to wild relatives of crop plants and animals. Thus the preservation of biodiversity must also include traditionally used strains already in existence in crops and domestic animals. Environmental economics (or ecological economics) provides methods of assigning economic values to species, communities and ecosystem. These values include the harvest (or market place) value of resources, the value provided by un-harvested resources in their natural habitat, and the future value of resources. For example, the Asian wild guar could be valued for the meat harvested from its current populations, its value for eco-tourism, or its future potential in cattle breeding.

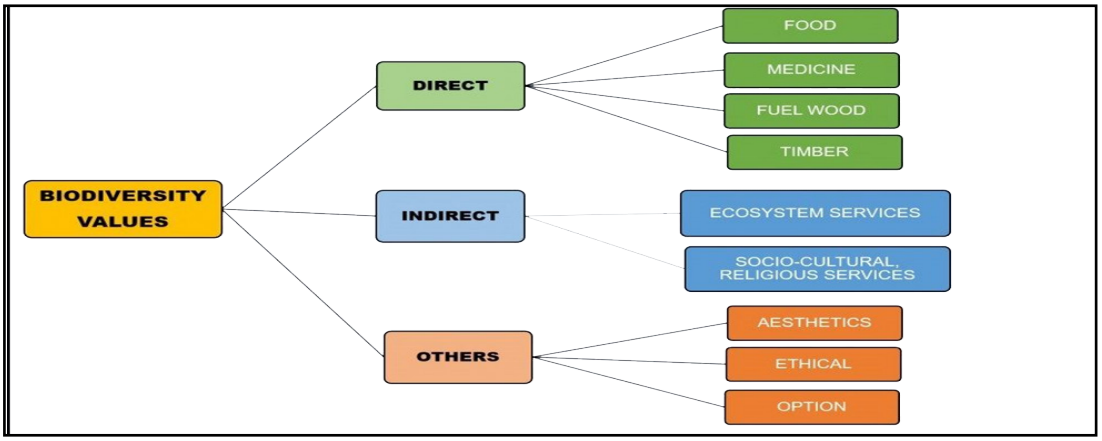

Fig.2.3.3. Values of Biodiversity

Recap

- Biodiversity describes the richness and variety of life on earth. It is the most complex and important feature of our planet. Without biodiversity, life would not sustain.
- Biodiversity is measured by two major components: species richness, and species evenness.
- Species richness: It is the measure of the number of species found in a community. It takes in to account only the numbers and not the abundance of the species.

- Species Evenness: Species evenness takes into account the number of species and the relative abundance of species in a community.
- Simpson index : It was introduced in 1949 by Edward H Simpson. It is a measure of diversity which takes in to account the number of species present, as well as the relative abundance of each species.
- Genetic diversity is the total number of genetic characteristics in the genetic makeup of a species. A single species might show high diversity at the genetic level (E.g. Homo sapiens: Chinese, Indian American, African etc.). Genetic diversity allows species to adapt to changing environments.
- It is the ratio of one species population over total number of organisms across all species in the given biome. 'Zero' would be infinite diversity, and 'One' represents only one species present. Species diversity is a measure of the diversity within an ecological community that incorporates both species richness (the number of species in a community) and the evenness of species.
- Ecosystem diversity deals with the variations in ecosystems within a geographical location and their overall impact on human existence and the environment. It is a type of biodiversity which refers to variation in species rather than ecosystems.
- Biodiversity provides a variety of environmental services from its species and ecosystems that are essential at the global, regional and local levels.
- The values of biodiversity include Consumptive use value, Productive use value, Social values, Ethical and moral values, Aesthetic value, and Option value.

Objective Type Questions

1. Who coined the term biodiversity ?
2. Who introduced Simpson index in 1949 ?
3. Who developed Shannon-weiner index ?
4. Entropy or degree of surprise quantifies in which index?
5. Who divided the diversity in to Alpha, Beta and Gamma?
6. Define Species Richness.
7. Define Species Evenness.
8. What is meant by the term Species diversity?

Answers to Objective Type Questions

1. Walter Rosen
2. Edward H Simpson
3. Claude Shannon
4. Shannon-Weiner-Index
5. Whittaker (1965)
6. It is the measure of the number of species found in a community.
7. It takes into account the number of species and the relative abundance of species in a community.

8. Diversity within an ecological community that incorporates both species richness and the evenness of species is called Species diversity.

Self Assessment Questions

1. Define biodiversity.
2. Describe the significance of biodiversity.
3. What are the measures of biodiversity? Explain.
4. What are hotspots of biodiversity? Give an example.
5. Explain how ecosystem diversity contributes to biodiversity.
6. Write an essay on values of biodiversity.
7. How biodiversity can be used as a resource by man?

Assignments

1. Write down the values of the nearest biodiversity richness area
2. Find out the species richness in an ecosystem.

Suggested Reading

1. E-pgpathsa
2. www.sciencing.com

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Unit 4
India as a Mega Diversity Nation

Learning Outcomes

- Understands about the mega diversity in India
- Learns about status of biodiversity in India
- Learns about biodiversity hotspots in India
- Learns about the endemic species in India

Prerequisites

Unity in diversity- that is India. Let us have a general understanding of our nation's biodiversity and values.

India is a mega diverse country having only 2.4% of the world's land area but it accommodates 7-8% species of flora and fauna. It includes more than 45,000 species of plants and 91,000 species of animals.

The diverse physical features and climatic conditions of India are responsible for a variety of ecosystems such as forests, grasslands, wetlands, deserts, coastal and marine ecosystems.

Have you heard about "hotspots"?. Biodiversity hotspot is a biogeographic region that contains significant reservoir of biodiversity and is under threat and destruction.

India has four hotspots out of 34 identified globally. They are Himalaya, Indo-Burma, Western Ghats and Sundarlands.

Keywords

Mega diversity, Hot spots, Western Ghats, Sundalands

Discussion

2.4.1 India as a Biodiversity Nation

Why is India known as a mega diversity nation? Do you know why India's diversity differs from other nations.?

India is a mega diverse country having only 2.4% of the world's land area but it accommodates 7-8% of the world's species of flora and fauna. It includes more than 45,000 species of plants and 91,000 species of animals. It is situated at the tri-junction of the Afro-tropical, Indo-Malayan and Palearctic realms, and all of this support rich biodiversity. India is also a recognized centre of crop diversity and produces hundreds of varieties of crop plants such as rice, maize, millets, etc. The diverse physical features and climatic conditions of India are responsible for a variety of ecosys-

tems such as forests, grasslands, wetlands, deserts, coastal and marine ecosystems.

Geological events in the landmass of India have provided conditions for high levels of biological diversity. A split in the single giant continent around 70 million years ago, led to the formation of northern and southern continents. India's special geographical position and radiation of species is responsible for its rich and varied biodiversity. Among the biologically rich nations, India stands among the top 10 or 15 countries for its great variety of plants and animals, many of which are not found elsewhere. India has 350 different mammals (rated eighth highest in the world), 1,200 species of birds (eighth in the world), 453 species of reptiles (fifth in the world) and 45,000 plant species, of which most are angiosperms, (fifteenth in the world). These include especially high species diversity of ferns (1022 species) and orchids (1082 species). India has 50,000 known species of insects, including 13,000 butterflies and moths. It is estimated that the number of unknown species could be several times higher.

It is estimated that 18% of Indian plants are endemic to the country and found nowhere else in the world. Among the plant species the flowering plants have a much higher degree of endemism, a third of these are not found else where in the world. Among amphibians found in India, 62% are unique to this country. Among lizards, of the 153 species recorded, 50% are endemic. High endemism has also been recorded for various groups of insects, marine worms, centipedes, mayflies and fresh water sponges. Endemism is the phenomenon which is the presence of endemic species in an area. Endemic species are those which can live only in an unique ecosystem.

Apart from the high biodiversity of Indian wild plants and animals, there is also a great diversity of cultivated crops and breeds of domestic livestock. This is a result of several thousand years during which civilizations have grown and flourished in the Indian subcontinent. The traditional cultivars included 30,000 to 50,000 varieties of rice and a number of cereals, vegetables and fruit. The highest diversity of cultivars is concentrated in the high rainfall areas of the Western Ghats, Eastern Ghats, Northern Himalayas and the North Eastern hills. Genebanks have collected over 34,000 cereals and 22,000 pulses grown in India. India has 27 indigenous breeds of cattle, 40 breeds of sheep, 22 breeds of goats and 8 breeds of buffaloes.

2.4.2 Hot spots of Biodiversity

The idea of hotspots was first given by ecologist Norman Myers in 1988. Biodiversity hotspot is a biogeographic region that contains significant reservoir of biodiversity and is under threat and destruction. The main criteria for determining a hotspot are endemism (the presence of species found nowhere else on earth) and the degree of threat. Biodiversity hotspots are regions with high species richness and a high degree of endemism.

According to CI, to qualify as a hotspot a region must meet two strict criteria:

1. It must contain at least 1,500 species of vascular plants (> 0.5% of the world's total) as endemics – which is to say, it must have a high percentage of plant life found nowhere else on the planet. A hotspot, in other words, is irreplaceable.

2. It has to have lost at least 70% of its original habitat. (It must have 30% or less of its original natural vegetation). In other words, it must be threatened.

In 1999, CI identified 25 biodiversity hotspots in the book "Hotspots: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions". The 35 biodiversity hotspots cover 2.3% of the Earth's land surface, yet more than 50% of the world's plant species

and 42% of all terrestrial vertebrate species are endemic to these areas. In 2011, the Forests of East Australia region was identified as the 35th biodiversity hotspot. Therefore, according to Conservation International, at present, there are 36 biodiversity rich areas in the world that have been qualified as hotspots, which represent just 2.5% of earth's land surface, but support over 50% of the world's endemic plant species, and nearly 43% of bird, mammal, reptile and amphibian species as endemics.

2.4.3 Biodiversity hotspots in India

India, the seventh largest country in the world by geographical area (constitutes 2.4% of the total geographical area of the world) with varied physiographic divisions, climatic regimes, and ecological habitats exhibits a rich floral diversity, and harbours nearly 8% of the globally known flora, of which 28% of floral elements are endemic to the country. India is one of the 17 mega diversity countries in the world. India has four hotspots out of 34 identified globally (Conservation International 2013), which are as following:

1. Himalaya:

It includes the entire Indian Himalayan region. [Jammu and Kashmir, Himachal Pradesh, Uttarakhand, northern part of West Bengal (Darjeeling), Sikkim, northern part of Assam and Arunachal Pradesh] and that falling in Pakistan, Tibet, Nepal, Bhutan, China and Myanmar. The Himalayan mountains with elevation ranging from less than 500 m to more than 8,000 m supports a variety of ecosystems, from alluvial grasslands (the tallest in the world) and subtropical broadleaf forests along the foothills to temperate broadleaf forests in the mid hills, mixed conifer and conifer forests in the higher hills, and alpine meadows above the tree line.

2.Indo-Burma:

It includes the entire North-eastern India, except Assam and Andaman group of Islands (and Myanmar, Thailand, Vietnam, Laos, Cambodia and southern China) The Indo-Burma hotspot is the largest among the 36 recognized hotspots of the world with a total geographical area of 2,308,815 km2. Forests are the most species-rich ecosystems in the hotspot. The hotspot supports a variety of forest types, from evergreen forests with a high diversity of canopy tree species, through semi-evergreen and mixed deciduous forests, to relatively (tree) species-poor deciduous forests. The limestone karst formations found throughout the hotspot support highly unique ecosystems, with high levels of endemism, particularly among plants, reptiles and molluscs, and these unique species are found nowhere else.

3. Western Ghats and Sri Lanka:

They include entire Western Ghats (and Sri Lanka). The Western Ghats of southwestern India and the highlands of southwestern Sri Lanka, separated by 400 km, but strikingly similar in their geology, climate and evolutionary history, covering an area of 1,89,611 km^2 have been designated as the biodiversity hotspot. The Western Ghats, a biogeographically important formation of the Gondwanaland, is formed of the Malabar plains and the chain of mountains running parallel to India's west coast, about 30 to 50 km inland. The Western Ghats indigenously known as 'Sahyadri' covers an area of about 1,64,280 km^2, constituting 5% of the total area of India. It stretches for about 1,600 km, starting downwards from the Tapti River in Gujarat to the country's southernmost tip Kanyakumari in Tamil Nadu. The mountain range is interrupted by a number of natural gaps and passes, and the widest being the 24–30 km one, called the Palakkad (Palghat) Gap.

4. Sundalands:

It includes Nicobar group of Islands (and Indonesia, Malaysia, Singapore, Brunei, Philippines). The Sundaland hotspot covers a group of some 17,000 islands in the western half of the Indonesian archipelago, and stretching around 5,000 km along the equator between Asia and Australia. The hotspot covers about 1.6 million km2 area; majorly occupied by the islands of Borneo (725,000 km²) and Sumatra (427,300 km²). The Sundaland hotspot is adjacent to three other hotspots, namely Wallacea to the east, Indo-Burma to the west, and the Philippines to the north. The landscape comprises of high mountain ranges (Mount Kinabalu with 4,101 m elevation, is the highest peak), volcanoes (23 are active), alluvial plains, lakes, swamps, and shallow coastal waters.

Recap

- India is a mega diverse country having only 2.4% of the world's land area but it accommodates 7-8% species of flora and fauna. It includes more than 45,000 species of plants and 91,000 species of animals.
- The diverse physical features and climatic conditions of India are responsible for a variety of ecosystems such as forests, grasslands, wetlands, deserts, coastal and marine ecosystems.
- The highest diversity of cultivars is concentrated in the high rainfall areas of the Western Ghats, Eastern Ghats, Northern Himalayas and the North Eastern hills.
- The idea of hotspots was first given by ecologist Norman Myers in 1988. Biodiversity hotspot is a biogeographic region that contains significant reservoir of biodiversity and is under threat and destruction.
- India has four hotspots out of 34 identified globally (Conservation International 2013), which are Himalaya, Indo-Burma, Western Ghats and Sri Lanka and Sundalands.
- The main criteria for determining a hotspot are endemism (the presence of species found nowhere else on earth) and degree of threat.
- According to CI, to qualify as a hotspot a region must meet two strict criteria:

1. It must contain at least 1,500 species of vascular plants (> 0.5% of the world's total) as endemics – which is to say, it must have a high percentage of plant life found nowhere else on the planet. A hotspot, in other words, is irreplace able.
2. It has to have lost at least 70% of its original habitat. (It must have 30% or less of its original natural vegetation). In other words, it must be threatened.

- Himalaya: Includes the entire Indian Himalayan region (and that falling in Pakistan, Tibet, Nepal, Bhutan, China and Myanmar). Includes the entire Indian Himalayan region [Jammu and Kashmir, HimachalPradesh, Uttarakhand, northern part of West Bengal (Darjeeling), Sikkim, northern part of Assam and Arunachal Pradesh]

- Includes entire North-eastern India, except Assam and Andaman group of Islands (and Myanmar, Thailand, Vietnam, Laos, Cambodia and southern China) The Indo-Burma hotspot is the largest among the 36 recognized hotspots of the world with a total geographical area of 2,308,815 km2 (Mittermeier & al., 2004).
- Includes entire Western Ghats (and Sri Lanka). The Western Ghats of southwestern India and the highlands of southwestern Sri Lanka, separated by 400 km, but strikingly similar in their geology, climate and evolutionary history, covering an area of 1,89,611 km2 have been designated as the biodiversity hotspot.

Objective Type Questions

1. Who defined the term Biodiversity hotspots?
2. Who developed the concept of Mega-diverse countries first?
3. Which is the most prevalent hotspots of biodiversity in India?
4. The degree of Biodiversity increases towards….?
5. Which is defined as an ecological state of a species being unique to a specific geographical location?
6. Define biodiversity hotspots?
7. How many biogeographical regions are there in India?
8. How many biodiversity hotspots are there in India?

Answers to Objective Type Questions

1. Norman Myers
2. Russell Mittermeier in 1988
3. Western Ghats
4. Equator
5. Endemic Species
6. Biodiversity hotspots are regions with high species richness and a high degree of endemism.
7. 11
8. 36

Self Assessment Questions

1. India is a megadiversity country. Justify the statement.
2. List out the biodiversity hotspots of India. Write short note on any one of the hotspots.
3. Write short note on Sundalands.

4. What are the criteria of hotspots?
5. Define biodiversity hotspot.
6. India is situated at the tri-junction of the ……., Indo-Malayan and Palearctic realms, and all of this support rich biodiversity.

Assignments

1. Find out the endemic species in Biodiversity Hot spots in India
2. Collect details of the Biogeographical regions in India.

Suggested Reading

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Unit 5
Threats to Biodiversity

Learning Outcomes

- Learns about major threats to biodiversity.
- Learns principal causes of natural background extinctions.
- Learns about IUCN threatened species of plants and animals.
- Learns about Red Data Book.

Prerequisites

It is of great importance that we have a general awareness on threats to biodiversity. Do you know that any sort of change incurred by natural or anthropogenic activities in the local environmental conditions may pose a threat to the plant/ animal/ microbial diversity sustaining there.

When an animal loses the natural home or habitat that it needs to survive, its numbers decline rapidly, and it moves toward extinction. The main causes are poaching of Wildlife and Man-Wildlife conflicts. Threatened species refer to the species vulnerable to extinction in the near future.

We also need to know species Critically Endangered, Extinct species, Endemic species and Keystone species. Have you heard about the The Red Data Book-- a public document that is created for recording endangered and rare species of plants, animals, fungi as well as some local subspecies that are present in a particular region?

Keywords

Habitat, Wildlife, Rare, Extinct, Endemic, Vulnerable, IUCN

Discussion

Do you know what the threats to Biodiversity are? Which plants and animals from our region are included in the IUCN list?

At present biodiversity on the Earth is facing various threats. One of the major threats is habitat destruction which occurs due to deforestation and human interference. Indiscriminate devastation of rich biodiversity on our planet is posing a threat not just to plants and animals but to the entire humanity. Although, species may become extinct due to natural selection and other natural causes, a number of species are fast disappearing from the face of the earth due to man's intervention. We could

cause many more to become extinct even before we know them. Global climate change has significantly altered hydrological pattern and other ecological functions triggering or aggravating biodiversity loss.

The main causes of threat to biodiversity are habitat loss, degradation and fragmentation of habitat, introduction of invasive alien species, climate change, habitat change, nutrient pollution and loading and overexploitation. Habitat destruction (also termed habitat loss and habitat reduction) is the process by which a natural habitat becomes incapable of supporting its native species. The organisms that previously inhabited the site are displaced or dead, thereby reducing biodiversity and species abundance. Man has begun to overuse or misuse most of these natural ecosystems. Due to this 'unsustainable' resource-use, once productive forests and grasslands have been turned into deserts and wastelands have increased all over the world.

2.5.1 Habitat loss

The primary effect of habitat destruction is a reduction in biodiversity, which refers to the variety and abundance of different species of animals and plants in a particular setting. When an animal loses the natural home or habitat that it needs to survive, its numbers decline rapidly, and it moves toward extinction. Humans rely on technology to modify their environment and replace certain functions that were once performed by the natural ecosystem. Other species cannot do this. Elimination of their ecosystem whether it is a forest, a desert, a grassland, a freshwater estuarine, or a marine environment will kill the individuals in the species. Human destruction of habitats accelerated in the latter half of the twentieth century.

In the tropics, these losses also represent the extinction of species because of high levels of endemism. Tropical forests are under threat largely from conversion to other land-uses, while coral reefs are experiencing increasing levels of over exploitation and pollution. If current rate of loss of tropical forests continues for the next 30 years (about 1 percent per year), the projected number of species that the remaining forests could support would be reduced by 5 to 10 percent relative to the forest in the absence of human disturbance.

2.5.2 Poaching of Wildlife

The illegal hunting as well as harvesting of animals is the second biggest direct threat to species after habitat destruction. Poaching poses a growing threat to animals such as elephants and rhinos, as well as to smaller creatures, including certain lizards and monkeys. Poaching of wildlife for trade and commercial purposes has been on the rise for the last many decades. It has been a significant cause of the extinction of hundreds of species and the endangerment of many more, such as whales and many African large mammals, Asian tigers, etc. Most extinction over the past several hundred years is mainly due to overharvesting for food, fashion, and profit.

In 2015, the United Nations General Assembly unanimously adopted a resolution for tackling illicit trafficking in wildlife. The Sustainable Development Goals have laid down specific targets to combat poaching and trafficking of protected species. Specific threats to certain animals are related to large economic benefits. Skin and bones from tigers, ivory from elephants, horns from rhinos and the perfume from the musk deer are extensively used abroad. Bears are killed for their gall bladders. Variety of wild plants with real, or at times dubious, medicinal value are being over harvested. The commonly collected plants include Rauvolfia, Datura, etc. Collection of garden plants includes orchids, ferns and moss.

2.5.3 Man-Wildlife Conflicts

Man-wildlife conflict refers to the interaction between wild animals and people and the consequential negative impact on both of them. Worldwide Fund for Nature (WWF) defines this conflict as "any interaction between humans and wildlife that results in a negative impact on human social, economic, or cultural life, on the conservation of wildlife population, or on the environment." Although man-wildlife conflict is as old as human civilization, in modern times the degree of conflict has been on the rise due to high rise in human population in the past several centuries.

There are many consequences of man versus wildlife conflicts. The major consequences are:

- Destruction of wildlife habitats
- Injury and loss of life of both humans and wildlife
- Crop damage and livestock depredation
- Damage to human property
- Decrease in wildlife population and reduction in geographic ranges
- Trophic cascades

Wildlife faces numerous threats. The effects of climate change, loss of habitat from deforestation, illegal wildlife trade, infrastructure and conflict with humans are factors that led to a significant decline of wildlife species and to the possible extinction of species whose numbers were really low already. Mangroves have been cleared for fuel wood and prawn farming, which has led to a decrease in the habitat essential for breeding of marine fish. Wetlands have been drained to increase agricultural land. The current destruction of the remaining large areas of wilderness habitats, especially in the super diverse tropical forests and coral reefs, is the most important threat worldwide to biodiversity. Scientists have estimated that human activities are likely to eliminate approximately 10 million species by the year 2050. At the present rate of extinction, about 25% of the world's species will undergo extinction fairly rapidly. Human actions could well exterminate 25% of the world's species within the next twenty or thirty years. Much of this mega extinction spasm is related to human population growth, industrialization and changes in land-use patterns. A major part of these extinctions will occur in 'biorich' areas such as tropical forests, wetlands, and coral reefs. The loss of wild habitats due to rapid human population growth and short term economic development are major contributors to the rapid global destruction of biodiversity.

Rare species: are basically those species that are infrequently encountered. Such a designation can be made by the national or the state governments and also the provinces.

However this designation is different from endangered or threatened species. If a species has a large and dispersed population, that particular species may be considered as endangered or vulnerable but not rare. Still, rare species are usually considered threatened because it is not likely that a small population size can recover from ecological disasters.

For example, if a species is only found as an endangered species, it cannot be termed rare. The International Union for Conservation of Nature (IUCN) uses the term 'rare' to designate those species which are found in isolated geographical locations. They are not classified as endangered but are classified as 'at risk'. The concept of rare species can also be used for those species which have a very narrow endemic range or fragmented habitat.

It is believed that almost 75 percent of the known can be classified under the designation 'rare species'. Many of the rare species are at risk of being given the designation of endangered or vulnerable if the negative factors

affecting them continue to operate. Some of the rarest species in the world are - giant otter, sumatran rhinoceros, vaquita, red wolves, etc. IUCN categorized them and made a list called 'red list'. Another document which consists of a list of rare and endangered species in an area was established by the Russian federation. This book is known as Red Data Book. These documents consisting of a list of species are used as a guide for researchers to estimate the level of threat. There are separate books for both flora and fauna.

Threatened Species:

Threatened species are any species which are vulnerable to extinction in the near future. International Union for Conservation of Nature treats threatened species not as a single category, but as a group of three categories: vulnerable, endangered, and critically endangered, depending on the degree to which they are threatened.

Critically Endangered Species:

Critically Endangered (Cr) is the highest risk category assigned by the IUCN for wild species. Critically endangered species means the numbers of a species have decreased, or will decrease, by 80% within three generations. It is therefore considered to be facing an extremely high risk of extinction in the wild. Threatened Species are any species, including animals, plants, fungi, etc., that are vulnerable to endangerment shortly.

Extinct Species:

A taxon is extinct when there is no doubt that the last individual has died. It cannot be found in the areas it once inhabited. A species may be extinct from a local area, country, region, or area in the continent or the Earth. Eg: Dodo, Passenger Pigeon. Extinction of a particular animal or plant species occurs when there are no more individuals of that species alive anywhere in the world. This is a natural part of evolution. But sometimes extinctions happen at a much faster rate than usual.

Endangered Species:

These are species that are in danger of extinction. The survival of such species is difficult if the negative factors that have led to a decline in their population continue to operate. Endangered species are any species that is at risk of extinction because of a sudden rapid decrease in its population or a loss of its critical habitat. One of the principal factors in the endangerment or extinction of a species is the destruction or pollution of its native habitat. Giant panda, Tiger, Whooping crane, Blue whale, Asian elephant, Sea otter, Snow leopard, Gorilla are listed as endangered species. Endangered species can be defined as those species which are under risk or threat of being extinct. Endangered species, sooner or later enter the extinction phase. In order to prevent this, necessary actions have to be taken. If a species which was native to a region and its population strength reduced from 50 percent to 5 percent, such species are known are Endangered species.

Vulnerable (VU) Species:

Vulnerable species is a species which has been categorised by the IUCN as likely to become endangered unless the circumstances threatening its survival and reproduction improve. It is therefore considered to be facing a high risk of extinction in the wild.

Endemic Species:

These are species found only in some particular areas, usually isolated by natural or geographical barriers. Endemic species are those plants and animals that exist only in one geographical region. Species can be endemic to large or small areas of the world. Some may be endemic to the particular continent; some are endemic to a part of a continent, and others to a single island. Endemic species are import-

ant because they are in the habitats restricted to a particular area due to climate change, urban development or other occurrences. Endemic species are often endangered, so it is important to save the species. Usually, an area that contains the endemic species is isolated in some way so that species have difficulty spreading to other areas. A native species is one that is found in certain ecology due to natural processes, such as natural distribution and development.

Native species are also called indigenous species. The key aspect of the species being native is that it occurs in an area without human influence. When a species is indigenous, it is found in a particular location or surrounding areas. An endemic species, however is a native species found only in a picky area, large or small. Often an endemic species is confined to a certain area because they are highly adapted to the particular niche. They may eat only a certain type of plant that is found nowhere else, or a plant is perfectly adapted to flourish in a very particular climate and soil type. Because of the area of expertise and inability to move into new habitats, some endemic species are at particular risk of destruction when a new disease hits, when the habitats quality is threatened, or if an invasive species enters its region and becomes a competitor or predator. The extreme opposite of endemism is cosmopolitan distribution.

Keystone Species:

Keystone species is a species whose addition to or loss from an ecosystem leads to major changes in the occurrence of at least one other species. Certain species in an ecosystem are considered more important in determining the presence of many other species in that ecosystem. All top predators (Tiger, Lion, Crocodile, Elephant) are considered as keystone species because they regulate all other animal population indirectly. Hence top predators are given much consideration in conservation. If keystone species is lost, it will result in the degradation of the whole ecosystem. For example, certain plant species (Ebony tree, Indian-laurel) exclusively depends upon bats for its pollination. If the bat population is reduced, then regeneration of particular plants becomes more difficult

Foundation Species:

Foundation species is a dominant primary producer in an ecosystem both in terms of abundance and influence. Example: kelp in kelp forests and corals in coral reefs.

Flagship Species:

A flagship species is a species chosen to represent an environmental cause, such as an ecosystem in need of conservation. These species are chosen for their vulnerability, attractiveness or distinctiveness in order to engender support and acknowledgement from the public at large. Example: Indian Tiger, African Elephant, Giant Panda of China, the Leatherback Sea Turtle, etc.

2.5.4 The Red Data Book

Is a public document that is created for recording endangered and rare species of plants, animals, fungi as well as some local subspecies present in a particular region. The Red Data Book helps us in providing complete information for research, studies and also for monitoring the programmes on rare and endangered species and their habitats. This book is mainly created to identify and protect those species which are on the verge of extinction. The name of this book has its origins in Russia, it was originally known as the Red Data Book of the Russian Federation or the RDBRF. The book was based on research conducted between 1961 and 1964 by biologists in Russia. Hence, it is also called the Russian Red Data Book.

Currently, the International Union for Conservation of Nature maintains the Red Data Book. IUCN is the world's most detailed inventory centre of the global conservation status of biological species. The International Union for Conservation of Nature (IUCN) was founded in 1948 with an aim to maintain a complete record of every species that ever lived.

The Red Data Book contains the complete list of threatened species. The main aim behind this documentation is to provide complete information for research and analysis of different species.

The Red Data Book contains colour-coded information sheets, which are arranged according to the extinction risk of many species and subspecies.

- Black represents species that are confirmed to be extinct.
- Red represents species that are endangered.
- Amber for those species whose status is considered to be vulnerable.
- White is assigned for species that are rare.
- Green for species that were formerly endangered, but their numbers have started to recover.
- Grey coloured for the species that are classified as vulnerable, endangered, or rare but sufficient information is not available to be properly classified.

Recap

- Any sort of change incurred by natural or anthropogenic activities in the local environmental conditions may pose a threat to the plant/ animal/ microbial diversity sustaining there.
- The primary effect of habitat destruction is a reduction in biodiversity, which refers to the variety and abundance of different species of animals and plants in a particular setting. When an animal loses the natural home or habitat that it needs to survive, its numbers decline rapidly, and it moves toward extinction.
- Poaching of Wildlife: The illegal hunting and harvesting of animals is the second biggest direct threat to species after habitat destruction. Poaching poses a growing threat to animals such as elephants and rhinos, as well as to smaller creatures, including certain lizards and monkeys.
- Man-Wildlife conflicts: Man-wildlife conflict refers to the interaction between wild animals and people and the consequential negative impact on both of them.
- Rare species: are basically those animals that are infrequently encountered. Such a designation can be made by the national or the state governments and also the provinces.
- Threatened species: Threatened species are species which are vulnerable to extinction in the near future.

- Critically Endangered (Cr) is the highest risk category assigned by the IUCN for wild species. Critically endangered species means a species numbers have decreased, or will decrease by 80% within three generations.
- Extinct species: A taxon is extinct when there is no doubt that the last individual has died. It cannot be found in the areas it once inhabited.
- Endemic species: These are species found only in some particular areas, usually isolated by natural or geographical barriers. Endemic species are those plants and animals that exist only in one geographical region.
- Keystone species is a species whose addition to or loss from an ecosystem leads to major changes in the occurrence of at least one other species.
- The Red Data Book: is a public document that is created for recording endangered and rare species of plants, animals, fungi as well as some local subspecies that are present in a particular region.

Objective Type Questions

1. Expansion of IUCN.
2. When is National Endangered Species Day observed?
3. What does Critically endangered species mean?
4. What is Red Data Book?
5. Name the animal which is endangered and also the National animal of India.
6. What is endemic species?
7. Keystone species.

Answers to Objective Type Questions

1. The International Union for Conservation of Nature
2. May 21
3. Extremely high risk of extinction in the wild
4. It is a public document created for recording endangered and rare species of plants, animals, fungi as well as some local subspecies that are present in a particular region.
5. Bengal Tiger
6. These are species found only in some particular areas, usually isolated by natural or geographical barriers.
7. Whose addition or loss from an ecosystem leads to major changes in the occurrence of at least one other species.

Self Assessment Questions

1. Percentage of CO2 in the atmosphere is …… .
2. What are the functions of atmosphere?
3. Explain the structure of atmosphere with well labelled diagram.
4. What is the average thickness of lithosphere?
5. Define biosphere.
6. Differentiate weather and climate.
7. Average weather for a particular region and time period, usually taken over 30-years is called …… .
8. Earth is called …… because of the presence of water.

Assignments

1. List out some plants and animals from India in Red Data Book
2. Find out endemic species in a biogeographical region.

Suggested Reading

1. E-pgpathshala
2. www.Sciensing.com

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SREENARAYANAGURU OPEN UNIVERSITY

Unit 6
Biodiversity Conservation at Global, National and Local Levels

Learning Outcomes

- Learns about Biodiversity conservation at global, national and local levels
- Learns about Exsitu and Insitu conservation methods
- Learns about In-vitro techniques of conservation
- Learns about convergence and divergence species.

Prerequisites

India has currently over 100 national parks and several sanctuaries. What are these for? They are mainly for ecological conservation.

There are over 1000 major ecoregions in the world. Of these, 200 are said to be the richest, rarest, natural areas.

We need to work for the Conservation of biodiversity to prevent the loss of genetic diversity of a species, to save a species from becoming extinct, and to protect ecosystems damage and degradation.

We should also know about the Core Zone, Buffer zone and Transition Zone.

Keywords

Biodiversity, Conservation, Convergence evolution, National parks, Wildlife Sanctuaries, Biosphere reserves,

Discussion

2.6.1 Biodiversity at global, national and local levels

The earth's biodiversity is distributed in specific ecological regions. There are over a thousand major ecoregions in the world. Of these, 200 are said to be the richest, rarest and most distinctive natural areas. These areas are referred to as the Global 200. It has been estimated that 50,000 endemic plants which comprise 20% of global plant life, probably occur in only 18 'hot spots' in the world. Countries which have a relatively large proportion of these hot spots of diversity are referred to as 'mega diversity nations' The rate at which the

extinction of species is occurring throughout India remains obscure. It is likely to be extremely high as India's wilderness areas are shrinking rapidly. Our globally accepted national 'hot spots' are in the forests of the North-East and the Western Ghats, which are included in the world's most biorich areas. The Andaman and Nicobar Islands are extremely rich in species and many subspecies of different animals and birds have evolved. Among the endemic species i.e., those species found only in India, and a large proportion of them are concentrated in these three areas.

Ecosystems are divided into terrestrial or land based ecosystems, and aquatic ecosystems in water. These form the two major habitat conditions for the Earth's living organisms. All the living organisms in an area live in communities of plants and animals. They interact with their non-living environment, and with each other at different points in time for a large number of reasons. Life can exist only in a small portion of the earth's land, water and its atmosphere. At a global level the thin skin of the earth on the land, the sea and the air, forms the biosphere. There are several distinctive geographical regions in India- the Himalayas, the Gangetic Plains, the Highlands of Central India, the Western and Eastern Ghats, the Semi-arid desert in the West, the Deccan Plateau, the Coastal Belts, and the Andaman and Nicobar Islands. These geographically distinctive areas have plants and animals that have been adapted to live in each of these regions. Ecosystems have both non-living and living components typical to an area giving it its own special characteristics that are easily observed. The living community of plants and animals in any area together with the non-living components of the environment such as soil, air and water, constitute the ecosystem. Some ecosystems are fairly robust and are less affected by a certain level of human disturbance. Others are highly fragile and are quickly destroyed by human activities. Mountain ecosystems are extremely fragile as degradation of forest cover leads to severe erosion of soil and changes in river courses. Island ecosystems are easily affected by any form of human activity which can lead to the rapid extinction of several of their unique species of plants and animals. Evergreen forests and coral reefs are also examples of species rich fragile ecosystems which must be protected against a variety of human activities that lead to their degradation. River and wetland ecosystems can be seriously affected by pollution and changes in surrounding land use.

There are at present 1.8 million species known and documented by scientists in the world. However, scientists have estimated that the number of species of plants and animals on earth could vary from 1.5 to 20 billion. Thus the majority of species are yet to be discovered. Most of the world's biorich nations are in the South, which are the developing nations. In contrast, the majority of the countries capable of exploiting biodiversity are the Northern nations, in the economically developed world. These nations however have low levels of biodiversity. Hence, the developed world has come to support the concept that biodiversity must be considered to be a 'global resource'.

Countries with diversities higher than India are located in South America such as Brazil, and South East Asian countries such as Malaysia and Indonesia. The species found in these countries, however, are different from what India has.

Throughout the world, the value of biologically rich natural areas is now being increasingly appreciated as being of unimaginable value. International agreements such as the World Heritage Convention attempt to protect and support such areas. India is a signatory to the convention and has included several protected

Areas as World Heritage sites. These include Manas on the border between Bhutan and India, Kaziranga in Assam, Bharatpur in U.P., Nandadevi in the Himalayas, and the Sunderbans in the Ganges delta in West Bengal. India has also signed the Convention in the Trade of Endangered Species (CITES) which is intended to reduce the utilization of endangered plants and animals by controlling trade in their products and in the pet trade.

Conservation is the planned management of natural resources, to retain the balance in nature and retain the diversity. It also includes wise use of natural resources in such a way that the needs of present generation are met and at the same time leaving enough for the future generations. "Biodiversity conservation refers to the protection, upliftment, and management of biodiversity in order to derive sustainable benefits for present and future generations." Biodiversity conservation is the protection and management of biodiversity to obtain resources for sustainable development. Conservation of biodiversity is important to:-

a) prevent the loss of genetic diversity of a species,

b) save a species from becoming extinct, and

c) protect ecosystems' damage and degradation

Convergent evolution: is when two species with different ancestral origins develop similar characteristics, while divergent evolution refers to when two species diverge from a common ancestor and develop different characteristics.

Conservation efforts can be grouped into the following category:

1. In situ (on-site) conservation includes the protection of plants and animals within their natural habitats or in protected areas. Protected areas are land or sea dedicated to protect and maintain biodiversity. In this method, the natural ecosystem is maintained and protected. The in situ conservation has several advantages. Following are the important advantages of in situ conservation:

1. It is a cost-effective and convenient method of conserving biodiversity.

2. A large number of living organisms can be conserved simultaneously.

3. Since the organisms are in a natural ecosystem, they can evolve better and can easily adjust to different environmental conditions.

Certain protected areas where in situ conservation takes place include national parks, wildlife sanctuaries and biosphere reserves.

2.6.2 National Parks

These are small reserves maintained by the governments. Its boundaries are well demarcated and human activities such as grazing, forestry, habitat and cultivation are prohibited. For eg., Kanha National Park, Bandipur National Park. "National Parks are the areas that are set by the government to conserve the natural environment." National parks are areas that aim to protect the natural environment. They are also involved in public recreation and enjoyment activities. India has currently over 100 national parks distributed across the country, stretching across various biomes. The Hailey National Park is the first national park in India. It is one of the finest examples of ecological conservation. The other national parks in India include:

Table 2.6.1 National Parks in India

SL NO	National Park	State
1	Bandipur National Park	Karnataka
2	Bandhavgarh National Park	Madhya Pradhesh
3	Bhadra Wildlife Sanctuary	Karnataka
4	Chinnar Wildlife Sanctuary	Kerala
5	Corbett National Park	Uttarakhand
6	Dandeli Wildlife Sanctuary	Karnataka
7	Dudhwa National Park	Uttar Pradhesh
8	Gir National Park	Gujarat
9	Hemis National Park	Jammu & Kashmir
10	Kanha National Park	Madhya Pradhesh
11	Kaziranga National Park	Assam
12	Keoladeo Ghana National Park	Rajasthan
13	Manas National Park	Assam
14	Nagarhole National Park	Karnataka
15	Panna National Park	Madhya Pradesh
16	Periyar National Park	Kerala
17	Pench National Park	Madhya Pradesh
18	Ranthambore National Park	Rajasthan
19	Sariska National Park	Rajasthan
20	Tadoba Andhari Tiger Reserve	Maharashtra
21	The Great Himalayan National Park	Himachal Pradhesh

All these national parks are abodes to a large number of wild animals because of the optimum environmental conditions with proper upbringing and breeding facilities. The significant terrestrial ecosystem coming along the IndoMalayan ecozone consists of temperate, polar, wet, dry regions for different kind of species to live. The species include elephant, tiger, cobra, crocodile, apes, sambar deer, spotted deer, rhinoceros, goats, lions along with different types of flora and fauna. Indian wildlife has around 99 world-recognized national parks in different parts of the country. All these national parks and the wildlife reserves have been recognized by the IUCN or the International Union for the Conservation of Nature under the second category of protected areas.

2.6.3 Wildlife Sanctuaries

These are the regions where only wild animals are found. Human activities such as timber harvesting, cultivation, collection of wood and other forest products are allowed here as long as they do not interfere with the conservation project. Also, tourists visit these places for recreation. Sanctuaries are naturally occurring areas that are meant to protect the endangered species from hunting, poaching and predation. Here the animals are not bred for commercial purposes. It provides a safe, healthy and se-

cured refuge to all the wild animals. A wildlife sanctuary is an area where animal habitats and their surroundings are protected from any sort of disturbance. The capturing, killing and poaching of animals is strictly prohibited in these regions. They aim at providing a comfortable living to the animals.

There are a number of reasons for establishing wildlife sanctuaries. Some of the reasons are listed below:

- The wildlife sanctuaries are established to protect the endangered species.
- It is quite difficult to always relocate the animals from their natural habitat; therefore, protecting them in their natural environment is advantageous.
- The endangered species are specially monitored in the wildlife sanctuaries. If they reproduce and grow in number while under protection, a few specimens can be kept for breeding in the conservation parks for their survival.
- Biologist activities and researches are permitted in the wildlife sanctuaries so that researchers can learn about the animals living there.
- A few sanctuaries take in injured and abandoned animals and rehabilitate them to health before releasing them in the forest.
- Wildlife sanctuaries preserve the endangered species and protect them from humans and predators. Tourism is not permitted in a wildlife sanctuary. People are not allowed unescorted there. The main objective of establishing a wildlife sanctuary is to educate humans as to how to treat the animals. The animals are taken care of and allowed to live peacefully in their natural habitats.

Table 2.6.2 Wildlife sanctuaries in India

SL NO	Wildlife Sanctuaries	State
1	Bharatpur Bird Sanctuary	Rajasthan
2	Chilika Lake Bird Sanctuary	Odisha
3	Chinnar Wildlife Sanctuary	Kerala
4	Gir National Park and Wildlife Sanctuary	Gujarat
5	Govind Wildlife Sanctuary	Uttarakhand
6	Madumalai Sanctuary	Tamil Nadu
7	Periyar Wildlife Sanctuary	Kerala

2.6.4 Biosphere Reserves

Biosphere reserves are multi-purpose protected areas where the wildlife, traditional lifestyle of the inhabitants and domesticated plants and animals are protected. Tourist and research activities are permitted here. Biosphere reserves are the protected areas meant for the conservation of plants and animals. It also restores the traditional life of the tribals living in that area. They conserve the biodiversity of that area.

There are three biosphere reserve zones:

Core Zone: This is a legally protected area where human intervention is strictly prohibited. It is the innermost undisturbed ecosystem. The information from these areas helps to assess the sustainability of activities, or maintenance of environmental quality in the surrounding areas.

Buffer zone: The area surrounding the core zone is the buffer zone. Here only the research and education activities are permitted to hu-

Table 2.6.3 Biosphere Reserves in India

SL NO	Biosphere Reserves	State
1	Nilgiri Biosphere Reserve (2000)	Tamil Nadu, Kerala, Karnataka
2	Sundarbans Biosphere Reserve (2001)	West Bengal
3	Gulf of Mannar Biosphere Reserve (2001)	Tamil Nadu
4	Nanda Devi Biosphere Reserve (2004)	Uttarakhand
5	Simlipal Biosphere Reserve (2009)	Odisha
6	Pachmarhi Biosphere Reserve (2009)	Madhya Pradesh
7	Nokrek Biosphere Reserve (2009)	Meghalaya
8	Achanakmar-Amarkantak Biosphere Reserve (2012)	Chhattisgarh, Madhya Pradesh
9	Great Nicobar Biosphere Reserve (2013)	Great Nicobar
10	Agasthyamalai Biosphere Reserve (2016)	Kerala and Tamil Nadu
11	Khangchendzonga National Park (2018)	Sikkim
12	Cold desert Biosphere Reserve (2009)	Himachal Pradhesh
13	Dehang-Debang Biosphere Reserve (2008)	Arunachal Pradhesh
14	Dibru-Saikhowa, Biosphere Reserve (2007	Assam
15	Seshachalam Biosphere Reserve (2010)	Andra Pradhesh
16	Similipal, Biosphere Reserve (1994)	Odissa
17	Manas Biosphere Reserve (1989)	Assam
18	Kachchh,Biosphere Reserve (2010)	Gujarat

mans. These activities should not obstruct the conservation objectives of the core area. This area also includes activities that help to manage natural vegetation, agricultural land, fisheries, or forests to enhance the quality of production.

This zone might also include recreation and tourism facilities. Human activities are less intensive in this zone as compared to the transition zone.

Transition Zone: It is the peripheral area of a biosphere reserve where human activities like cropping, recreation, forestry, and settlements are permitted with the cooperation of reserve management and local people. Through these activities, the degraded area is brought backto its natural form. The local communities, scientists, conservation agencies, cultural groups, and other stakeholders work in this zone to use the area in a sustainable way for the welfare of humans living there.There are 18 Biosphere Reserves in India established by the government that protect large areas of natural habitats. These areas are provided with the buffer zones that are open for some economic uses. Not only the flora and fauna but also the humans inhabiting these areas are protected. The Biosphere Reserves are identified by the Man and Biosphere Reserve Program to promote sustainable development. This program was initiated by UNESCO in 1971.

2. Ex-situ (off-site) conservation of plants and animals outside their natural habitats. These include botanical gardens, zoo, gene banks, seek bank, tissue culture and cryopreservation. Ex-situ conservation of biodiversity involves the breeding and maintenance of endangered species in artificial ecosystems such as zoos,

nurseries, botanical gardens, gene banks, etc. There is less competition for food, water and space among the organisms.

Ex-situ conservation has the following advantages:

1. The animals are provided with a longer time and breeding activity.

2. The species bred in captivity can be reintroduced in the wild.

3. Genetic techniques can be used for the preservation of endangered specie

Ex- situ conservation literally means, 'off-site conservation'. It is the process of protecting an endangered species of plant or animal by removing part of the population from a threatened habitat and placing it in a new location, which may be a wild area or within the care of humans. While ex- situ conservation comprises some of the oldest and best known conservation methods, it also involves newer, sometimes controversial laboratory methods.

There are two ways or modes of Ex- situ conservation.

1. Conventional methods

2. Biotechnological methods

Gene Banks

Plant genetic resources gene banks store, maintain and reproduce living samples of the world's huge diversity of crop varieties and their wild relatives. They ensure that the varieties and landraces of the crops and their wild relatives that underpin our food supply are both secure in the long term and available for use by farmers, plant breeders and researchers. Gene banks conserve genetic resources. The most fundamental activity in a gene bank is to treat a new sample in a way that will prolong its viability as long as possible while ensuring its quality. The samples (or accessions as they are called) are monitored to ensure that they are not losing viability. A cornerstone of gene bank operations is the reproduction-called regeneration-of its plant material. Plant samples must periodically be grown out, regenerated, and new seed harvested because, even under the best of conservation conditions, samples will eventually die. To conserve and regenerate genetic resources, gene banks first must collect genetic resources. But gene banks aren't built just to conserve genetic resources; they are intended to ensure that these resources are used, whether it is in farmers' fields, breeding programmes or in research institutions. This means making sure the collections are properly characterized and documented; and that the documentation is available to those who need it.

Biodiversity at all its levels, genetic species and as intact ecosystems, can be best preserved in- situ by setting aside an adequate representation of wilderness as 'Protected Areas'. These should consist of a network of National Parks and Wildlife Sanctuaries with each distinctive ecosystem included in the network. Such a net- work would preserve the total diversity of life of a region. In the past National Parks and Sanctuaries in India were notified to preserve major wildlife species such as tigers, lions, elephants, and deer. The objective of these areas should be expanded to the preservation of relatively intact natural ecosystems, where biological diversity from microscopic unicellular plants and animals, to the giant trees and major mammals.

Botanical gardens

Botanical gardens and zoos are the most conventional methods of ex- situ conservation, all of which house whole, protected specimens for breeding and reintroduction into the wild when necessary and possible. These facilities provide not only housing and care for specimens of endangered species, but also have an educational value.

Seed Bank

Undeniably, the most cost-effective method of providing plant genetic resources for long-term ex-situ conservation is through the storage of seeds under very specific conditions. The following techniques well developed for crop plants by organisations such as the International Plant Genetic Resources Institute (IPGRI), previously the International Board of Plant Genetic Resources (IBPGR), and the Food and Agricultural Organisation of the United Nations (FAO). The main advantage of seed banking is that it allows large populations to be preserved and genetic erosion to be minimised by providing optimum conditions and reducing the need for regeneration.

Field Gene banks

Field gene banks or living collections are the main conservation strategy for long-lived perennials, recalcitrant species and vegetatively propagated species. Their main limitation is that they take a great deal of space and are difficult to maintain and protect from natural disasters. They are susceptible to the spread of diseases and may suffer from neglect. Furthermore, out-breeders require controlled pollination for regeneration from seed. In many circumstances they are the only available option for the conservation of important germplasm. When displayed, the plants have an important educational value and can easily be accessed for research purposes.

Cryopreservation

It is a process where organelles, cells, tissues, extracellular matrix, organs, or any other biological constructs susceptible to damage caused by unregulated chemical kinetics are preserved by cooling to very low temperatures typically −80 °C using solid carbon dioxide or −196 °C using nitrogen. Cryopreservation methods seek to reach low temperatures without causing additional damage caused by the formation of ice crystals during freezing. In this system stability is imposed by ultra low temperature and storage is at, or close to -196^{0}C using liquid Nitrogen (or the vapour immediately above it), as practical and convenient oxygen. At such temperature normal cellular chemical reactions do not occur as energy levels are too low to allow sufficient molecular motion to complete the reaction. The majority of the chemical changes that might occur in a cell are therefore, effectively prevented and so the cell is stabilized to the maximum extent practically possible. The potential of conservation system for in-vitro material based upon cryogenic storage is therefore, clear and the technique has become relatively widely used.

Project Tiger

Project Tiger was launched by the Government of India with the support of WWF-International in 1973 and was the first such initiative aimed at protecting this key species and all its habitats. Project Tiger was initiated in nine Tiger Reserves in different ecosystems of the country covering an area of 16339 sq. km. By 2001 the number of Tiger Reserves increased to 27, covering an area of 37761 sq. km. The tiger count climbed from 268 in 1972 in the nine Tiger Reserves, to around 1500 in 1997 in the 23 Tiger Reserves. The Project tiger recognized the fact that tigers cannot be protected in isolation, and that to protect the tiger, its habitat needed to be protected.

Crocodile Conservation

Crocodiles have been threatened as their skin is used for making leather articles. This led to the near extinction of crocodiles in the wild in the 1960s in India.

A Crocodile Breeding and Conservation Program was initiated in 1975 to protect the remaining population of crocodilians in their natural habitat and by creating breeding centres. It is perhaps one of the most successful ex-situ conservation breeding projects in the

country. Crocodiles have been extensively bred in over 30 captive breeding centres, zoos and other sites, where successful breeding takes place. Thousands of crocodiles of all three species have been bred and restocked in 20 natural water bodies.

Project Elephant

Project Elephant was launched in 1992 to ensure the long-term survival of a viable population of elephants in their natural habitats in north and north- eastern India and south India. It is being implemented in 12 States. In spite of this, our elephant herds are at threat as their habitat is shrinking and their migration routes are disrupted by human activities However species cannot be protected individually as they are all inter dependent. Thus the whole ecosystem must be protected. The biologist's view point deals with areas that are relatively species rich, or those where rare, threatened or endangered species are found, or those with 'endemic' species which are not found elsewhere. As rare endemic species are found only in a small area, these easily become extinct due to human activity. Such areas must be given an added importance as their biodiversity is a special feature of the region. Animals such as elephants require different types of habitat to feed during different seasons. They utilize open grasslands after the rains when the young grass shoots which are highly nutritious. As the grasses dry, the elephants move into the forest to feed on foliage from the trees. A Protected Area that is meant to protect elephants must therefore be large enough and include diverse habitat types to support a complete complement of inter linked species.

Convergence and divergence in species

Convergent evolution is the process by which two species develop similar features despite not sharing a recent common ancestor. It is independent evolution of similar features in species of different periods or epochs in time. These species have different ancestral origins. For example sharks and dolphins look relatively similar despite being entirely unrelated. Divergent evolution occurs when two separate species evolve differently from a common ancestor. The adaptive radiation of the Darwin finches of the Galapagos are classic examples of divergence in nature.

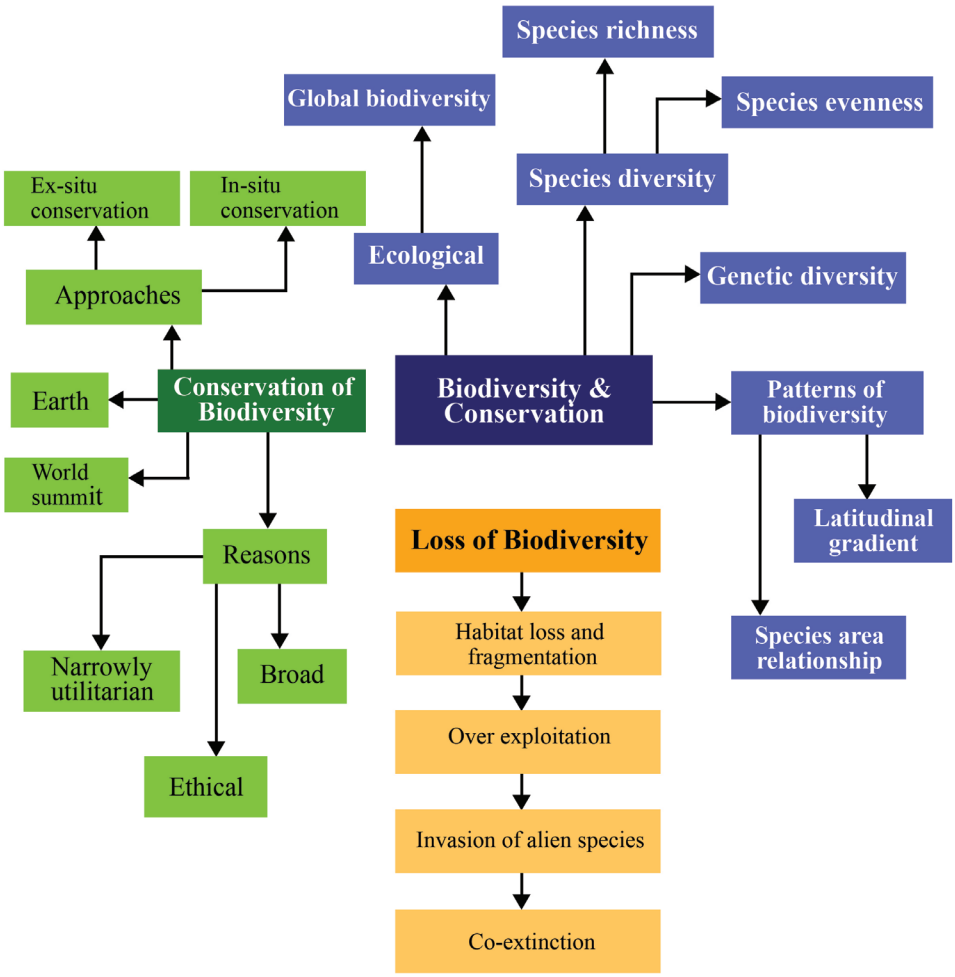

Fig :2.6.1. Biodiversity and conservation concept map

Recap

- The earth's biodiversity is distributed in specific ecological regions. There are over a thousand major ecoregions in the world. Of these, 200 are said to be the richest, rarest and most distinctive natural areas.
- Conservation of biodiversity is important to:-
  a) prevent the loss of genetic diversity of a species,
  b) save a species from becoming extinct, and
  c) protect ecosystems damage and degradation
- In situ (on-site) conservation includes the protection of plants and animals within their natural habitats or in protected areas.

- National Parks: These are small reserves maintained by the government. Its boundaries are well demarcated and human activities such as grazing, forestry, habitat and cultivation are prohibited.
- Wildlife Sanctuaries: These are the regions where only wild animals are found. Human activities such as timber harvesting, cultivation, collection of woods and other forest products are allowed here as long as they do not interfere with the conservation project.
- Biosphere Reserves: are multi-purpose protected areas where the wildlife, traditional lifestyle of the inhabitants and domesticated plants and animals are protected. Tourist and research activities are permitted here.
- Core Zone: This is a legally protected area where human intervention is strictly prohibited. It is the innermost undisturbed ecosystem.
- Buffer zone: The area surrounding the core zone is the buffer zone. Here only the research and education activities are permitted to humans.
- Transition Zone: It is the peripheral area of a biosphere reserve where human activities like cropping, recreation, forestry, and settlements are permitted with the cooperation of reserve management and local people.
- Ex- situ (off-site) conservation: of plants and animals outside their natural habitats. These include botanical gardens, zoo, gene banks, seek bank, tissue culture and cryopreservation

Objective Type Questions

1. Mention an example of Exsitu conservation.
2. In which year was project Tiger launched?
3. In which year was Project Elephant launched?
4. What is cryopreservation?
5. Which agency launched Man and Biosphere programme?
6. Chilika Lake Bird Sanctuary is in which state.
7. Khangchendzonga National Park is in which state?
8. Nanda Devi Biosphere Reserve is in which state?
9. Expansion of CITES.
10. Which is the first national park in India ?

Answers to Objective Type Questions

1. Seed Bank
2. 1973
3. 1992
4. It is a process where organelles, cells, tissues, extracellular matrix, organs, or any other biological constructs susceptible to damage caused by unregulated chemical kinetics are preserved by cooling to very low temperatures typically −80 °C using solid carbon dioxide or −196 °C using nitrogen.
5. UNESCO (1971)
6. Odisha
7. Sikkim
8. Utharakhand
9. Convention on International Trade in Endangered Species
10. The Hailey National Park

Self Assessment Questions

1. What is 'Global 200'?
2. Differentiate convergent and divergent evolution.
3. Define biodiversity conservation.
4. Explain National Parks with examples.
5. What are wildlife sanctuaries? What are the reasons for the establishment of wildlife sanctuaries?
6. Write an essay on biosphere reserves
7. Differentiate buffer zones and transition zones.
8. Differentiate gene banks and seed banks.
9. Project Tiger was launched by the Government of India with the sup- port of WWF-International in …… .

Assignments

1. Give awareness to the public about Biodiversity Conservation methods and its importance.
2. Prepare a list of protected endemic plants and animals in any Wildlife Sanctuaries.

Suggested Reading

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BLOCK - 03

Social Issues and Sustainable Development

Unit 1
Environment and Human Health

Learning Outcomes

- Understands the health relationship between people and environment
- Learns to appreciate the ethical, cross-cultural, and historical context of environmental issues and the links between human and natural systems.
- Learns about promoting healthier environments to improve health
- Learns about offering a comprehensive approach to the environment health management plans, which would be a systematic approach to estimate the burden of disease.

Prerequisites

All of us know that human health is related with the environment. It is only natural that we should be aware of the different environmental factors that affect human health. We call these factors Health hazards.

They are chemical, physical or biological factors in our environment that cat can have negative impacts on our short- or long-term health.

Another important aspect is Environmental health hazard including traditional hazards of poor sanitation and shelter, as well as agricultural and industrial contamination of air, water, food and land.

Some of the common diseases that affect us are Asbestosis, Fluorosis, Asthma and Allergies.

You might also have heard about Indian Association of Occupational Health (IAOH) and National Institute of Occupational Health (NIOH) engaged in the task of promoting occupational health.

Keywords

Health, Environmental Quality, Environmental Diseases, Environmental Degradation, Occupational Health Hazards

Discussion

How is human health related to the environment? What are the different environmental factors that affect human health?

3.1.1 Environment and human health

Human health and well-being are intimately linked to the state of the environment. Good quality natural environments provide basic needs, in terms of clean air and water, fertile land for food production, and energy and material inputs for production. Environmental degradation can have a significant impact on human health. Although the environment sustains human life, it can also cause diseases. Lack of basic necessities is a significant cause of human mortality. Environmental hazards increase the risk of cancer, heart disease, asthma, and many other illnesses.

Natural environments provide numerous challenges to human health and well-being, and many of these challenges are continuing to grow and develop, both in ways that we can reasonably forecast and ways that we cannot. Moreover, social and economic factors mean that different segments of society are affected in differing ways and to varying degrees. The natural environment contributes significantly to people's health through the quality of air we breathe, the food we eat and the water we drink. On the one hand, it offers health enhancing economic and recreational opportunities, while on the other, it is threatened by activities such as transport, industrial processes, and agricultural and waste management practices. Environmental pollutants and potentially pathogenic organisms can harm people's health through a series of complex transport and exposure pathways.

Global climate change will have a wide range of health impacts. Overall, negative health impacts are anticipated to outweigh positive health impacts. Some health impacts would result from changes in the frequencies and intensities of extremes of heat and cold and of floods and droughts. Other health impacts would result from the impacts of climate change on ecological and social systems and would include changes in infectious disease occurrence, local food production and nutritional adequacy, and concentrations of local air pollutants and aeroallergens, as well as various health consequences of population displacement and economic disruption.

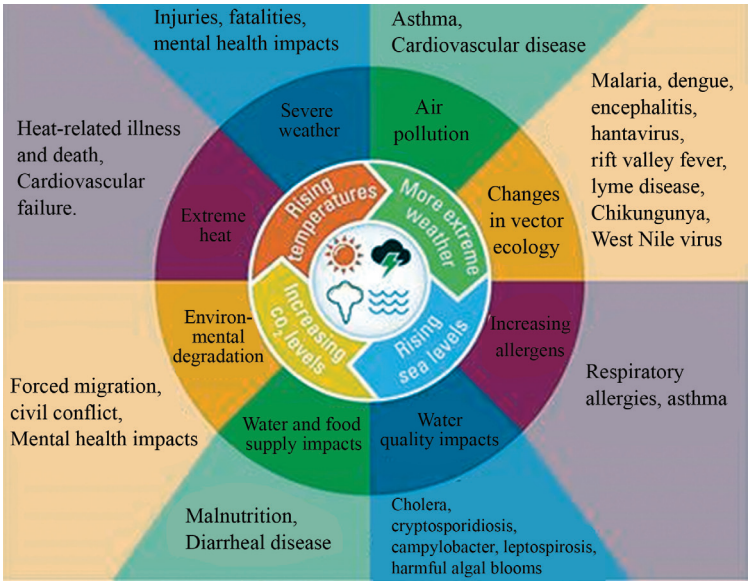

Fig 3.1.1 Impact of climate change on human health (Source: U.S. Global Change Research Program)

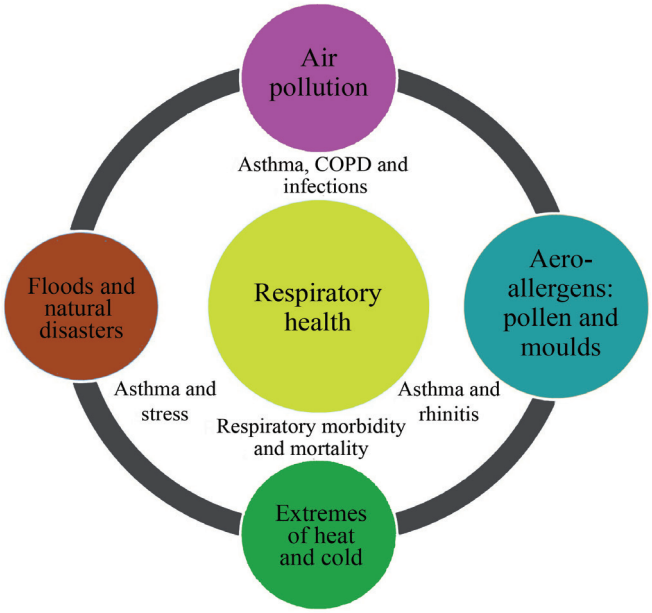

Fig 3.1.2 Climate change and respiratory diseases (Source: European Respiratory Society)

3.1.2 Impacts of environmental degradation on human health

Natural environment degradation refers to the destruction and loss of native species and natural processes such that only certain components of the original biodiversity and ecological functions persist, often with significantly altered natural communities. Environmental degradation is the disintegration of the earth or deterioration of the environment through the consumption of assets, for example, air, water and soil; the destruction of environments and the eradication of wildlife. There is growing concern about the links between the environment and health. Many factors influence the health of a population, including diet, sanitation, socio-economic status, literacy, and lifestyle. A person is exposed to many environmental factors within his/her local environment: chemical emissions from consumer products (particles, air pollutants), environmental noise, moulds etc. Humans need to interact with the environment to obtain our food, water, fuel, medicines, building materials and many other things. Advances in science and technology have helped us to exploit the environment for our benefit, but in the other side, as a result of human interventions, pollution becomes a major concern and caused environmental damage. Vulnerability and exposure, however, vary markedly between different groups and areas, with children and the elderly being particularly at risk. There is reasonable understanding of cause-and effect relationships between water, air pollution and human health. However, the health consequences of other environmental factors and exposures, such as those resulting from climate change and chemicals in the environment are less understood. The environment directly affects health status and plays a major role in quality of life, years of healthy life lived, and health disparities. Poor air quality is linked to premature death, cancer, and long-term damage to respiratory and cardiovascular systems. Second-hand smoke containing toxic and cancer-causing chemicals contributes to heart disease and lung cancer in non-smoking adults. Globally, nearly 25% of

Fig 3.1.3 Environmental impacts on human health and well being (Source: WHO, 2017)

all deaths and the total disease burden can be attributed to environmental factors. Poor environmental quality has its greatest impact on people whose health status is already at risk

3.1.3 Environmental Health Hazards

Health has benefited greatly from development, and industrialization in particular, as well as from increased societal and personal wealth, substantially improved transportation, and enhanced health and education services. Without a doubt, compared to centuries or even decades ago, people are living longer and are healthier on a global basis. Industrialization has, however, had negative health effects on the population as a whole as well as on the workers. These impacts have been brought on either directly by exposure to dangers and hazardous substances or indirectly through local and global environmental deterioration. The highest level of a worker's overall physical, mental, and social wellbeing is referred to as their occupational health. It is the area of medicine that deals with all occupational health and safety issues. It places a lot of attention on preventing dangers at the ground level. Preventive medicine is essentially what occupational health is. Similar to occupational health risks, environmental risks might be biological, chemical, physical, biomechanical, or psychosocial in origin. Traditional environmental health risks such as inadequate housing and sanitation are also present, in addition to agricultural and industrial contamination of the air, water, food, and land. These risks have had a variety of negative effects on health, from severe direct effects to long-lasting effects to mild, indirect, and even disputed effects. The health issues brought on by environmental and occupational risks are particularly severe in developing nations, where effective measures of hazard control are not yet widely adopted.

3.1.4 Types of environmental diseases

The distribution of infectious diseases is influenced by intricate socioeconomic and demographic factors. These include factors such as the size and behaviour of the human population, the kind and location of dwellings,

the availability and implementation of vector control programmes, access to health care, and general environmental hygiene. The recent revival has primarily been caused by social and demographic causes such population increase, urbanisation, immigration, changes in land use and agricultural methods, deforestation, international travel, and the collapse of public health systems. The Intergovernmental Panel on Climate Change warned that climate change may raise the burden of diarrheal diseases and contribute to the expansion of risk areas for infectious diseases like dengue, putting more people at risk. In addition to allergies and asthma, neurotoxic effects of environmental contaminants, environmental influences on the onset of puberty, food, and fertility, as well as cancer, heart disease, and obesity associated with risk factors correlated to environment, diet, and genetic factors, there are a number of diseases that warrant concern. Asthma and allergic reactions, two conditions that are becoming more and more common, especially in youngsters, are influenced by outdoor air pollution. Since individuals breathe both indoor and outdoor air, it is necessary to take an integrated approach to reducing both interior and outdoor air pollution.

The phenomena of global climate change is now thought to be closely related to human activity. We can now comprehend long-term changes in climate better thanks to advances in meteorology. A prediction of the location and timing of infectious disease outbreaks might be made with the help of such knowledge. Disease hazards brought on by flooding are reduced in industrialised nations by flood control measures, sanitary infrastructure, and monitoring programmes to identify and manage epidemics. Increases in diarrheal illness, cholera, dysentery, and typhoid are particularly worrisome in emerging nations.

3.1.5 Occupational diseases

Occupational disease is any illness associated with a particular occupation or industry. Such diseases result from a variety of biological, chemical, physical and psychological factors that are present in the work environment or are otherwise encountered in the course of employment. The major occupational diseases/morbidity of concern in India are silicosis, musculoskeletal injuries, coal workers' pneumoconiosis, chronic obstructive lung diseases, asbestosis, byssinosis, pesticide poisoning and noise induced hearing loss. Growing population is the major concern of the government and is considered as the principal obstacle to the economic growth of the country. Emerging occupational health problems are to be tackled along with the existing traditional public health problems like communicable diseases, malnutrition, poor environmental sanitation and inadequate medical care.

3.1.5.1 Asbestosis

Asbestosis is a chronic lung condition caused by prolonged exposure to high concentrations of asbestos fibres in the air which comes from old and brittle asbestos products that release tiny, even microscopic, fibres. Though asbestosis is believed to be mostly an occupational disease, there are reports of second hand exposure to asbestos containing dust. Asbestos is present in the environment naturally, primarily in underground rock. In most areas asbestos fibres are not released into the air because the rock is too deep to be disturbed easily. When asbestos fibres are inhaled, they can cause inflammation and scarring of lung tissues. Prolonged exposure to these fibres may cause the condition asbestosis, one of over 200 types of pulmonary fibrosis which is also classified as an interstitial lung disease.

3.1.5.2 Silicosis

Silicosis is a form of occupational lung disease caused by inhaling large amounts of crystalline silica dust, usually over many years. Those who work in glass manufacturing, tunnel work and stone cutting are more likely to develop silicosis. Silica is a substance naturally found in certain types of stone, rock, sand and clay. Working with these materials can create a very fine dust that can be easily inhaled. Symptoms of silicosis usually appear after many years of exposure.

In early stages, symptoms are mild and include cough, sputum and progressive shortness of breath. As the scarring continues to worsen, the first real signs of a problem may be an abnormal chest X-ray and a slowly developing cough. It is possible to get silicosis from one exposure to a massive concentration of crystalline silica dust without a respirator. This condition is the rarest form of the disease and is called acute silicosis. Another form of the disease is called accelerated silicosis which is an aggressive and incurable form of lung disease that traditionally affects construction workers, farmers, miners and engineers. It is caused by breathing in unsafe levels of silica dust, which can scar lungs and cause them to stiffen. Although silicosis has been recognized for many centuries, its prevalence increased markedly with the introduction of mechanized mining.

3.1.5.3 Fluorosis

Fluorosis is a crippling disease resulting from deposition of fluorides in the hard and soft tissues of body. It is a public health problem caused by excess intake of fluoride through drinking water/food products/industrial pollutants over a long period. Ingestion of excess fluoride, most commonly in drinking-water, can cause fluorosis which affects the teeth and bones. Moderate amounts lead to dental effects, but long-term ingestion of large amounts can lead to potentially severe skeletal problems. Paradoxically, low levels of fluoride intake help to prevent dental caries. The control of drinking-water quality is therefore critical in preventing fluorosis. Symptoms of fluorosis range from tiny white specks or streaks that may be unnoticeable to dark brown stains and rough, pitted enamel that is difficult to clean. Chronic high-level exposure to fluoride can lead to skeletal fluorosis. In skeletal fluorosis, fluoride accumulates in the bone progressively over many years. The early symptoms of skeletal fluorosis include stiffness and pain in the joints. In severe cases, the bone structure may change and ligaments may calcify, with resulting impairment of muscles and pain. Acute high-level exposure to fluoride causes immediate effects of abdominal pain, excessive saliva, nausea and vomiting. Seizures and muscle spasms may also occur.

3.1.5.4 Asthma

Asthma is a condition in which airways narrow and swell and may produce extra mucus. This can make breathing difficult and trigger coughing, a whistling sound (wheezing) when you breathe out, and shortness of breath. Urbanization is associated with increased asthma prevalence, probably due to multiple lifestyle factors. Exposure to a range of environmental allergens and irritants are also thought to increase the risk of asthma, including indoor and outdoor air pollution, house dust mites, moulds, and occupational exposure to chemicals, fumes, or dust. Environmental factors which cause asthma are those that induce airway inflammation with eosinophils (more common) or neutrophils along with airway hyper responsiveness (AHR). Environmental tobacco smoke and mould growth are the indoor factors most consistently associated with respiratory morbidity, but their roles in initiating allergic asthma remain uncertain.

3.1.5.6 Allergies

Environmental changes are thought to be the main factor in the rapid increase and worsening of allergic diseases. In fact, various environmental pollutants such as air pollutants and chemical substances, have been shown to worsen various allergies in experimental studies. The most extensively studied environmental factors influencing allergy are airborne allergens: dust mites, pollens, fungi and animal dander. With the increase in urbanization and industrialization, air pollution has been on a rise. Correlatively, cases of air pollution allergy have also shot up. Air pollution alone causes allergic rhinitis in 40% of the world population. To eliminate and control allergic diseases, medical measures are necessary, but it is also essential to tackle this issue by ameliorating environmental changes.

Recap

- Health hazards are chemical, physical or biological factors in our environment that can have negative impacts on our short- or long-term health
- Environmental health hazards include traditional hazards of poor sanitation and shelter, as well as agricultural and industrial contamination of air, water, food and land.
- Occupational health concerns with monitoring the concentration of toxic substances in the environment, determining safe exposure levels, suggesting procedures to limit worker exposure, and monitoring workers for signs of overexposure.
- Asbestosis is a chronic fibrotic lung disease that results from the long-term inhalation of respirable asbestos fibres.
- Silicosis is a respiratory disease caused by inhalation of silica dust that leads to inflammation and then scarring of the lung tissue. Silicosis mainly affects workers exposed to silica dust in jobs such as construction and mining.
- Fluorosis: Ingestion of excess fluoride, most commonly in drinking-water, can cause fluorosis which affects the teeth and bones. Moderate amounts lead to dental effects, but long-term ingestion of large amounts can lead to potentially severe skeletal problems.
- Asthma: A serious and life threatening chronic respiratory disease that affects the quality of life with exposure to air pollution. Air pollution can make asthma symptoms worse and trigger asthma attacks.
- Allergies: Urbanization, high levels of vehicle emissions and westernized lifestyle are correlated with an increased frequency of respiratory allergy, mainly in people who live in urban areas in comparison with people living in rural areas.

Objective Type Questions

1. What is environmental degradation?
2. Define environmental health?
3. What are Environmental Health Hazards?
4. Name the association comprising health professionals, industrial hygienists, safety professionals and social workers to promote occupational health.
5. Name of the WHO collaborative and reference centre for occupational health, established in Ahmadabad, Gujarat, India.

Answers to Objective Type Questions

1. The deterioration of the environment through depletion of resources like air, water and soil.
2. Environmental health is the branch of public health that focuses on the inter relationships between people and their environment.
3. An environmental health hazard is a substance that has the ability to cause an adverse health event. This includes physical, chemical, and biological factors that are external to a person.
4. Indian Association of Occupational Health (IAOH)
5. National Institute of Occupational Health (NIOH)

Self Assessment Questions

1. Describe the impacts of global climate change on human health.
2. What are environmental diseases? Give examples.
3. Explain occupational diseases with examples.
4. What is allergy? What are the reasons for allergy?
5. Crippling disease resulting from deposition of fluorides in the hard and soft tissues of body is …….. .
6. ……. is a chronic lung condition caused by prolonged exposure to high concentrations of asbestos fibres in the air.
7. What is acute silicosis?

Assignments

1. What we can do to protect children from environmental risks?
2. What is the role of environmental health in occupational health?

Suggested Reading

1. Read sample narrative essays to understand the structure and features of environment and human health.

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Unit 2
Epidemiological Issues in Health

Learning Outcomes

- Learns to identify the cause of a disease and its relevant risk factors.
- Learns to demonstrate the link between water and health and show the profound influence of water supply and quality on public health.
- Learns to describe health needs in terms of the distribution of specific diseases
- Learns to study the progression of disease and to evaluate preventive and therapeutic measures for a disease or condition.

Prerequisites

All of us are familiar with several diseases that are common and everywhere. These diseases are caused by pathogens. Pathogens may be viruses, bacteria, or fungi.

Do you know that we can divide these diseases as water borne, air borne and animal borne? Water-borne diseases are the ones caused by pathogenic microbes spread via contaminated water. Cholera, diarrhoea, typhoid, amebiasis, hepatitis, gastroenteritis, giardiasis, campylobacteriosis, scabies, and worm infections are some examples.

Airborne disease is caused by droplets of pathogens which are expelled into the air by coughing, sneezing or talking. Many common infections can spread by airborne transmission are tuberculosis, influenza, small pox.

Vectors are living organisms that can transmit infectious pathogens between humans, or from animals to humans. Vector-Borne Disease: Disease that results from an infection transmitted to humans and other animals by blood-feeding anthropods, such as mosquitoes, ticks, and fleas. Examples of vector-borne diseases include Dengue fever, West Nile Virus, Lyme disease, and malaria.

Proper surveillance and assessment including measures for promoting/protecting the health and wellbeing of the population is very important. We can have a healthy and happy society only by preventing and controlling these diseases.

Keywords

Epidemic, Mortality, Surveillance, Prevalence, Health, Diagnosis, Risk factor, Population

Discussion

3.2.1 Epidemiology and health issues

How does epidemiology affect health care? What are the important issues epidemiology can address?

Epidemiology is concerned with the frequency and pattern of health events in a population. Frequency refers not only to the number of health events, for example, the number of cases of meningitis or diabetes in a population, but also to the relationship of that number to the size of the population. The term "epidemiology" is now frequently used to refer to the study of disease in general, including associated ailments, as well as infectious and epidemic diseases. Obesity, mental illness, and high blood pressure are a few examples of areas that epidemiology researches. In order to understand how political, social, and scientific factors interact to increase the risk of contracting a disease, epidemiologists must understand the factors that underlie disease distribution, their sources and causes, and methods for controlling it. This makes epidemiology a special science.

The major areas of epidemiological study include disease causation, transmission, outbreak investigation, disease surveillance, environmental epidemiology, forensic epidemiology, occupational epidemiology, screening, bio monitoring, and comparisons of treatment effects such as in clinical trials. Epidemiologists rely on other scientific disciplines like biology to better understand disease processes, statistics to make efficient use of the data and draw appropriate conclusions, social sciences to better understand proximate and distal causes, and engineering for exposure assessment.

In the past epidemiology has helped to explain the transmission of diseases, such as cholera and measles, by discovering factors shared by individuals who became sick. Modern epidemiologists have contributed to an understanding of factors that influence the risk of heart disease and cancer, which account for most deaths in developed countries today. The fundamental influences on health and disease include natural changes in the environment; environmental changes arising from human invention, discovery, and manipulation; changes in the interaction between humans, microbes, and animals usually for cultural reasons; changes in human circumstances, cultures, and behaviours; and the genetic evolution of microbes, animals, and humans. Among a range of core epidemiologic functions recognised (CDC, 2012), monitoring and surveillance as well as outbreak investigation are most immediately relevant in identifying and stopping the spread of infectious disease in a population. Epidemiologists study outbreaks of diseases, the causes, locations, and how various communities are affected, utilizing relative information to aid in the prevention of future outbreaks. Epidemiologists help to keep the public informed of methods to maintain and improve public health. The areas of specialization of epidemiologists include cardiovascular disease, genetics, infectious disease, environmental causes and ageing.

A traditional model of infectious disease causation, known as the Epidemiologic Triad is depicted in the figure below. The triad consists of an external agent, a host, and an environment in which host and agent are brought together, causing the disease to occur in the host. A vector, an organism that transmits infection by conveying the pathogen from one host to another without causing the disease itself, could be part of the infectious process.

The mosquito, or Anopheles, is a well-known

illustration of a vector. The parasite plasmodium is ingested by the mosquito along with the blood of a host that has been affected. The mosquito is unaffected by the plasmodium. However, the plasmodium can cause malaria in the affected person once it has been stored in the salivary glands and then injected into the next human the mosquito feeds on. Thus, malaria is transmitted by the Anopheles mosquito.

Another well-known example of a vector is the Ixodes genus of ticks, which can transmit Lyme disease.

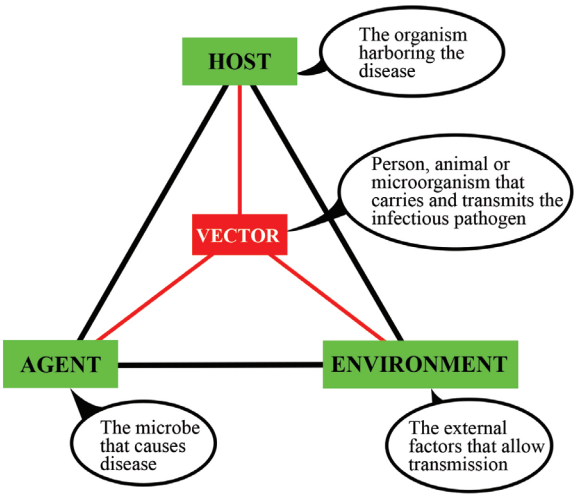

Fig 3.2.1 Epidemiological triad of disease (Source: U.S. National Institutes of Health's National Library of Medicine)

3.2.2 Water related diseases and their public health importance

Diseases associated with water exposure include those brought on by both direct and indirect skin contact with water while bathing or engaging in other water-related activities, as well as illnesses brought on by ingestion of water. Waterborne or water-associated microorganisms, as well as hazardous compounds, can cause disease. A broader definition includes diseases connected to vectors that spend part of their life cycle in water habitats, diseases related to inhaling contaminated water aerosols, and diseases related to illness dueto water shortage or contamination during adverse climate events, such as floods and droughts. Water may contain the infectious organisms (pathogens) that cause contagious diseases in people or may offer the ideal conditions for the reproduction and spread of the vectors that transport those pathogens. Environmental changes brought on by such projects may have a significant impact on the epidemiology of disease through their effect on vector ecology whenever a parasite or another disease-causing organism is present and there is a susceptible human population. In densely inhabited areas near irrigated lands, disease transmission may spread especially quickly. Good engineering practices and effective water management can prevent or lessen the effects of diseases related to water.

3.2.3 Categories of Water-related Disease and Water-borne diseases

Water related and water borne diseases are different. Microorganisms, parasites, poisons, and chemical contamination of water are some of the causes of diseases that are associated to water. Water borne diseases indicate direct transmission and is typically used to refer to illness brought on by pathogens that are microbiological or chemical pollutants in water. Seven categories of water-related disease can thus be identified such as waterborne microbiological disease; waterborne chemical disease; water hygiene disease; water contact disease; water vector habitat disease; excretal disposal disease and water aerosol disease.

The majority of water-borne diseases worldwide mainly affect children due to poor hygiene and weak immunity. Most of these diseases are life-threatening. The knowledge of the different types of water-borne diseases has come to the forefront with the advent of glo-

balization over the past few decades. Several pathogenic microorganisms which were previously unknown, have become the focus of major research in this field. About 844 million people lack even a basic drinking-water service. In fact, approximately 159 million individuals are dependent on surface water, the World Health Organization (WHO) reports. Additionally, at least 2 billion people utilize a drinking water source that is contaminated with feces. These water sources can transmit water-borne diseases, which have been linked to about 502,000 diarrheal deaths every year. The pathogenic microorganisms, their toxic exudates, and other contaminants together, cause serious conditions such as cholera, diarrhea, typhoid, amebiasis, hepatitis, gastroenteritis, giardiasis, campylobacteriosis, scabies, worm infections, etc.

Climate change plays a crucial role in the outbreaks of such infections. Major precipitation events such as heavy rains and snowfall increase the risk of the water-borne diseases. Several instances of the outbreak of epidemic infections after natural calamities such as flood have been recorded in history. The overflowing of sewage treatment plants during floods becomes the immediate risk that needs to be curbed. On the other hand, drought-affected areas also become high-risk due to the accumulation of high concentration of pathogens in a limited amount of available water sources. Natural calamities such as earthquakes or major cyclones often cause drastic changes in the ecosystem of the water bodies. Sometimes, the newly created environment (pH, temperature, etc) is favourable for the growth of a particular type of pathogen. The unprocessed water from such sources becomes harmful for routine use due to the high microbial burden. The mere negligence of the cleaning staff of water treatment plants can also cause huge damage to the community, especially in small towns where people do not have water purifiers installed in their homes. Also, the persistent usage of contaminated water for agricultural purposes (due to lack of pure water in the area) results in the colonization of pathogens in the soil. Consuming crops in that particular area may predispose the residents to disease-causing microorganisms.

In affected individuals, antibacterial, anti-parasitic, or antiviral medications are used for treatment depending on the nature of the disease. Additionally, maintaining personal hygiene also dramatically reduces the occurrence of water-borne diseases. Apart from the precautions at an individual level, several other approaches including mass recycling of water and carbon sequestration are employed to control the water-borne diseases.

3.2.4 Vector-borne diseases

Vectors are living organisms that can transmit infectious diseases between humans or from animals to humans. Many of these vectors are bloodsucking insects that ingest disease-producing micro-organisms during a blood meal from an infected host (human or animal) and later inject them into a new host during their next blood meal. Mosquitoes are the best known disease vector. Others include certain species of ticks, flies, sand flies, fleas, bugs and freshwater snails.

Vector-borne diseases are illnesses caused by pathogens and parasites in human populations. Every year more than one billion people are infected and more than one million people die from vector-borne diseases including malaria, dengue, schistosomiasis, leishmaniasis, chagas disease, yellow fever, lymphatic filariasis and onchocerciasis. These diseases affect urban, peri-urban and rural communities but thrive predominantly among communities with poor living conditions – particularly lack of access to adequate housing, safe drinking

water and sanitation. Malnourished people and those with weakened immunity are especially vulnerable. These diseases also exacerbate poverty. Illness and disability prevent people from working and supporting themselves and their family, causing further hardship and impeding economic development. Dengue, for example, imposes a substantial economic burden on families and governments, both in medical costs and in working days lost due to illness. In order to reduce poverty and promote economic growth, vector-borne diseases are crucial.

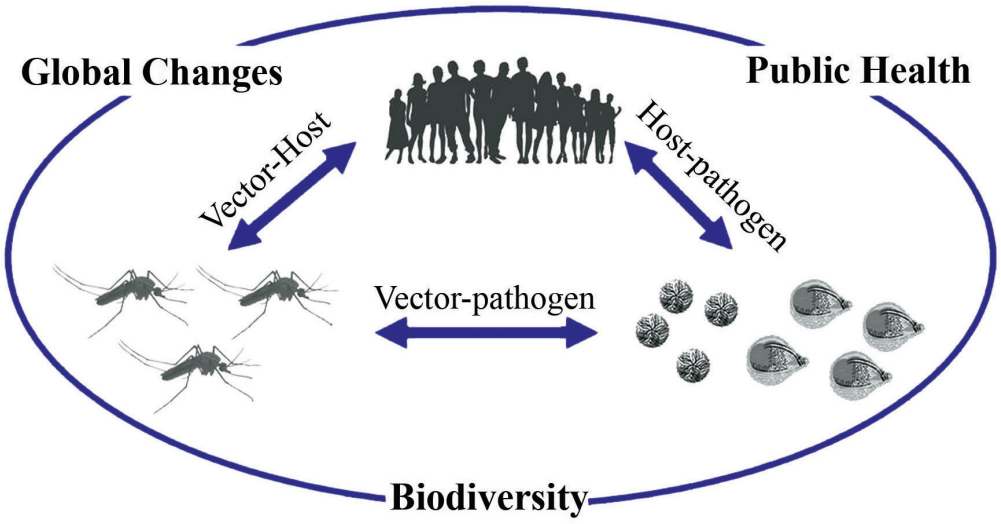

Fig 3.2.2 Biodiversity and infectious diseases
(Source: U.S. Global Change Research Program)

3.2.5 Air-borne diseases

Airborne diseases are caused by pathogenic microbes small enough to be discharged from an infected person via coughing, sneezing, laughing and close personal contact or aerosolization of the microbe. The discharged microbes remain suspended in the air on dust particles, respiratory and water droplets. The microorganisms may come from a person or animal who has a disease or from soil, garbage, or other sources. There are many types of airborne diseases, and the symptoms, treatment, and outlook will vary according to the disease.

What are the methods of preventing the transmission of air-borne diseases?

Ways of preventing transmission include the use of personal protective equipment and effective ventilation systems. Depending on the disease, an individual can help prevent transmission by avoiding close contact with others or wearing a face mask. Air currents can disperse the microorganisms, but how far they travel depends partly on the environment.The more the droplets travel from the source, the lower the risk of infection, due to environmental factors.

Depending on the pathogens, factors that affect how long they remain active include:

- air temperature
- humidity
- exposure to sunlight or other forms of radiation
- the weight of the particles, which can affect how long they take to settle
- the structure and stability of the pathogen

It is not always possible to prevent the spread of airborne diseases, but individuals and authorities can take measures to reduce the risk by recommending or ensuring adequate ventilation and the use of protective equipment.

Depending on the type of organism, the degree of exposure, and individual factors, airborne particles may cause illness to develop if exposure occurs. Many diseases can arise after exposure to airborne particles, including

- the common cold, which can develop from a rhinovirus
- chickenpox, caused by the Varicella zoster virus
- mumps, caused by a paramyxovirus
- measles, caused by another paramyxovirus
- whooping cough, a bacterial infection caused by Bordetella pertussis
- COVID-19, caused by the SARS-CoV-2 virus
- aspergillosis, caused by the Aspergillus fungus
- tuberculosis (TB), caused by the bacterium Mycobacterium tuberculosis
- anthrax, a bacterial infection resulting from contact with Bacillus anthracis spores
- diphtheria, a bacterial infection caused by Corynebacterium diphtheriae
- meningitis, which can result from exposure to certain bacterial, viral, or fungal particles

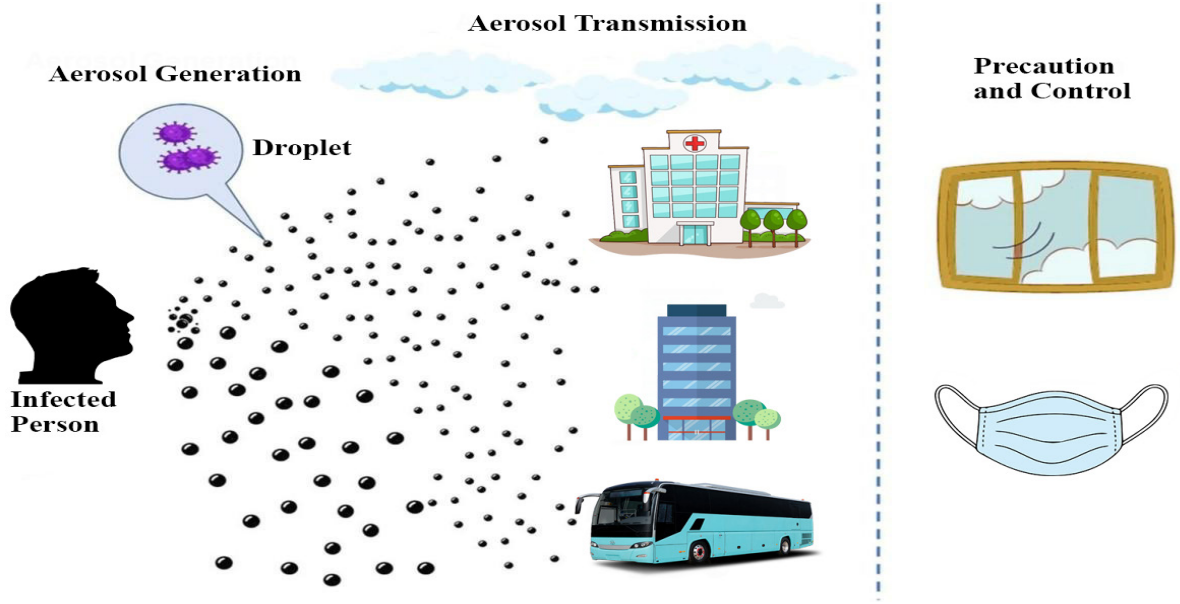

Fig 3.2.3 Air borne vs Droplet transmission (Source: wikipedia.org)

Recap

- Epidemiology is the science concerned with the study of the factors that influence and determine the frequency and distribution of disease, injury, and other health - related events and their causes in a defined human population.
- Epidemiologists use data as an information source for communicating information to people and to influence public policy.
- Water quality refers to the chemical, physical, and biological characteristics of water based on the standards of its usage.
- Water related disease encompasses illness resulting from both direct and indirect exposure to water, whether by consumption or by skin exposure during bathing or recreational water use. It includes disease due to water-borne or water-associated pathogens and toxic substances.
- Water-borne diseases are the ones caused by pathogenic microbes spread via contaminated water. Cholera, diarrhoea, typhoid, amebiasis, hepatitis, gastroenteritis, giardiasis, campylobacteriosis, scabies, and worm infections are some examples.
- Vectors are living organisms that can transmit infectious pathogens between humans, or from animals to humans.
- Vector-Borne Disease: Disease that results from an infection transmitted to humans and other animals by blood-feeding anthropods, such as mosquitoes, ticks, and fleas. Examples of vector-borne diseases include Dengue fever, West Nile Virus, Lyme disease, and malaria.
- Airborne disease is caused by droplets of pathogens which are expelled into the air by coughing, sneezing or talking. The relevant pathogens may be viruses, bacteria, or fungi. Many common infections can spread by airborne transmission are tuberculosis, influenza and small pox.

Objective Type Questions

1. Name one of the prime causes of illness in third world countries of the tropical and subtropical regions?
2. What is the most common water-borne disease?
3. Name the virus which causes chickenpox?
4. Name the disease caused by paramyxovirus.
5. Insects responsible for transmitting diseases are called?
6. Extremely small solid particles, or very small liquid droplets, suspended in the atmosphere are commonly referred to as…..

7. Diseases that are always present in a community, usually at a low, more or less constant, frequency are classified as having which pattern?
8. Diseases that are due mostly to environmental changes, increased population densities, and pollution that result from modernization in third world nations are referred to as.....

Answers to Objective Type Questions

1. Malaria
2. Diarrhea
3. Varicella zoster virus
4. Measles / Mumps
5. Vector
6. Aerosols
7. Epidemic
8. Diseases of development

Self Assessment Questions

1. What is epidemiology?
2. What do you mean by epidemiological triad?
3. Malaria is transmitted by the …….. .
4. Write a short note on water related diseases and its health importance.
5. Describe the categories of water related diseases.
6. Define vectors and vector-borne diseases.
7. With examples, describe air-borne diseases.
8. List out the factors affecting pathogenicity.
9. Write an essay on environmental epidemiology.

Assignments

1. List out the major tasks of epidemiology.
2. List the vector-borne diseases according to their vector.
3. Discuss the methods of vector control.
4. Read sample narrative essays to understand the structure and features.

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Unit 3
Need for Public Awareness on Aspects Related to Environment

Learning Outcomes

- Understands the fragility of our environment and the importance of its protection
- Develops awareness of and concern for environmental issues among the general public worldwide
- Learns to embrace and protect the trees and to resist deforestation
- Learns to conserve the ecological biodiversity

Prerequisites

All of us look at Baba Amte, Sunder lal Bahuguna and Medha Patkar with reverence. Why? They have been responsible for movements against environmental destruction.

It is very important that we have an awareness and sensitivity to the total environment and its related problems.

Some of movements for the protection of Nature and forest in India include Chipko Movement, Save Silent Valley Movement, Jungle Bachao Andholan, Appiko Movement and Narmada Bachao Andholan (NBA).

Do you know the origin of the word ―Chipko‖? ―Chipko‖ comes from the word ‖embrace‖, Chipko Movement was initiated for the protection of trees.

Nature can only be protected and preserved by the combined and coordinated action of the people.

Keywords

Environmental awareness, Environmental movements, Chipko movement, Narmada Bachao Andholan

Discussion

Why is environmental awareness important? Why are environmental movements important?

Mother Nature is the environment, and we must respect her in order to preserve our own way of life. In their own surroundings, all living and non-living things are constantly interacting with one another. Nothing can

exist without environment. Particularly, humans cannot thrive in the absence of an environment. Mankind and the environment are mutually dependent. The state of the environment is greatly impacted by human activity, which also has an impact on the general advancement of our society. In terms of physical, chemical, and biological aspects, the environment has both natural and artificial components. Over time, natural changes take place, whereas man-made changes are mostly the result of scientific and technological advancements based on human activity.

Environmental awareness is critical because it can help to minimise pollution and global warming. It can also lead to a more sustainable world by promoting renewable resources such as solar, wind and water. The most crucial thing that environmental awareness accomplishes is educating people about the risks of maintaining our current level of consumption. This is so that people can properly see the extent of the harm and the threats facing our planet. As a result, awareness is focused on issues like global warming, sustainable development, and environmental health.

3.3.1 Need for public awareness

Since our environment is also getting degraded due to human activities, we need to do something about it to sustain the quality. We frequently believe that the government ought to implement suitable measures. But all of us are equally responsible to protect our environment. The future of humanity is primarily concerned with public environmental awareness. It ranks among the most significant markers of a nation's civilization. It represents a variety of environmental circumstances, including knowledge, actions, and attitudes toward a sustainable society. The degree to which the general public is aware of the significance and ramifications of a certain programme or activity is known as public awareness. Increasing public knowledge is not the same as directing the people's behaviour. It involves educating people about topics and providing information so that they can decide for themselves. Both print media and electronic media can strongly influence public opinion. Politicians should respond positively to a strong publicly supported activity. NGOs can take an active role in creating awareness from grass root levels to the top-most policy decision makers.

Public awareness of the environment is the ability to understand the surrounding world, including understandings of all the changes occurring in the environment, understanding of cause- and-effect relationships between the quality of the environment and human behaviour, and a sense of responsibility to preserve them.

3.3.2 Environmental movements in India

An environmental movement is a social or political movement for the conservation of environment or improvement of the state of the environment. The terms "green movement" or "conservation movement" are alternatively used to denote the same concept. The environmental movements favour the sustainable management of natural resources. The movements often stress the protection of the environment via changes in public policy. Many movements are centred on ecology, health and human rights. Environmental movements range from the highly organized and formally institutionalized ones to the radically informal activities. The spatial scope of various environmental movements range from being local to almost global.

Environmental and public health struggles are ongoing within India. In order to promote small industries for rural villages using local resources, environmentalist and Gandhian so-

cial Activist, Chandi Prasad Bhatt established a cooperative organisation called Dasholi Gram Swarajya Sangh (later renamed Dasholi Gram Swarajya Mandal [DGSM]). It was inaugurated by Sucheta Kriplani and founded on land donated by Shyma Devi. The Chipko movement, which started in 1974, was finally launched in response to this endeavour.

3.3.3 Major Environmental Movements in India

The major environmental movements in India during the period up to 2000 are the following.

1. Chipko Movement
2. Save Silent Valley Movement
3. Jungle Bachao Andholan
4. Appiko Movement
5. Narmada Bachao Andholan (NBA)

3.3.3.1 Chipko Movement

What is meant by Chipko, the name of the movement? Chipko comes from the word "embrace", as the villagers hugged the trees and encircled them to prevent them from being hacked down. The Chipko movement or Chipko Andolan, was a forest conservation movement in India. It began in 1973 in Khumtung (at the foothills of Himalayas), Mizoram, and then a part of Uttar Pradesh and went on to become a rallying point for many later environmental movements all over the world. It created a precedent for starting nonviolent protest in India. However, it was Sunderlal Bahuguna, a Gandhian activist, who gave the movement a proper direction and its success meant that the world immediately took notice of this non- violent movement, which was to inspire in time many similar eco-groups by helping to slow down the rapid deforestation, expose vested interests, increase social awareness and the need to save trees, increase ecological awareness, and demonstrate the viability of people's power. He used the slogan "Ecology is the permanent economy". Above all, it stirred up the existing civil society in India, which began to address the issues of tribal and marginalized people. The Chipko Andolan or the Chipko movement is a movement that practiced methods of Satyagraha where both male and female activists from Uttarakhand played vital roles, including Gaura Devi, Suraksha Devi, Sudesha Devi, Bachni Devi and Chandi Prasad Bhatt, Virushka Devi and others. And it is true that the support for the movement came mainly from the womenfolk.

Fig 3.3.1 A Poster of Chipko Movement

In 1987, the Chipko movement was awarded the Right Livelihood Award by Sunderlal Bahuguna for its dedication to the conservation, restoration and ecologically-sound use of India's natural resources.

Women's participation in the Chipko agitation was a very novel aspect of the movement. The forest contractors of the region usually doubled up as suppliers of alcohol to men.Women held sustained agitations against the habit of alcoholism and broadened the agenda of the movement to cover other social issues. The movement achieved a victory when the government issued a ban on felling of trees in the Himalayan regions for fifteen years in1980 by then Prime Minister Indira Gandhi, until the green cover was fully restored. One of the

prominent Chipko leaders, Gandhian Sunderlal Bahuguna, took a 5,000 kilometre (3000 mile) trans-Himalaya foot march in 1981–83, spreading the Chipko message to a far greater area. Gradually, women set up cooperatives to guard local forests, and also organized fodder production at rates conducive to local environment. Next, they joined hands with land rotation schemes for fodder collection, helped replant degraded land, and established nurseries stocked with species they selected.

The Chipko Movement was a big success against the people who wanted to cut down a huge number of trees for personal benefits. The movement succeeded in creating a trigger for other people and communities in India to come forward to protest, and protect the trees. Soon the movement became a national phenomenon and became one of the biggest ecological movements.

3.3.3.2 Narmada Bachao Andolan

Narmada Bachao Andolan (NBA) is an Indian social movement spearheaded by native tribals (adivasis), farmers, environmentalists and human rights activists against a number of large dam projects across the Narmada River, which flows through the states of Gujarat, Madhya Pradesh and Maharashtra. Sardar Sarovar Dam in Gujarat is one of the biggest dams on the river and was one of the first focal points of the movement. It is part of the Narmada Dam Project, whose main aim is to provide irrigation and electricity to people of the above states. The mode of campaign under NBA includes court actions, hunger strikes, rallies and gathering support from notable film and art personalities. The NBA, with its leading spokespersons Medha Patkar and Baba Amte, received the Right Livelihood Award in 1991.

Narmada is India‘s largest west flowing river, which supports a large variety of people with distinguished culture and tradition ranging from the indigenous (tribal) people inhabited in the jungles to a large number of the rural population. Narmada Bachao Andolan, the most powerful mass movement, started in 1985, against the construction of a huge dam on the Narmada river. As per the Narmada Dam Project, the plan was to build over 3000 big and small dams along the river. The proposed Sardar Sarovar Dam and Narmada Sagar were to displace more than 250,000 people. The big fight of the Save the Narmada Movement was over the resettlement or the rehabilitation of these people. According to Narmada Bachao Andolan, the dams force the displacement of about a million people and affect many more, largely poor peasants and tribals. They also cause immense ecological damage through the inundation of forests, including prime habitats of rare species. The movement was heavily criticised by many people who saw it as an obstruction in the process of economic development, as the project was considered essential for providing access to water to a large number of people.

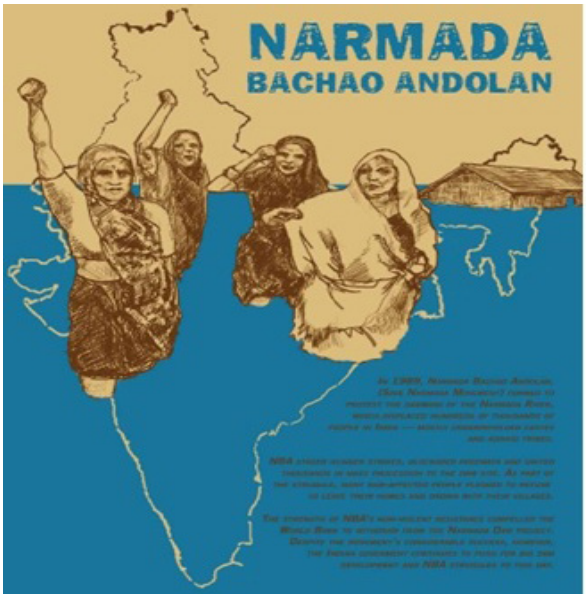

Fig 3.3.2 A Poster of Narmada Bachao Andolan

According to one NBA partner, the campaign against the construction of dams on the Narmada River is —symbolic of a global struggle

for social and environmental justice, while the NBA itself is a symbol. Though the movement started to save the rights of the indigenous population, the focus of the NBA shifted towards rehabilitation and resettlement. But even so, the World Bank's exit, the Harsud Rally, and other notable success occurred between 1990 and 1993. Its influence has diminished since then, largely because people now believe that the Sardar Sarovar Project (SSP) will move on regardless of what, given the Indian government's will to support it. Notwithstanding this, Medha Patkar and the NBA keep on challenging the SSP.

Recap

- Environmental awareness is an ideology that evokes the necessity and responsibility of humans to respect, protect, and preserve the natural world from its anthropogenic (caused by humans) afflictions.
- Environmental movement is a type of social movement that involves an array of individuals, groups and coalitions that perceive a common interest in environmental protection and act to bring about changes in environmental policies and practices.
- Chipko movement was launched to protect the Himalayan forests from destruction and to protest against the colonial forest policy during the early decades of the twentieth century.
- Narmada Bachao Andolan is the most powerful mass movement, started in 1985, against the construction of huge dam on the Narmada River to provide project information and legal representation to the concerned residents of the Narmada valley.

Objective Type Questions

1. In which year did the Chipko Movement start?
2. In which year did the Narmada Bachao Andola start?
3. Name the leader of Narmada Bachao Andolan?
4. Name two leaders of Chipko Movement?
5. What was the aim of Chipko Movement?
6. What was the aim of Narmada Bachao Andolan?
7. Name the award given to Chipko Movement for its ecologically-sound use of India's natural resources.
8. Name the labour cooperative started by Chandi Prasad Bhatt.

Answers to Objective Type Questions

1. 1973
2. 1985
3. Medha Patkar

4. Chandi Prasad Bhatt, Sunderlal Bhauguna
5. To protect the Himalayan forests from destruction
6. To question the rationale behind thedevelopmental projects especially dam construction across the river.
7. Right Livelihood Award
8. Dasholi Gram Swarajya Sangh

Self Assessment Questions

1. List out the famous environmental movements.
2. What do you mean by 'green movement'.
3. Write short note on Chipko Movement.
4. Chipko comes from the word …… .
5. What was the role of women in Chipko Movement?
6. Write short note on Narmada Bachao Andolan.
7. What is the name of the dam proposed in Narmada Sagar?
8. The Chipko movement or Chipko Andolan began in which place?

Assignments

1. Highlight the main issues and concerns of the environmental movements in India.
2. In your opinion, how are the environmental and ecological rights related to democracy and development in India? Explain.
3. How can we promote environmental awareness?
4. Read sample narrative essays to understand the structure and features.

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SREENARAYANAGURU OPEN UNIVERSITY

Unit 4
Current Environment Conservation Activities

Learning Outcomes

- Learns to prevent and control degradation of land, water, vegetation and air.
- Learns to facilitate the conservation of natural resources for our future generations.
- Learns to ensure the protection of biodiversity and to implement sustainable development.
- Learns to encourage the concept of sustainable sanitation practices and to create awareness about health and hygiene.
- Learns to envisage a clean and green state through waste management, organic farming and conservation of water resources with people's support.
- Learns to create ecofriendly environment and create awareness on biodiversity conservation.

Prerequisites

In which logo does the Indian National Tricolor appear on the bridge of Mahatma Gandhi's glasses? It is definitely the Swachh Bharat Abhiyan. What does it indicate? It represents the coming together of the entire country to realise Mahatma Gandhi's goal of creating a clean India.

Many schools in Kerala have different clubs like Eco club, Nature Club and Tourism Club; and probably many of you were members of the same. Why do we have such clubs?

We are also familiar with Haritha Keralam Mission. It is now seen that many panchayats have declared the area as Open Defecation Free (ODF).

These and several other clubs and projects have made the country cleaner and safer. It is the need of the hour to sensitize, motivate and educate the entire population of the need about environment conservation. We should also create awareness among society about environment and related issues.

Organizing activities to reduce pollution in our living place and protecting the environment are what we need for making the world a safe place to live and preserving the Earth for the future.

Keywords

Cleanliness, Green Kerala, Waste Management, Environment Conservation, Swachh Bharat Abhiyan, Haritha Keralam Mission, Eco-club, Nature club

Discussion

3.4.1 Environmental Conservation

The term "conservation" refers to the safeguarding, maintenance, management, or restoration of natural areas and the ecological communities that live there. A natural resource must be carefully maintained and cared for in order to prevent its extinction. Conservation works in two ways. It is a style of life that works against the reckless commercial and corporate activities and is intended to protect nature by safeguarding essential resources. Conservation safeguards the ecosystem by using natural resources sensibly. For instance, sustainable logging techniques are often used in forest conservation to reduce deforestation.

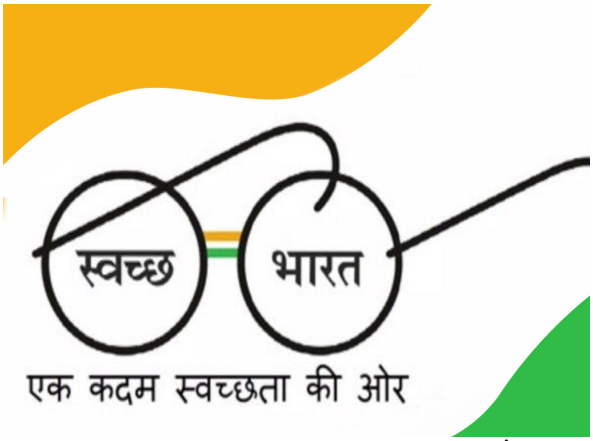
Environmental conservation is the process of protecting the environment against species extinction and ecosystem collapse, which are mostly brought about by pollution and human activity. Given that we are all reliant on one another for survival, conservation is essential for preserving and assisting both animals and trees. We can breathe and respire easier because of trees' ability to transform the carbon dioxide created by industry into oxygen. Despite the fact that they are very distinct from one another, the terms environmental conservation and preservation are sometimes used synonymously. The proper management of the environment and its resources for both present and future uses is referred to as conservation.

3.4.2 Environment Conservation Activities

3.4.2.1 Swachh Bharat Abhiyan

The Swachh Bharat Abhiyan is the most significant cleanliness campaign by the Government of India. Shri Narendra Modi led a cleanliness pledge at India Gate in 2019, which about thirty lakh government employees across the country joined. He also flagged off a walkathon at Rajpath.While leading the mass movement for cleanliness, the Prime Minister exhorted people to fulfil Mahatma Gandhi's dream of a clean and hygienic India. He gave the mantra of "Won't mess up, won't let". Shri Narendra Modi also invited nine people to join the cleanliness drive and requested each of them to draw nine more into the initiative. By inviting people to participate in the drive, the Swachhta Abhiyan has turned into a National Movement. The objectives of Swachh Bharat Abhiyan are:

1. To promote cleanliness and hygiene in a holistic manner.
2. To reduce the incidence of open defecation.
3. To bring improvement in the quality of life in rural areas.
4. To encourage the concept of sustainable sanitation practices.
5. To create awareness about health and hygiene.



The National Tricolor appears on the bridge of Mahatma Gandhi's glasses, which are included in the logo. It represents the coming together of the entire country to realise Mahatma Gandhi's goal of creating a clean India.

People from different sections of the society have come forward and joined this mass movement of cleanliness. From government officials to jawans, bollywood actors to the sportspersons, industrialists to spiritual leaders have lined up for the noble work. Millions of people across the country have been day-after-day joining the cleanliness initiatives of the government departments, NGOs and local community centres to make India clean. Organising frequent cleanliness campaigns for spreading awareness about hygiene through plays and music are also being widely carried out across the nation.

Swachh Bharat Abhiyan has become a Jan Andolan receiving tremendous support from the people. Citizens too have turned out in large numbers and pledged for a neat and clean India. Taking the broom to sweep the streets, cleaning up the garbage, focussing on sanitation and maintaining a hygienic environment have become a practice after the launch of the Swachh Bharat Abhiyan. People have started to take part and are helping to spread the message of "Cleanliness is next to Godliness".

3.4.2.2 Haritha Keralam Mission

Kerala, the southern tip of the Indian Peninsula has been immensely blessed by Nature, with its rich and varied flora and fauna, lush green forests, enthralling waterfalls, mighty mountains, virgin beaches and breathtaking backwaters. The expanse of greenery and abundance of water bodies stand as the hallmark of this land. Depletion of water resources, unscientific methods of solid waste management, air pollution, dumping garbage and chemical effluence in the water bodies, loss of grass cover, abuse of agricultural land and deforestation are some of the threats the State is confronted with. With a vision to bestow an eco-friendly land with its greenery and serenity to the posterity, the Government of Kerala has envisioned a people-centric endeavour named Mission Haritha Keralam, a mission under the umbrella project named Nava Kerala Mission.

Mission Haritha Kerala aims to promote eco-friendly environment, sustainable development of natural resources, effective solid waste management, rejuvenation of the water reserves, sanitation and social hygiene, promotion of organic cultivation, zero pesticide food products, healthy foods, propagation of herbicides and organic farming, protection of biodiversity and so on. Environmental sustainability is framed with a biocentric approach which places humans within the greater context of their natural environment.

Haritha Keralam Mission is one among the well designed and impactful programmes under the overall development banner of the Government of Kerala. It encompasses three other Missions, Hygienic Waste Management for effective waste disposal, JalaSamirdhi for water conservation, Sujalam Suphalam for agricultural development, implemented through Local Self-Government bodies in a people-centric mode under the Water Resources, Local – Self Government and the Agricultural Department respectively.

Though Kerala receives twice the national average rainfall, it is not capitalised, as the bulk of the rainwater flows into the sea within 48 to

72 hours of rainfall. As such, it has become a pressing necessity to harvest rainwater and replenish the groundwater. Perceiving the magnitude of this issue, the Haritha Keralam Mission undertakes vital steps in order to preserve the water bodies across the state.

The Water Conservation Sub Mission emphasizes to instil a new culture for water conservation in the State by the way of rejuvenating the existing water bodies, cleansing and protecting them with pure and pristine water right from the village ponds to the reservoirs at large, so as to tackle the water woes. The message of the 3Rs approach towards (Reduce, Reserve and Recycle) use of water has to be imprinted in the minds of the citizen with the active participation of voluntary organization, youth associations, students, social and philanthropic organizations discerning groups and people from all walks of life. Local self – governing institutions are the premier bodies for making this venture a success. It is envisaged to revitalize and safeguard the existing wells, ponds, springs, canals and streams across this land in the first phase. In the second phase, rivers, reservoirs, lakes, backwaters and other larger water bodies will be cleaned and protected. The reunification of streams and rivers, the revival of dead rivers with enhanced free flow of water is aimed at this stage thereby, spreading the message of conservation of water sources, judicious use of wells, water recharging and rainwater harvesting.

Activities to ensure hygienic, cleaner and healthier surroundings, better sanitation, waste disposal at the source of generation, promotion of organic farming, prevention of dumping garbage in the water bodies, zero pesticide cultivation, and pure and pollution free water bodies, are all on the move for the cause of greener and cleaner Kerala under the stewardship of Hygienic Waste Management and Agricultural Development Karmasenas. Organic vegetable farming in all households, promoting paddy cultivation in barren lands, vegetable cultivation in rooftops, and planting of saplings are the focal points emphasized and encouraged by the Sujalam Suphalam projects. In addition, promotion of biogas plants, decentralized waste disposal management on Thumboormoozhy model, dispensing plastic and e-waste on Block level basis and effective disposal of hospital waste are some of the waste disposal methods envisioned by the Hygiene Waste Management Sub Mission. Moreover, centralized waste disposal management with modern technologies will be implemented in the urban cities of Trivandrum, Kochi and Kozhikode.

3.4.2.3 Eco-club

Eco is an abbreviation for ecology, the system of relationships between living things, and with their environment. The eco-club is a group which works to contribute to improving environmental conditions. They offer programs and activities to encourage others to reduce pollution, plant trees and more. Eco club activities can help the teacher to meet the objectives of Environmental Education, which are to create awareness and sensitivity among individuals and social groups to the total environment and its allied factors.

Eco Clubs play an important role in creating environmental awareness amongst the future generation.

Fig 3.4.1 Eco-club of National Green Corps

1. Motivate the students to keep their surroundings green and clean by undertaking planting of trees.

2. Promote the ethos of conservation of water by minimizing the use of water.

3. Motivate students to imbibe habits and life style for minimum waste generation, source separation of waste and disposing the waste to the nearest storage point.

4.Educate students to create awareness amongst public and sanitary workers, so as to stop the indiscriminate burning of waste which causes respiratory diseases.

5. Sensitize the students to minimize the use of plastic bags, not to throw them in public places as they choke drains and sewers, cause water logging and provide breeding ground for mosquitoes.

6.Organize tree plantation programmes, awareness programmes such as Quiz, essay, painting competitions, rallies, nukkad natak etc. regarding various environmental issues and educate children about re-use of waste material and preparation of products out of waste.

7. Organize Nature Trail in Wild Life Sanctuaries/Parks/Forest areas to know about the Bio- diversity.

Eco club or green club is a voluntary group which promotes the participation of students in learning about, and improving their environment. Students and young people can organize themselves into a green club to learn more about this topic and to take action to better their immediate environment.

3.4.2.4 Nature Club

It is said that nature is the best teacher. It teaches us about the survival of the fittest and nourishes us in all aspects. Nature has endowed us with incredible assets like biodiversity and natural resources. The conservation of these assets has become the need of the times. It is our responsibility to leave this planet in a better shape for the future generation than we found it. Nature Club is a dedicated program to create awareness among the students, faculty and staff about nature and related issues. Nature club is the convergence of nature lovers to promote, monitor and operate the environmental and sustainable activities in the society, starting from college campus with the novel objectives of facilitating the skill development for environmental protection, promoting environmental awareness among all sections of society, spreading environmental and education among students. The various objectives of nature club are:

- To sensitize, motivate and educate student and staff about environment conservation.
- To create awareness among society about environment and related issues.
- Organizing activities to reduce pollution in the district.
- Encouraging efforts to protect and conserve biodiversity in vicinage.
- Executing small scale projects within the campus.
- Contributing to environment awareness and conservation drives in collaboration with regional nature clubs and institutes.

The Nature Club conducts various activities such as observing Plantation Day, Vermicomposting of biodegradable waste, maintenance

of Butterfly Garden, Herbal Garden, nature trail etc., throughout the year. The nature club gives most of the students an opportunity to break free from their daily routine and experience life in the simplicity and splendour of mother Earth.

Recap

- Environmental Conservation is the practice of preserving the natural world.
- To prevent it from collapsing as a result of human activities
- Unsustainable agriculture, deforestation and burning fossil fuels.
- Voluntary activities aim mainly at global environmental conservation, pollution control, maintenance of the natural environment.
- Aims to achieve universal sanitation coverage and to encourage hygienic sanitation practice.
- Hygienic Waste Management for effective waste disposal, oil and water conservation, agricultural development with a special thrust on organic farming are the three focal points of Mission Haritha Keralam.
- Nature club: A conservation programme composed of a group of people, who can spread conservation awareness in society.
- Eco-Club: promotes the participation of students in learning about and improving their environment.

Objective Type Questions

1. When did Swachh Bharat Abhiyan start?
2. Who is the inspiration behind Swachh Bharat Abhiyan?
3. Which ministry started Swachh Bharat Abhiyan?
4. When did Haritha Kerala Mission start?
5. When was Eco-club started?
6. What is the slogan of Haritha Kerala Mission?
7. Swachh Bharat Abhiyan was launched on the occasion the birth anniversary of a famous Indian leader. Who was it?
8. What is the full form of ODF?

Answers to Objective Type Questions

1. 2 October 2014
2. Mahatma Gandhi
3. Ministry of Housing and Urban Affairs, Government of India
4. 10 November 2016
5. 2001
6. To safeguard the natural resources
7. Mahatma Gandhi
8. Open Defecation Free

Self Assessment Questions

1. Define environmental conservation.
2. Write short note on Swachch Bharat Abhiyan.
3. Mission Haritha Kerala aims to promote eco-friendly environment, sustainable development of natural resources.
4. Write about some moves for the cause of building greener and cleaner Kerala.
5. What are the roles of eco clubs in educational institutions?
6. Write a short note on the objectives of nature club.
7. Write an essay on various environmental conservation activities.

Assignments

1. What kind of activities can be done for environmental conservation?
2. As a student, what can you do to save the environment?
3. Write a short note on Eco club.
4. What are the salient features of Haritha Kerala Mission ?
5 What are the objectives of swachh bharath mission?

Suggested Reading

1. Read sample narrative essays to understand the structure and features.

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Unit 5
Population Growth, Population Explosion and Associated Issues

Learning Outcomes

- Knows about achieving a balance between population growth rate and available resources
- Understands about the fatal effects of over population
- Learns about the significant issues of population growth
- Gets an awareness about the challenges posed by population growth

Prerequisites

What are the main challenges of population growth? What are the main problems caused by a growing population? We are all familiar with the Malthusian theory which states that population multiplies in geometrical progression while resources multiply in an arithmetical progression.

We are also familiar with overpopulation, an undesirable condition where the number of the existing human population exceeds the actual carrying capacity of the Earth.

Why is there an imbalance between births and deaths? What are the issues of population growth? They include exacerbating food and water shortages, reducing resilience in the face of climate change, and making it harder for the most vulnerable communities to rise out of intergenerational poverty.

Today we speak of population explosion. It refers to the rapid increase in the number of people in an area. It is a situation where the economy of the country cannot cope with the rapid growth of the population. The effects of population explosion are many and varied. Population explosion leads to environmental degradation. Higher birth rate brings more pollution, more toxic wastes and damage to biosphere. Population explosion hinders the economic development.

Keywords

Population Density, Fertility, Family planning, Social welfare, Climate change, Deforestation

Discussion

What are the main challenges of population growth? What are the main problems caused by a growing population?

3.5.1 Population Growth

Population is growing rapidly, far outpacing the ability of our planet to support it, given current practices. Overpopulation is associ-

ated with negative environmental and economic outcomes ranging from the impacts of over-farming, deforestation, and water pollution to eutrophication and global warming. With a growing population, poverty and urbanization are degrading the environment. Population pressure on arable land contributes to land degradation. The increasing population numbers and growing affluence have already resulted in rapid growth of energy production and consumption in India. Population impacts on the environment primarily through the use of natural resources and production of wastes. It also associated with environmental stresses like loss of biodiversity, air and water pollution and increased pressure on arable land. Poverty is said to be both a cause and effect of environmental degradation. Population growth and economic development are causing several serious environmental problems in India. These include pressure on land, deforestation and water scarcity and water pollution.

Population is an important source of development, yet it is a major source of environmental degradation when it exceeds the threshold limits of the support systems. Unless the relationship between the multiplying population and the life support system can be stabilized, development programs, though innovative, are not likely to yield desired results. Human population issues are extremely important when it comes to our way of life and our future on this planet. Rapid population growth in a country like India is threatening the environment through expansion and intensification of agriculture, uncontrolled growth of urbanization and industrialization, and destruction of natural habitats. Rapid population growth plays an important role in declining per capita agricultural land, forest and water resources.

3.5.2 Major issues related to population growth

Unsustainable population growth and lack of access to reproductive health care also puts pressure on human communities, exacerbating food and water shortages, reducing resilience in the face of climate change, and making it harder for the most vulnerable communities to rise out of intergenerational poverty. Overpopulation in India is causing even more problems. An increasing population living on the same land will quickly use up the limited resources the country has. Medical conditions are getting worse and diseases are spreading fast. Overcrowding leads to further demand for limited resources and this, in turn, can lead to more conflict and warfare. As humans seek out more resources, they take over land that was once the habitat of other species leading to huge biodiversity loss. Population growth is based on four fundamental factors: birth rate, death rate, immigration, and emigration. The root of overpopulation is the difference between the overall birth rate and death rate in populations. If the number of children born each year equals the number of adults that die, the population will stabilize. Talking about overpopulation shows that while there are many factors that can increase the death rate for short periods of time, the ones that increase the birth rate do so over a long period of time. The Figure 3.5.1 shows the population growth statistics of India from 2010-2020 compared to the previous years.

The fatal effects of over population are:

1. Depletion of natural resources: The effects of overpopulation are quite severe. The first of these is the depletion of resources. The Earth can only produce a limited amount

of water and food, which is falling short of the current needs. Most of the environmental damage seen in the last fifty-odd years is because of the growing number of people on the planet. They include cutting down forests, hunting wildlife in a reckless manner, causing pollution, and creating a host of other problems.

2. Degradation of environment: The overuse of coal, oil, and natural gas has started producing some serious effects on our environment. Besides, the exponential rise in the number of vehicles and industries has badly affected the quality of air. The rise in the amount of carbon dioxide emissions leads to global warming. Melting of polar ice caps, changing climate patterns and rise in sea levels are a few of the consequences that we might have to face due to environmental pollution.

3. Rise in Unemployment: When a country becomes overpopulated, it gives rise to unemployment as there are fewer jobs to support a large number of people. The rise in unemployment gives rise to crime, such as theft, as people want to feed their families and provide them basic amenities of life.

4. Conflicts and wars: Overpopulation in developing countries puts a major strain on the resources to be utilized for development. Conflicts over water are becoming a source of tension among countries, which could result in wars. It causes more diseases to spread and makes them harder to control. Starvation is a huge issue that the world is facing, and the mortality rate for children is being fuelled by it. Poverty is the biggest hallmark we see when talking about overpopulation. All of this will only become worse if solutions are not sought out for the factors affecting our population.

5. High cost of living: As the difference between demand and supply continues to expand due to overpopulation, it raises the prices of various essential commodities, including food, shelter, and healthcare. This means that people have to pay more to survive and feed their families.

6. Malnutrition, Starvation and Famine: When the availability of resources is scarce, starvation, malnutrition, along with ill health and diseases caused by diet-deficiency such as rickets become more likely. Famine is typically associated with less- developed regions, and there is a high correlation with poverty levels.

7. Pandemics and Epidemics: Poverty is linked to many environmental and social reasons, including overcrowded and unhygienic living conditions, malnutrition and inaccessible, inadequate, or non-existent health care, by which the poor are more likely to be exposed to infectious diseases. Further, high densities of population increase the chance of the emergence of new pandemics and epidemics.

8. Water Shortage: Roughly 1% of the world‘s water is fresh and accessible. Overpopulation is a major issue that creates immense pressure on the world‘s freshwater supplies. As per a study, the human demand for freshwater would stand at approximately 70% of freshwater available on the planet by 2025. Therefore, people living in impoverished areas that already have limited access to such water will be at great risk.

9. Faster Climate Change: Overpopulation forces larger nations, like China and India, to continue to develop their industrial capacities. They now rank as two of the three largest contributors to emissions in the world, other than the United States. According to scientists, human activities are changing global temperatures. If more is not done to reduce individual carbon footprints on a wide scale, larger populations may speed these changes up.

10. Increased intensive farming: With the growth of population over the years, farming

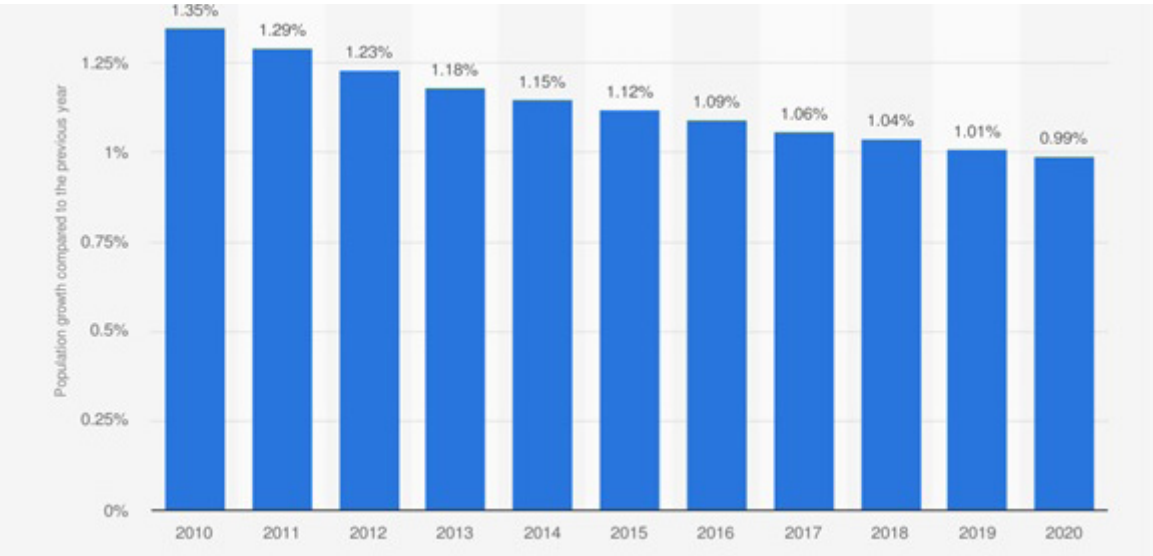

Fig 3.5.1 population growth statistics of India from 2010-2020

practices have evolved to produce enough food required to feed a larger number of people. However, this intensive farming methods cause damage to local ecosystem and the land may pose problems in the future. Furthermore, intensive farming is also contributing to climate change due to the machinery applied. If the population continues to grow at its current rate, this effect will likely intensify.

3.5.3 Population Explosion and its issues

In the year 2000, the world population was 6.3 billion and it is predicted to grow four times in the next 100 years. This unprecedented growth of human population at an alarming rate is referred to as population explosion. Population explosion is causing severe resource depletion and environmental degradation. Population explosion is the pyramiding of numbers of a biological population, especially the recent great increase in human numbers, resulting from increased survival and exponential population growth. Population explosion gives rise to a number of social problems. It leads to migration of people from rural areas to the urban areas causing the growth of slum areas. People live in most unhygienic and insanitary conditions. Unemployment and poverty lead to frustration and anger among the educated youth. The main effects of population explosion are the following:

1. Problem of Investment Requirement: Indian population is growing at a rate of 1.8 percent per annum. In order to achieve a given rate of increase in per capita income, larger investment is needed. This adversely affects the growth rate of the economy.

2. Problem of Capital Formation: Composition of population in India hampers the increase in capital formation. High birth rate and low expectancy of life means large number of dependents in the total population. In India 35 percent of population is composed of persons less than 14 years of age. Most of these people depend on others for subsistence. They are unproductive consumers. The burden of dependents reduces the capacity of the people to save. So the rate of capital formation falls.

3. Effect on per Capita Income: Large size

of population in India and its rapid rate of growth results into low per capita availability of capital.

4. Effect on Food Problem: Rapid rate of growth of population has been the root cause of the food problem.

5. Problem of Unemployment: Large size of population results in a large army of labour force. But due to shortage of capital resources it becomes difficult to provide gainful employment to the entire working population. Disguised unemployment in rural areas and open unemployment in urban areas are the normal features of an under developed country like India.

6. Low Standard of Living: Rapid growth of population accounts for low standard of living in India. Even the bare necessities of life are not available adequately.

7. Poverty: Rising population increases poverty in India. People have to spend a large portion of their resources for bringing up their wards. It results in less savings and low rate of capital formation. Hence improvement in production technique becomes impossible. It means low productivity of labour.

8. Population and Social Problems: Population explosion gives rise to a number of social problems. It leads to migration of people from rural areas to the urban areas causing the growth of slum areas. People live in most unhygienic and insanitary conditions. Unemployment and poverty lead to frustration and anger among the educated youth. This leads to robbery, beggary, prostitution and murder etc. Overcrowding, traffic congestions, frequent accidents and pollution in big cities are the direct result of over-population.

9. More Pressure on Land: Rising rate of population growth exerts pressure on land. On the one hand, per capita availability of land goes on diminishing and on the other, the problem of sub-division and fragmentation of holdings goes on increasing. It adversely affects the economic development of the country.

10. Pressure on Environment: Population explosion leads to environmental degradation. Higher birth rate brings more pollution, more toxic wastes and damage to biosphere. Briefly speaking, population explosion hinders the economic development. It should be controlled effectively.

Recap

- Overpopulation is an undesirable condition where the number of the existing human population exceeds the actual carrying capacity of Earth. Overpopulation is caused by a number of factors. Reduced mortality rate, better medical facilities, depletion of precious resources are few of the causes which result in overpopulation.
- Population growth refers to the increase in the number of individuals in a population in a particular year. The primary cause of population growth is an imbalance between births and deaths.
- Issues of population growth: Exacerbating food and water shortages, reducing resilience in the face of climate change, and making it harder for the most vul-

nerable communities to rise out of intergenerational poverty.

- Effects of population growth: Loss of biodiversity, air and water pollution and increased pressure on land. Excessive deforestation and overgrazing by the growing population have led to land degradation. It also leads to the cutting of forests for cultivation leading to several environmental change.
- Population explosion: It refers to the rapid increase in the number of people in an area. It is a situation where the economy of the country cannot cope with the rapid growth of the population.
- Effects of population explosion: Population explosion leads to environmental degradation. Higher birth rate brings more pollution, more toxic wastes and damage to biosphere. Population explosion hinders economic development.

Objective Type Questions

1. Which one is playing a major role in declining per capita agricultural land, forest and water resources?
2. Which one of the environmental segments is badly affected by the exponential rise in the number of vehicles and industries?
3. What was the main problem associated with the disparity between demand and supply continues to expand due to overpopulation?
4. What is the growth rate of Indian population?
5. What is the major reason behind the poverty?
6. Which one is normally associated with less-developed regions, and is having high correlation poverty levels?
7. How much quantum of world's water is fresh and accessible?
8. What is the growth of population expected in coming 100 years?

Answers to Objective Type Questions

1. Rapid population growth
2. Air quality
3. High cost of living
4. 1.8% per annum
5. Rising population
6. Famine
7. 1 %
8. Four times

Self Assessment Questions

1. Define population growth.
2. Write an essay on the effects of population growth.
3. What are the problems of intensive farming?
4. What is population explosion?
5. Connect population with social problems
6. How can poverty be related to pandemic and epidemic?
7. What are the factors affecting population growth?
8. Draw a relation between population growth and degradation of environment. Justify.

Assignments

1. Prepare composite bar graphs, one for India and the other for your respective states showing the proportion of male and female workers in agriculture, household industries and other sectors, and compare.
2. Give an account of the occupational structure of India‘s population.
3. Why do some states of India have higher rates of work participation than others?

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Unit 6
Sustainable Development

Learning Outcomes

- Learns about reconciling economic growth, environmental balance and social progress, ensuring that all people have the same opportunities and can lead a better life without compromising the planet
- Learns about building resilient infrastructure, promoting inclusive and sustainable industrialization and promoting innovation
- Learns about ensuring healthy lives and promoting well-being for every-one of all ages
- Learns about taking urgent action to combat climate change and its effects
- Ensure inclusive and fair education of good quality and promoting life long learning for everyone

Prerequisites

The recent estimates show that physical inactivity, linked to poor walkability and lack of access to recreational areas, accounts for 3.3% of global deaths, according to the World Health Organization. We should have access to green spaces for improved health and well-being, and even in the treatment of mental illness.

Some of prominent goals in the Sustainable Development Goals include No Poverty, Zero hunger (No hunger), Good health and well-being, Quality education, Gender equality, Clean water and sanitation, Decent work and economic growth, Reduced inequality etc. It would be a heaven to live on earth if these and other goals are achieved. Let us strive for the same.

The main features of SD are respect and care for all kinds of life forms; improving the quality of the human life; minimizing the depletion of natural resources; and enabling the communities to care for their own environment. Let us learn as to practice them.

Keywords

Sustainable development, Development goals, Principles, Concepts, Economic growth.

Discussion

What are the concepts of sustainable development? What are the issues covered under Sustainable Development Goals (SDGs)?

3.6.1 Sustainable Development

The concept of sustainable development was described by the 1987 Bruntland Commission Report as —development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Sustainable development is a way for people to use resources without the resources running out. There are four dimensions to sustainable development – society, environment, culture and economy – which are intertwined, not separate. Sustainability is a paradigm for thinking about the future in which environmental, societal and economic considerations are balanced in the pursuit of an improved quality of life. For example, a prosperous society relies on a healthy environment to provide food and resources, safe drinking water and clean air for its citizens. Sustainability is most often defined as meeting the needs of the present without compromising the ability of future generations to meet theirs. It has three main pillars:

Economic, environmental, and social- these three pillars are informally referred to as people, planet and profits. Sustainable development encourages us to conserve and enhance our resource base, by gradually changing the ways in which we develop and use technologies. These include social progress and equality, environmental protection, conservation of natural resources and stable economic growth

The main features of sustainable development are:

i. It respects and cares for all kinds of life forms.

ii. It improves the quality of the human life.

iii. It minimises the depletion of natural resources.

iv. It enables the communities to care for their own environment.

3.6.2 Principles of sustainable development

Sustainable development (SD) is one of the leading issues in the contemporary development discourse. It is an approach to development that takes the environmental dimension and which owes its origin to various debates and environmental movements in 1970s and 1980s regarding the connection between environment and economic development. The approach seeks to reconcile human needs and the capacity of the environment to cope with the consequences of the economic system so that these needs can be met not only in the present, but also for future generations. It holds that wealth of nations does not rest solely on its economic wealth but also on the smooth development and protection of environmental resources.

The major principle of the concept is that the natural resources should be used in a manner which does not eliminate or degrade them, or otherwise diminish their usefulness for future generations. However, the concept has been criticized as being vague and unattainable which is introduced by developed countries to protect capitalism and impede development of other countries. Others believed that the implementation of sustainable development would mean a reversion to pre-modern life styles.

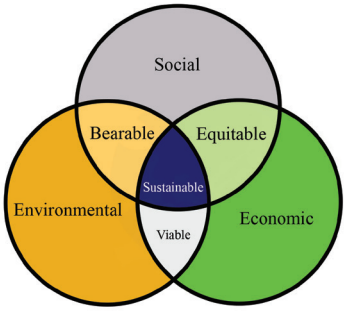

Fig 3.6.1 Elements of sustainable development

3.6.3 Sustainable Development

The principles of sustainable development are as follows:

i. Conservation of ecosystem.

ii. Development of sustainable society.

iii. Conservation of biodiversity.

iv. Control of population growth.

v. Development of human resources.

vi. Promotion of public participation.

3.6.4 Examples of Sustainable Development

1. Wind Energy:

Since the first windmill was built in Persia between 500 and 900 AD, people have used the power of the wind. In many areas in the 21st century, energy produced by wind power is now either less expensive than coal-generated electricity or on par with it. Due to their low cost and minimal land footprint, wind turbines are an excellent option for power generation. Wind energy production can coexist with other land uses like farming, conservation, and recreation. Wind energy can considerably complement or replace entire grid systems as the cost of wind power technologies continues to fall and energy storage and distribution infrastructure improves.

2. Solar Energy:

It is evident that there is a renewable energy revolution taking place in the world, and it is being driven by the sun. This revolution ranges from small rooftop solar panels to enormous solar farms that may achieve the same electricity production as a conventional power plant. The 94% of the pollution that a coal plant produces can be cut down by a solar farm. Additionally, it gets rid of harmful pollutants like mercury and sulphur nitrous oxides, which are important causes of the air pollution that causes millions of early deaths each year. In many places of the world, solar technology has become more affordable and is now cost-competitive with or less expensive than traditional power generation.

3. Crop Rotation:

Contrarily, crop rotation is defined as "the successive planting of various crops on the same ground to increase soil fertility and assist in controlling insects and illnesses." This method of farming is not new; rather, it is an older one that maximises the long-term growth prospects of the land while using no chemicals.

4. Water efficient fixtures:

We are starting to realise that water is not as unlimited as we originally thought because many nations throughout the world are experiencing water crisis. Showering, hand washing, and sewage transportation require necessary water usage that is unavoidable in the majority of buildings around the world. However, by using water-saving equipment and fittings, the amount of water needed for these fundamental services can be significantly decreased by more than 50%. Water-saving accessories include dual flush toilets, toilet stops, and low-flow faucets and showerheads. These devices can be readily and economically retrofitted into already-existing structures or requested for newer building projects.

5. Green Spaces:

: Urban areas must have green spaces, such as parks, marshland, lakes, forests, or other ecosystems, in order to be developed sustainably. While trees create oxygen and block out air pollution, these spaces are crucial for cooling cities.

In addition to providing safer locations for physical activity and pleasure, well-designed green spaces are essential for providing safer

routes for people travelling by foot or bicycle. Recent estimates reveal that lack of physical activity, linked to poor pedestrian space and lack of access to recreational places, contributes to 3.3% of global mortality, according to the World Health Organization. Exposure to green areas can therefore enhance health and wellbeing and even help alleviate mental illness.

These are only a handful of the many different types of sustainable development that could continue to promote good global change. The world is at a crossroads, and we still have time to change the course of global development toward one that is more ecological. As a result, it is necessary to alter the laws and policies that control development. In light of this, sustainable development will become not just the best and most practical option, but also the obvious one.

3.6.5 Sustainable Development Goals (SDGs)

The Sustainable Development Goals (SDGs), sometimes referred to as the Global Goals, were enacted by the United Nations in 2015 as a global call to action to eradicate poverty, safeguard the environment, and guarantee that by the year 2030, peace and prosperity will be experienced by everyone. In order to create a "blueprint to build a sustainable future for all," the Sustainable Development Goals (SDGs), also known as the Global Goals, are made of 17 interconnected international objectives. The UN General Assembly established the SDGs in 2015, with the goal of achieving them by the year 2030. The SDGs were created as part of the Post-2015 Development Agenda to replace the Millennium Development Goals, which were completed in 2015.

The 17 SDGs include: (a) No Poverty, (b) Zero Hunger, (c) Good Health and Well-being, (d) Quality Education, (e) Gender Equality, (f) Clean Water and Sanitation, (g) Affordable and Clean Energy, (h) Decent Work and Economic Growth, (i) Industry, Innovation and Infrastructure, (j) Reducing Inequality, (k) Sustainable Cities and Communities, (l) Responsible Consumption and Production, (m) Climate Action, (n) Life Below Water, (o). Life On Land, (p) Peace, Justice, and Strong Institutions, (q) Partnerships for the Goals.

Fig: 3.6.2 Sustainable Development Goals (Source: sciencedirect.org)

Goal 1: No Poverty

"End poverty in all its forms everywhere," states SDG. By 2030, if SDG 1 is achieved, severe poverty would be eradicated worldwide. The objective comprises seven targets and 13 indicators to track its progress. The five 'outcome targets' are: eliminating extreme poverty; cutting down the rate of poverty overall; putting social protection systems in place; guaranteeing equal access to property, essential services, technology, and financial resources; and enhancing resilience to natural, man-made, and interpersonal disasters. Mobilizing resources to eliminate poverty and creating frameworks for policy on eradicating poverty at all levels are the two aims related to "means of achieving" SDG 1.

Goal 2: Zero hunger (No hunger)

Ending hunger, achieving food security, enhancing nutrition, and promoting sustainable agriculture are the goals of SDG 2. Eight goals and fourteen indicators are included in SDG 2 to track progress. The five "outcome targets" are: 1) eradicating hunger and enhancing access to food; 2) eradicating all forms of malnutrition; 3) crop production; 4) resilient agricultural practises and sustainable food production systems; and genetic variation of seeds, cultivated plants, and farm animals; 5) investments in research and technology. Addressing trade barriers, market distortions in global agricultural markets, and food commodity markets and their substitutes are among the three "ways of achieving" aims.

Goal 3: Good health and well-being

"Ensure healthy lives and promote well-being for all at all ages" is the goal of SDG 3. SDG 3 comprises 28 indicators and 13 targets for tracking progress. "Outcome targets" are the first nine targets.

They are: 1) reducing maternal mortality and eliminating all preventable infant deaths, 2) combating communicable diseases, 3) ensuring a decline in non-communicable disease mortality, 4) promoting mental health, 5) preventing and treating substance abuse, 6) reducing traffic fatalities and injuries, 7) ensuring universal access to family planning services, 8) achieving universal health coverage, and 9) reducing illnesses and deaths from toxic substances and pollution.

The four "means to achieve" SDG 3 aims are 1) to implement the WHO Framework Convention on Tobacco Control, 2) promote research, development, and cheaper access to vaccinations and medications, 3) boost health financing and support for the medical workforce in developing nations, and 4) upgrade early warning systems for global health threats.

Goal 4: Quality education

The purpose of SDG 4 is to "provide inclusive and equitable quality education and encourage opportunities for lifelong learning for everyone." Ten targets in SDG 4 are monitored by 11 indicators. The seven "outcome-oriented targets" are: universal literacy and numeracy; free primary and secondary education; equal access to high-quality early childhood education; affordable technical, vocational, and higher education; increased numbers of people with skills necessary for financial success; elimination of all forms of discrimination in education; and education for sustainable development and global citizenship. The three "ways of accomplishing targets" are to construct and improve inclusive and secure schools, raise the number of higher education scholarships available to developing nations, and boost the availability of competent instructors in such nations.

Goal 5: Gender equality

SDG 5 states that all women and girls should be empowered. The "Leave No One Behind"

pledge, which strives to give women and girls equal rights and opportunity to live free of discrimination, including job discrimination and any violence, commits nations to accelerating development for those who are most in need. The goal of this is to empower all women and girls and achieve gender equality.

Goal 6: Clean water and sanitation

SDG 6 states that "Water and sanitation for all will be available, and shall be managed sustainably." Eleven indicators are used to assess the eight targets. The six "outcome-oriented targets" are: Safe and reliable drinking water; stopping open defecation and provide access to sanitation and hygiene; improving water quality, wastewater treatment, and safe reuse; increasing water-use efficiency and ensuring freshwater supplies; implementing IWRM; and protecting and restoring ecosystems that are related to water. The two "ways of achieving" objectives are to boost local participation in water and sewage management and increase water and sanitation assistance to developing nations.

Goal 7: Affordable and clean energy

SDG 7 states that "Ensure that all people have access to sufficient, cheap, modern, and sustainable energy." By 2030, the goal's five targets must be met. Six indicators are used to evaluate success in achieving the goals. Out of the five objectives, three are "outcome targets": Increasing access to modern energy, an increase in the worldwide share of renewable energy, and a multiplication of energy efficiency advancements. The final two goals are "means of attaining goals" and include expanding and improving energy services for poor nations as well as promoting access to research, technology, and investments in clean energy. These goals include expanding the use of renewable energy while ensuring that everyone has access to inexpensive and dependable electricity. This would entail increasing energy efficiency and international cooperation to promote greater open access to clean energy technology and increased investment in clean energy infrastructure.

Goal 8: Decent work and economic growth

SDG 8 states that we must "promote sustained, inclusive and sustainable economic growth, full and productive employment, and decent work for all." By 2030, SDG 8 must complete a total of twelve tasks. A few goals are set for 2030, while others are for 2020. The first ten are "outcome targets", which are the promotion of policies that support job creation and expanding businesses; the improvement of resource utilization in production and supply; full employment and decent work with wage equality; the elimination of modern day slavery, smuggling, and child labour; the protection of labour rights and the promotion of safe working environments; and the promotion of beneficial and sustainable tourism. Morever, there exists two targets for "means of achieving": boost trade support through aid; create a worldwide youth employment plan.

Goal 9: Industry, Innovation and Infrastructure

SDG 9 states that we must encourage innovation, advance inclusive and sustainable industrialization, and build resilient infrastructure. SDG 9 includes eight targets, and twelve indicators to track progress. The first five targets are "outcome objectives": Increase financial services and markets access; create sustainable, inclusive, and resilient infrastructures; modernise all sectors of the economy and infrastructure; expand scientific research; and advance industrial technology. The latter three targets are "means of accomplishing" objectives: Supporting domestic technological development, industry diversification, and ensuring that everyone has access to information and communications technologies, can help emerging nations build sustainable infra-

structure.

Goal 10: Reduced inequality

SDG 10 proposes to reduce income disparity both inside and across countries . Ten targets under the Goal must be completed by 2030. Indicators will track how well we are doing in relation to our goals. "Outcome targets" are the first seven objectives: They are to r educe income disparities; encourage universal social, economic, and political inclusion; guarantee equal treatment and eliminate discrimination; adopt social and fiscal policies that promote equality; improve global financial market and institution regulation; increase representation of developing nations in financial institutions; and implement responsible and well-managed immigration rules. The last three goals are "means of achievement" goals: stimulate development aid and investment in least developed countries; lower transaction costs for migrant remittances; and special and differential consideration for developing countries.

Goal 11: Sustainable cities and communities

The main objective of SDG 11 is to make cities and human settlements inclusive, secure, resiliant, and sustainable is . SDG 11 has 10 goals that must be met, and 15 indicators are used to track progress. The seven "outcome targets" are: providing access to safe and inclusive green spaces, affordable and sustainable transportation options, inclusive and sustainable urbanisation, protecting the world's natural and cultural heritage, reducing the negative effects of natural disasters, and reducing the environmental effects of cities. The three "means of accomplishing" the aims are: implementing policies for inclusiveness, resource efficiency, and catastrophe risk reduction; and assisting the least developed nations in developing structures that are sustainable and resilient.

Goal 12: Responsible consumption and production

SDG 12 states to "Ensure sustainable consumption and production patterns." The goal's 11 targets include implementing the 10-Year Framework of Programs on Sustainable Consumption and Production Patterns, achieving sustainable management and efficient use of natural resources, reducing by half the amount of food wasted per person globally at the retail and consumer levels, and reducing food wastage along production and supply chains, including post-harvest losses; reducing waste generation through waste prevention, reduction, recycling, and reuse; encouraging businesses to adopt sustainable practises; promoting sustainable public procurement practises; and ensuring that everyone has access to the necessary information and awareness for sustainable development. The three "means of achieving" goals are to assist developing nations in enhancing their technological and scientific capabilities, create and use tools to track the effects of sustainable development, and eliminate market distortions like fossil fuel subsidies that promote wasteful consumption.

Goal 13: Climate action

SDG 13 urges to "take urgent action to combat climate change and its impacts by regulating emissions and promoting developments in renewable energy." The goals address a variety of climate change-related topics. There are a total of five targets. "Output targets" are the first three objectives: Build knowledge and capacity to deal with climate change; increase resilience and adaptability to climate-related disasters; and incorporate climate change initiatives into policies and plans. The latter two objectives are "means of accomplishing" objectives: the UN Framework Convention on Climate Change must be put into action, and procedures to improve planning and man-

agement capacity must be encouraged. The main worldwide, intergovernmental platform for discussing the world's response to climate change is the United Nations Framework Convention on Climate Change (UNFCCC).

Goal 14: Life below water

SDG 14 demands that "oceans, seas, and marine resources will be conserved and sustainably used for sustainable development." "Outcome targets" are the first seven objectives: Increase the economic benefits from the sustainable use of marine resources while reducing marine pollution, protecting and restoring ecosystems, reducing ocean acidification, practising sustainable fishing, conserving coastal and marine areas, and eliminating incentives that encourage overfishing. The following three goals are "means of achieving" goals: increasing scientific understanding, research, and technology for the health of the oceans; assisting small-scale fishermen; and implementing and upholding international maritime law.

The world's population relies on the oceans and fisheries to meet its economic, social, and environmental demands. The planet's life comes from the oceans, which also control the temperature on a worldwide scale. They include approximately a million recognised species, making them the biggest ecosystem in the world. The 97% of the water on the globe is found in the oceans, which also cover more than two thirds of its surface. They are necessary to making the world habitable. Ocean temperatures and currents control climate, precipitation, and drinking water. The livelihood of more than 3 billion people depends on marine life. However, since the industrial revolution, acidification has increased by 26%. To advance the sustainable use of oceans, effective mitigation measures for the negative effects of increased ocean acidification are required.

Goal 15: Life on land

SDG 15 is intended for protecting, restoring, and promoting sustainable use of ecological systems, managing forests sustainably, preventing desertification, and halting biodiversity loss. The nine "outcome targets" are as follows: Protect access to genetic resources and equitable benefit sharing, conserve and restore terrestrial and freshwater ecosystems, stop deforestation and restore degraded forests, stop desertification and restore degraded land, guarantee the preservation of mountain ecosystems, prevent invasive alien species from invading terrestrial and aquatic ecosystems, and integrate ecosystem and biodiversity management. The three ways of attaining aims are to increase financial resources to protect and sustainably use ecosystems and biodiversity; finance and incentivise sustainable forest management; and combat global wildlife hunting and trafficking.

Ocean and Earth are essential to human existence. This specific objective strives to ensure sustainable livelihoods that can be enjoyed for many generations. About 80% of human food is made up of plants, hence agriculture is a huge economic resource. Forests encompass 30% of the Earth's surface by providing habitat for millions of species, significant sources of clean air and water, and become essential for preventing climate change.

Goal 16: Peace, justice and strong institutions

SDG 16 states that "peaceful and inclusive societies for sustainable development, access to justice for all, and the development of effective, responsible, and inclusive institutions at all levels" are to be promoted. Ten "outcome targets" make up the goal, and they are: Promote the rule of law and equal access to justice; combat organised crime and illicit financial and weapons flows; significantly reduce

corruption and bribery; develop effective, accountable, and transparent institutions; ensure responsive, inclusive, and representative decision-making; strengthen involvement in international governance; provide universal legal identity; ensure public safety; reduce crime; protect children from abuse, exploitation, trafficking, and violence. Additionally, there are two "means of achieving targets": promote and uphold non-discriminatory laws and policies; and strengthen state institutions to deter violence and fight crime and terrorism.

Goal 17: Partnership for the goals

Strengthening the methods of implementation and reviving the global collaboration for sustainable development are the goals of SDG 17. There are 24 indicators and 19 outcome targets for this goal. Each of the 16 earlier goals is thought to require greater international collaboration. Goal 17 is included to ensure that nations and organisations work together rather than against one another. The achievement of the SDGs as a whole is thought to depend on the creation of multi-stakeholder collaborations to share knowledge, skills, technology, and financial support. Enhancing North-South and South-South collaboration is one of the objectives, and public-private partnerships with civil societies are especially addressed.

Implementation of SDGs

The SDGs began to be implemented globally in 2016. The SDGs can also be "localised" in this way. Individuals, institutions, governments, and organisations of various types work independently toward one or more goals at once. Each government must create its own budget, plan of action, and national legislation to implement the goals. However, they must also be willing to consider and actively seek partners at the same time. The importance of global coordination makes alliances valuable. The SDGs state that collaborations with wealthier nations are necessary for developing countries with limited access to financial resources.

Recap

- Sustainable development is defined as an approach to developing or growing by using resources in a way that allows for them to renew or continue to exist for others. Using recycled materials or renewable resources when building is an example of sustainable development.
- Sustainable development is important as it saves national budget, fulfils the need of people, conserves natural resources, helps in the coordination between the natural resources and people and conserves natural resources for future generations.
- Principles of sustainable development: Firstly, the need for socio-economic development and secondly, need of limitation imposed on the environment's capability to cope with the present and future requirements.
- Six core principles of sustainability
    - o Respect and care for all forms of life.
    - o Improve the quality of human life.
    - o Conserve the earth's vitality and diversity.

- Minimize the depletion of natural resources.
- Change personal attitudes and practices toward the environment.
- Enable communities to care for their own environment.

▶ Sustainable Development Goals

The 17 SDGs are: (1) No Poverty (2) Zero Hunger (3) Good Health and Well-being 4) Quality Education (5) Gender Equality (6) Clean Water and Sanitation (7) Affordable and Clean Energy (8) Decent Work and Economic Growth (9) Industry, Innovation and Infrastructure (10) Reduced Inequality (11) Sustainable Cities and Communities (12) Responsible Consumption and Production (13) Climate Action (14) Life Below Water (15) Life On Land (16) Peace, Justice, and Strong Institutions (17) Partnerships for the Goals.

Objective Type Questions

1. According to Census 2011, what was the population growth rate of India from 2001 to 2011?
2. What is the reason for poor standard of living and malnutrition in India?
3. What is the need to control population growth in India?
4. Which state in India has the largest population as per 2011 Census?
5. A phenomenon that occurs when a species' population becomes larger than the carrying capacity of its environment is known as…..
6. What is responsible for fluctuation in population density?
7. Which state in India has the lowest population growth rate?

Answers to Objective Type Questions

1. 17.72%
2. Over population
3. To improve the standard of living among existing people.
4. Uttar Pradesh
5. Overpopulation
6. Natality
7. Kerala

Self Assessment Questions

1. The concept of sustainable development was described by the …… .
2. Define Sustainable Development.
3. Which are the four dimensions of Sustainable Development?
4. What are the main features of Sustainable Development?
5. What are the principles of Sustainable Development?
6. Write an essay on the examples of Sustainable Development.
7. What are green spaces?
8. What are Sustainable Development Goals (SDGs)? How many SDGs are there?
9. Write an essay of Sustainable Development Goals.

Suggested Reading

Read sample narrative essays to understand the structure and features of sustainable development

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BLOCK - 04

Environmental Ethics and Contemporary Environmental Issues

Unit 1
Concept of Environmental Ethics

Learning Outcomes

- Gets an awareness on ethics in environmental sciences.
- Learns about the inter linkages between the key terminologies in environmental ethics.
- Distinguish between environmental equity and environmental equality.
- Develops a sense of social and food security in our environment.

Prerequisites

Have you heard of the word "anthropocentricism"? It means human centred. Human beings consider themselves superior to all the creatures in the world and that they are the roof and crown of all creations. It is an illusion that has led to all the perils and destruction in the world. Now we have realised the dangers of such false dogmas. The world has begun to think of Environmental ethics that studies the moral relationship of human beings to, and also the value and moral status of, the environment and its non-human contents. The unit will shed light on different concepts like Biocentrism, Ecocentrism, Eco-feminism, Environmental Equity, and Environmental justice.

Keywords

Environmental ethics, Anthropocentrism, Biocentrism, Ecofeminism, Environmental equity, Food security.

Discussion

4.1.1 The Concept of Environmental Ethics

What do you mean by ethics? Is there a need for ethics in environment?

Environmental ethics is the part of environmental philosophy which considers extending the traditional boundaries of ethics from solely including humans to including the nonhuman world. It exerts influence on a large range of disciplines including law, sociology, theology, economics, ecology, and geography. Environmental ethics says that we should base our behaviour on a set of ethical values considering

other living beings in nature. It is about including the rights of nonhuman animals in our ethical and moral values. Environmental ethics believes that humans are a part of society just like other living creatures, which includes plants and animals. Environmental ethics is a key feature of environmental studies that establishes the relationship between humans and the earth. With environmental ethics, you can ensure that you are doing your part to keep the environment safe and protected.

4.1.2 Anthropocentrism

We humans believe that we are above all the other creatures. Do you think it is correct?

Anthropocentrism refers to a human-centred, or "anthropocentric," point of view. In philosophy, anthropocentrism can refer to the view that humans are the only, or primary, holders of moral standing. This is a basic belief in many western religions and philosophies. Anthropocentrism regards humans as separate from other organisms and superior to nature. According to this, humans alone has the intrinsic value for life.

Thus, anthropocentric views can be used to justify unlimited violence against the nonhuman world. However, it should also be noted that such violence does not follow as a logical necessity.

Some environmental ethicists argue that critics of anthropocentrism are misguided or even misanthropic. They contend: first that criticism of anthropocentrism can be counterproductive and misleading by failing to distinguish between legitimate and illegitimate human interests. Second, that humans differ greatly in their environmental impacts, and consequently, addressing human inequalities should be a precondition for environmental protection. Third, since ecosystems constitute the "life-support system" for humans, anthropocentrism can and should be a powerful motivation for environmental protection. Fourth, human self-love is not only natural but helpful as a starting point for loving others, including nonhumans.

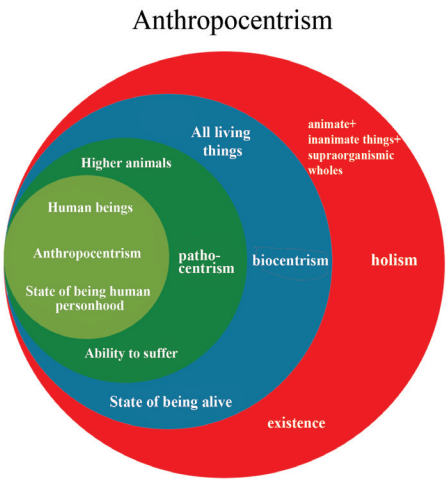


Fig: 4.1.1 Anthropocentrism model

4.1.3 Biocentrism

Biocentrism is the ethical perspective holding that all life deserves equal moral consideration or has equal moral standing. Although elements of biocentrism can be found in several religious traditions, it was not until the late decades of the 20th century that philosophical ethics in the western tradition addressed the topic in a systematic manner.

In order to promote environmentalism, it is crucial to understand how moral standing can be linked with values related to preserving the natural world. First, biocentrism results from a desire to avoid hurting sentient beings (those organisms which can perceive pleasure and pain) (e.g., harbouring concerns about killing animals). Second, biocentrism originate from a desire to uphold purity in nature. Avoiding harm and preserving purity have been identified as two separate forms of moral concern that rely on functionally distinct systems of cognitive and emotional processing.

When biocentrism is focused on avoiding harm, it is primarily aimed to protect sentient and humanized entities rather than other non-human entities, Biocentrism operates on general level rather than focussing on individual entities. A purity-based biocentrism is moderated by individual differences in spirituality and individual tendencies to treat certain objects as possessing more inherent value. In 1986, Paul Taylor published 'Respect for Nature', a treatise that is considered to be the first rigorous, philosophical defence of biocentric ethics. This book provided four basic principles that outline what Taylor termed a 'biocentric outlook' on life:

1. Humans are equal members of the earth's community of life.

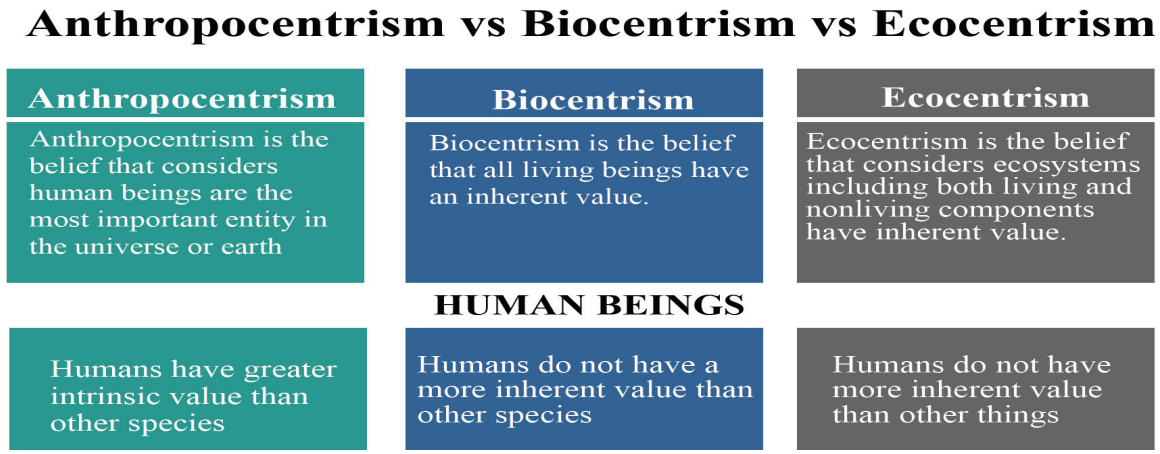
2. Humans and members of other species are interdependent.

3. All organisms are centres of life in the sense that each is a unique individual pursuing its own good in its own way.

4. Humans are not inherently superior to other living things.

4.1.4 Ecocentrism

Ecocentrism is the belief that ecosystems, including all things (living and nonliving), have inherent value regardless of their usefulness or importance to human beings. Therefore, ecocentrism recognizes a nature centred system of values. It recognizes the value of biodiversity over the value of single species. Similar to biocentrism, ecocentrism opposes anthropocentrism. However, unlike biocentrism and anthropocentrism, ecocentrism tends to include abiotic factors in the ecosystems under moral consideration. In other words, ecocentrism places importance on the ecosystem as a whole. It considers both living components and non-living components equally important, especially when making decisions regarding the environment. Unlike anthropocentrism, it places no special importance on human beings. Ecocentrism is only concerned with humans when considering how human beings influence the ecosystem as a whole. If we take the above example of climate change again, ecocentrists might also consider changes in abiotic factors like changing seas levels, ocean acidity, and weather patterns. Ecocentrism has a more holistic approach than biocentrism as it gives value to species, ecosystems, or the environment as a whole. In contrast to biocentrism, ecocentrism also uses abiotic factors or ecological components in nature to demonstrate the importance of non-living elements of the environment.



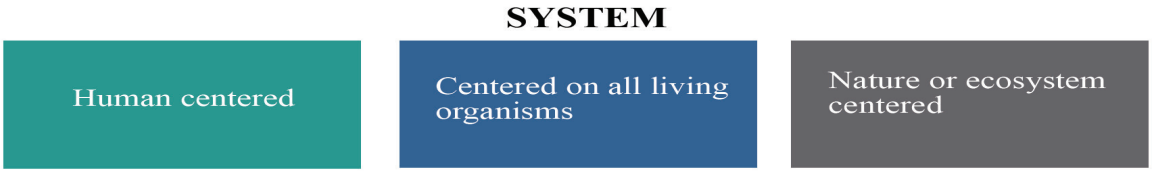


Fig : 4.1.2 Difference between Anthropocentrism, Biocentrism and Ecocentrism

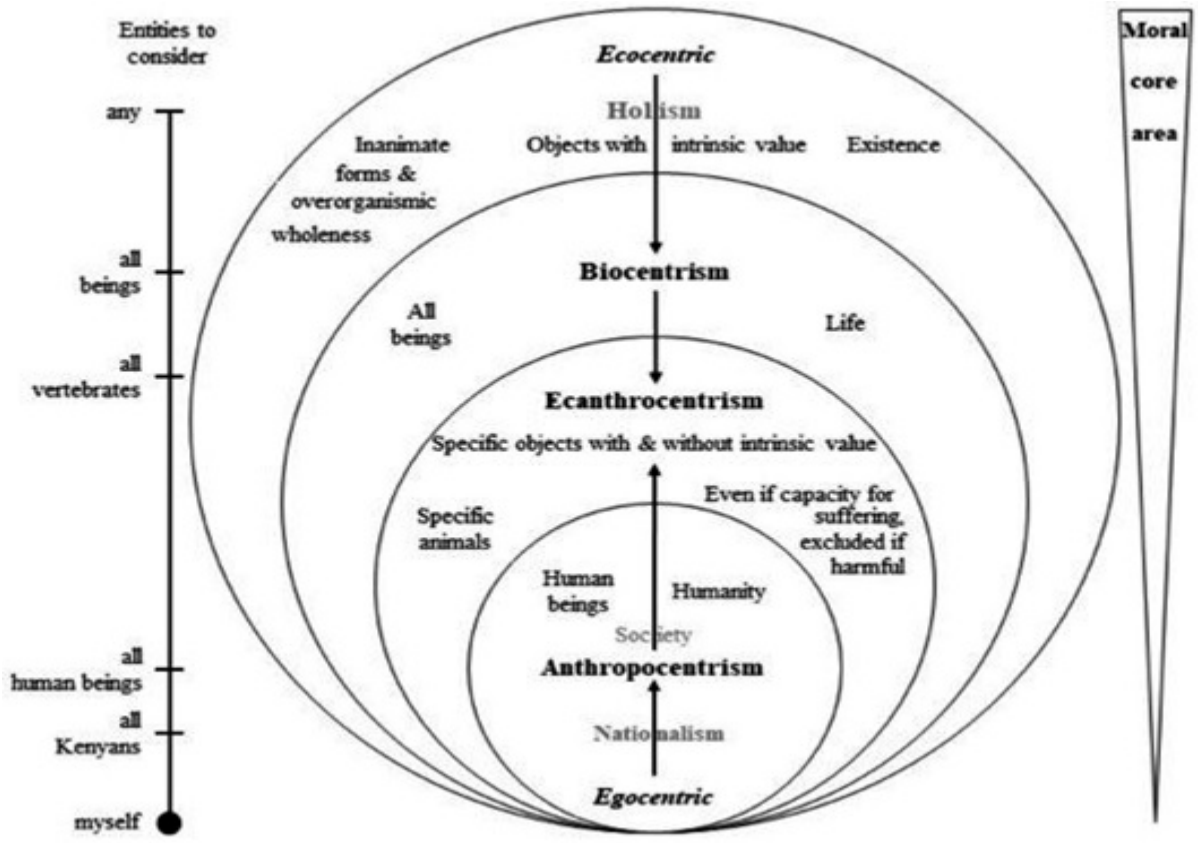


Fig: 4.1.3 Concept of Anthropocentrism, Biocentrism and Ecocentrism

4.1.5 Ecofeminism

Does our society give equal rights to women? What do you think?

The term eco-feminism was coined by Françoise d'Eaubonne, a French writer in 1974. This concept basically can be divided into two words namely 'eco' and 'feminism'. The term eco is related to 'natural' or 'environment' whereas the term 'feminism' is related to women. Eco-feminism put forward the idea that nature and women are significantly related to each other in terms of the similarities that they display.

The fundamental features of eco-feminism are as follows –

1) Women and nature share a special relationship. Hence women have an important stake in ending the exploitation of nature and conserving the environment.

2) There are important connections between

the domination over women and the exploitation of nature.

3) These connections can be traced ideologically to patriarchal thought which sees nature as inferior to culture. Since women are identified with nature, they are considered inferior and men identified with culture, are considered superior.

4) This change can be brought about through a reconceptualization of the relations between women, men and nature in non-hierarchical ways.

There are certain important similarities between women on one hand and nature on the other hand. Eco-feminists believe that both women and nature possess a reproductive or a regenerative capacity. In other words, a co-relation is taken into consideration between the life support system of nature and women's inborn life support systems. Another important similarity between nature and women is the nurture that they provide, women are largely responsible for the upbringing of children by providing them with love and care. In the same manner nature is also responsible for providing maintenance and survival to its different components. Apart from these two similarities, a third important source of the similarity between nature and women lies in the exploitation of both by men. It is human being and especially men who have been responsible for the degradation and exploitation of nature or environment. They have placed nature on an inferior level. Similarly, women have also been dominated and exploited by men and are given inferior status in the society. It is this similarity between the nature and women which lead to the emergence of the concept of eco-feminism.

The important fundamentals of eco-feminism are:

1) There is an important connection between the exploitation of women and exploitation of nature. The central insight of ecofeminism is that a historical, symbolic and political relationship exists between the degradation of nature and women.

2) Because women are identified with nature, women and nature have special relationship. Hence women have an important role in ending the degradation of nature and conserving the environment.

3) The suppression of women and nature can be understood in terms of the patriarchal ideology. According to it, nature is considered inferior to culture. Women are identified with nature and hence are considered inferior. On the other hand, men are identified with culture and therefore are considered superior.

4) The feminist movements and the environmental movements then become co-related because both stand for egalitarian (equal) and non-hierarchical principles. If they work together and develop a common perspective, changes can be brought about in the relationship of men with both nature and women. Since women and nature are placed below men, it is necessary to bring about a change. According to eco-feminism it is necessary for women and men to re-conceptualize their relations with one another and to nature in non-hierarchical (not divided into various layers of importance) ways.

5) Eco-feminism represents the combination of a radical ecology movement known as the deep ecology on one hand and feminism on the other. Deep ecology focuses on the destructive human patterns related to nature and replaces it with an constructive culture. Feminism also concentrates on eliminating the destructive cultural norms and practices, norms related to women and replacing them with freedom, individualism and democratic right for women. It is necessary to create consciousness regarding male monopolization of resources and power and replacing it with

an egalitarian approach. Thus, feminism and deep ecology show inter-connectedness.

6) The males are associated with aspects such as rationality, assertiveness, culture autonomy etc. On the other hand, the females are associated with aspects such as emotions, connectedness, nature, respectively. All these assumptions are result of a patriarchal mentality where the aspects associated with men are considered superior and those associated with women are considered as inferior. The patriarchal tendency also believes that nature and women are to be controlled by the males.

4.1.6 Environmental equity and justice

Do you think our society is providing equal rights to all classes?

Environmental Equity is the equitable distribution of the environmental burden, disaster hazards and pollution on all forms of social, economic and political sectors. This concept evolves on the premise that no single community should have privilege over other communities in facing environmental disturbances or crisis. The concept of Environmental Equity is derived from two words; Environment and Equity. Environment means the sum total of the surroundings of a living organism. The environment provides development and growth for both living and non-living beings. Equity is linked with Equality and it is based on the concept of an Egalitarian society. Thus, Environmental Equity is based on the principle that all people in this world are equal and deserve equal rights and opportunities to enjoy the benefits of the environment around us regardless of any disparity. Environmental equity is a basic human right.

Environmental equity can be broken down into two categories-fair treatment and meaningful involvement. Fair treatment means that no single sector of the population should be disproportionately affected by environmental crises as a result of laws or policies. Meaningful involvement means that groups can offer input regarding decisions that affect their health or their environment. This involvement also means that their input will be taken seriously and considered when making said decisions.

Environment Justice is a basic human right. The goal is just and fair treatment and involvement of all the people of all the communities in implementation and development of environmental laws, rules and policies regardless of origin, race, class, and nationality. The goal of environmental justice is achieved when everyone enjoys the same degree of protection against environmental hazards, pollution and each individual has a role in decision making which is significant for protecting the environment. The health of a community suffers when people do not have access to a healthy home, food, transportation fresh air, etc. Environmental Justice is important because it is a human right and everyone in this world deserves to live a healthy life. It is also the process of setting standards and laws for protecting the communities which are at risk due to the dumping of toxic waste and pollutants in their nearby locality. It also provides grants to the organizations that act on protecting these communities from risk.

Food security and social security

Food insecurity refers to both the inability to secure an adequate diet today and the risk of being unable to do so in the future. Food Security means that all people at all times have physical and economic access to adequate amounts of nutritious, safe, and culturally appropriate foods, which are produced in an environmentally sustainable and socially just manner People are able to make informed decisions about their food choices. Food Security also means that the people who produce our

food are able to earn a decent living. At the core of food security is access to healthy food and optimal nutrition for all. Food access is closely linked to food supply, so food security is dependent on a healthy and sustainable food system. The food system includes the production, processing, distribution, marketing, acquisition, and consumption of food.

Sustainable Food Systems

A healthy, sustainable food system is one that focuses on Environmental Health, Economic Vitality, Human Health & Social Equity.

- Environmental Health – ensures that food production and procurement do not compromise the land, air, or water now or for future generations.
- Economic Vitality – ensures that the people who are producing our food are able to earn a decent living wage doing so. This ensures that producers can continue to produce our food.
- Human Health & Social Equity – ensures that particular importance is placed on the health of the community, making sure that healthy foods are available economically and physically to the community and that people are able to access these foods in a dignified manner.

4.1.7 Social Security

Social Security is a concept comprising a menu of policy instruments that addresses poverty and vulnerability. It represents basically a system of protection of individuals who are in need of such protection by the State as an agent of the society. Such protection is relevant in contingencies such as retirement, resignation, retrenchment, death, disablement which are beyond the control of the individual members of the Society. Humans are born differently, they think differently and act differently. State as an agent of the society has an important mandate to harmonise such differences through a protective cover to the poor, the weak, the deprived and the disadvantaged. The concept of social security is now generally understood to mean protection provided by the society to its members through a series of public measures against the economic and social distress 'Social Security' has been recognized as an instrument for social transformation. Social security organised on a firm and sound basis will promote progress, since men and women benefit from increased security and are free from anxiety, they will become more productive. There is considerable controversy about the social and economic effects of social security, and most of the current debate is focused on its supposedly negative effects. Social Security is said to discourage people from working and saving and to encourage people to withdraw from the labour market prematurely. On the other hand, social security can also be seen to have a number of very positive economic effects. It can help to make people capable of earning an income and to increase their productive potential; it may help to maintain effective demand at the national level; and it may help create conditions in which a market economy can flourish, notably by encouraging workers to accept innovation and change. Social Security in India was traditionally the responsibility of the family/community in general. With the gradual process of industrialization/urbanization, breakup of the joint family set up and weakening of family bondage, the need for institutionalized arrangement to address the problem in a planned manner.

Recap

- Environmental ethics is the discipline in philosophy that studies the moral relationship of human beings to, and also the value and moral status of, the environment and its non-human contents.
- Philosophical discipline that specifies proper human relationships to the natural world.
- Anthropocentrism- Position that only human beings have moral worth or intrinsic value.
- Biocentrism- Position that all living beings have moral worth or intrinsic value.
- Ecocentrism is the belief that ecosystems, including all things (living and nonliving), have inherent value regardless of their perceived usefulness or importance to human beings.
- Eco-feminism is the idea that nature and women are significantly related to each other in terms of the similarities they display.
- The Environmental Equity is the equitable distribution of the environmental burden, disaster hazards and pollution on all forms of social, economic and political communities.
- Environmental Justice- when everyone enjoys the same degree of protection against environmental hazards pollution and each individual hasa role in decision making which is significant for the protecting environment
- Food insecurity refers to both the inability to secure an adequate diet today and the risk of being unable to do so in the future.
- Social security is a menu of policy instruments that addresses poverty and vulnerability, through social assistance, social insurance and efforts at social inclusion.

Objective Type Questions

1. Define environmental ethics?
2. Who are more important in anthropocentrist view?
3. When did ecofeminist movement emerge?
4. Define environmental equity?
5. What is ecosystem-based model of human ecology?
6. What is the notion of Anthropocentrism ?

Answers to Objective Type Questions

1. Environmental ethics is the discipline in philosophy that studies the moral relationship of human beings to, and also the value and moral status of, the environment and its non-human contents.
2. Humans
3. 1970
4. Environmental Equity is the equitable distribution of the environmental burden, disaster hazards and pollution on all forms of social, economic and political communities.
5. The relationship of specific human populations to specific ecosystems
6. Humans being are the most important entity in the world

Self Assessment Questions

1. Define Environmental Ethics. What is the need of it?
2. Write short note on Anthropocentrism with examples.
3. What is biocentrism?
4. What are the basic principles of biocentric outlook?
5. ……no special importance on human beings.
6. Discuss on the holistic approach of ecocentrism.
7. Compare between anthropocentrism, biocentrism and ecocentrism.
8. Write an essay on ecofeminism.
9. Comment on environmental equity and justice.
10. Write a short note on social security.

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Unit 2
Overview of Solid Waste Segregation and Management

Learning Outcomes

- Gets awareness on how to collect, treat and dispose solid waste we see around us.
- Get introduced to the idea of Zero Waste.
- Distinguish between macro and micro plastics in the environment.
- Gets aware of the environmental consequences of plastics and waste on the surrounding.

Prerequisites

Have a closer look at our surrounding and see the different types of waste generated. It is pathetic that the places we inhabit have become focus points of waste dumbing. We encounter waste garbage almost on all public roads and remote corners. This really worries and torments us. It is another common sight in India that people burn these waste matter causing pollution and dismay.

Plastics have become the menace of the day. The direct consequences of the ingestion of micro plastics include obstruction of the digestive tract and internal injury, frequently leading to reduced food consumption and concomitant decreased nutrition. This potentially results in starvation and death. In air -breathing organisms, micro plastics have been described to lodge in gills, which may translate into reduced respiration rates.

It is high time that we adopted strategies and techniques for zero waste. A zero waste approach conserves natural resources and reduces pollution from extraction, manufacturing and disposal. Reduce, Reuse, Recycle and Refuse are what we need for a safe and healthy living.

Keywords

Solid waste management, Zero waste, Microplastics, Incineration, Land filling, Composting.

Discussion

Have a closer look at our surrounding and see the different types of waste generated. Have you ever wondered how these wastes are managed?

4.2.1 Solid waste management

Solid waste refers to the range of garbage materials arising from plant, animal and human activities that are discarded as unwanted and useless. Solid waste is generated from industrial, residential, and commercial activities in a given area. The effective measures on how the solid waste will be managed is called as Solid Waste Management system or processes.

4.2.2 Functional Elements of the Waste Management System

There are six functional components of the waste management system, as outlined below:

1. Waste generation: This encompasses any activity involved in identifying materials that are no longer usable and are either gathered for systematic disposal or thrown away.

2. Onsite handling, storage, and processing: Storage is a system for keeping materials after they have been discarded and prior to collection and final disposal. This relates to activities at the point of waste generation, which facilitate easier collection. Improved storage facilities include:

- Small containers: household containers, plastic bins, etc.
- Large containers: communal bins, oil drums, etc.
- Shallow pits

3. Waste collection: This includes activities such as placing waste collection bins, collecting waste from those bins, and accumulating trash in the location where the collection vehicles are emptied. Although the collection-phase involves transportation, this is typically not the main stage of waste transportation Any collection system should be carefully planned to ensure that storage facilities do not become overloaded. Collection intervals and volumes of collected waste must be estimated carefully.

4. Waste transfer and transport: These are the activities involved in moving waste from the local waste collection locations to the regional waste disposal site in large waste transport vehicles. This is the stage when solid waste is transported to the final disposal site. There are various modes of transport which may be adopted and the chosen method depends upon local availability and the volume of waste to be transported. The types of transportation can be divided in to three categories:

- Human-powered: open hand-cart, hand-cart with bins, wheelbarrow, tricycle
- Animal-powered: donkey-drawn cart
- Motorised tractor and trailer, standard truck ,tipper-truck

5. Waste processing and recovery: This refers to the facilities, equipment, and techniques employed to recover reusable or recyclable materials from the waste stream and to improve the effectiveness of other functional elements of waste management.

6. Disposal: This is the final stage of waste management. It involves the activities aimed at the systematic disposal of waste materials in locations such as landfills or waste-to-energy facilities. This includes safe disposal, where associated risks are minimised. There are four main methods for the disposal of solid waste:

- Land application: burial or land filling
- Composting
- Burning or incineration
- Recycling (resource recovery)

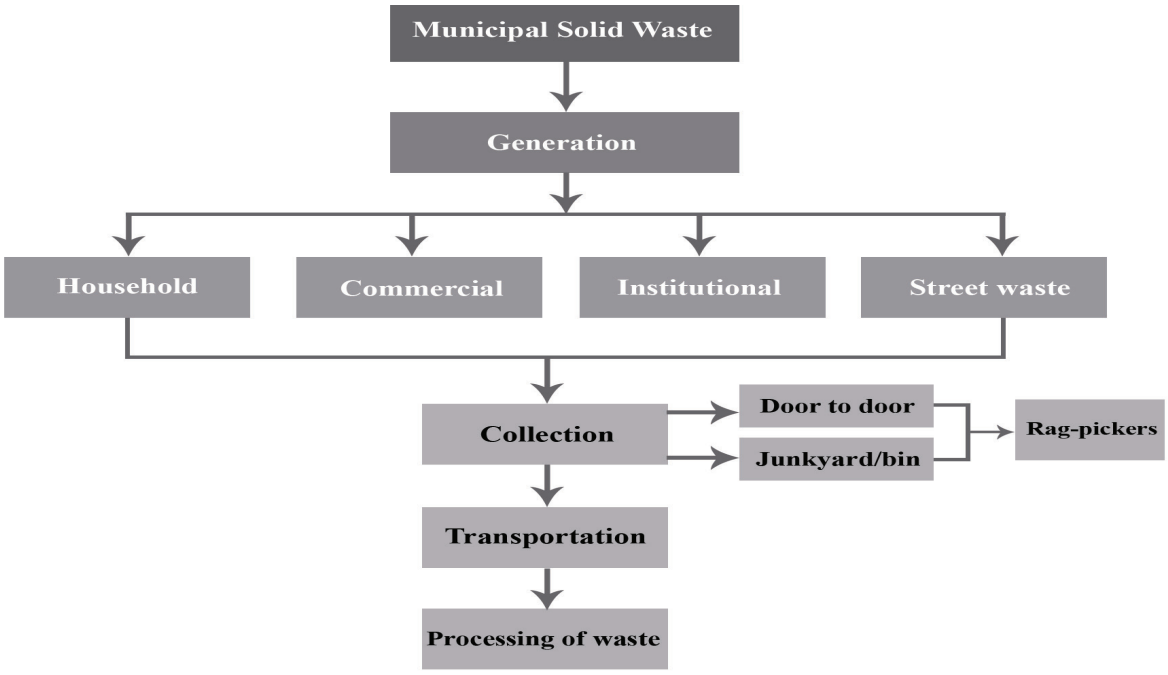


Fig: 4.2.1 Flowchart representing the processes involved in solid waste management

4.2.3 On-site disposal

On-site disposal is the handling of waste in the site of its production itself. These may be adapted for the particular site and situation in question.

a. Communal pit disposal

The simplest solid waste management system is where consumers dispose of waste directly into a communal pit. The size of this pit will depend on the number of people it serves. The recommended size or dimension is six cubic metres per fifty people. The pit should be fenced off to prevent small children falling in and should generally not be more than100 m from the dwellings. Ideally, waste should be covered at least weekly with a thin layer of soil to minimise flies and other pests.

b. Family pit disposal

Family pits may provide a better long-term option where there is adequate space. These should be fairly shallow (up to 1m deep) and families should be encouraged to regularly cover waste preventing oil from sweeping or ash from firewood used for cooking. This method is best suited where families have large plots and where organic food wastes are the main component of domestic refuse.

c. Communal bins

Communal bins or containers are designed to collect waste. Here, it will not be dispersed by wind or animals, and it can easily be removed for transportation and disposal. Plastic containers are generally inappropriate since these may be blown over by the wind, can easily be removed and may be desirable for alternative uses. A popular solution is to provide oil drum cut in half. The bases of these should be perforated to allow liquid to pass out and to prevent their use for other purposes. A lid and handles can be provided if necessary.

4.2.4 Off-site disposal options

The technology choices are general options for the final disposal of waste off-site.

a. Land filling

Once solid waste is transported off-site, it is normally taken to fill a site. Here the waste is placed in a large (pit/ trench) in the ground, which is back-filled with excavated soil each day waste is tipped. Ideally, about 0.5 m of soil should cover the deposited refuse at the end of each day to prevent animals from digging up the waste and flies from breeding.

The location of landfill sites should be decided upon through consultation with the local authorities and the affected population. Sites should preferably be fenced.

b. Incineration

Burning or incineration is often used for the disposal of combustible waste. This take place off-site or a considerable distance downwind of dwellings. Burning refuse within dwelling areas may create a significant smoke or fire hazard, especially if several fires are lit simultaneously. Burning may be used to reduce the volume of waste and maybe appropriate where there is limited space for burial or landfill. Waste should be ignited within pits and covered with soil once incinerated, in the same manner as land filling.

c. Composting

Simple composting of vegetables and other organic waste can be applied in many situations. Where people have their own gardens or vegetable plots, organic waste can be dug into the soil to add humus and fibre. This makes the waste perfectly safe and also assists the growth of plants. Properly managed composting requires careful monitoring of decomposing waste to control moisture and chemical levels and to promote microbial activity. This is designed to produce compost which is safe to handle and which acts as a good fertiliser. Such systems require considerable knowledge and experience and are best managed centrally. In general, they are unlikely to be appropriate in emergencies.

d. Recycling

Complex recycling systems are unlikely to be appropriate but the recycling of some waste items may be possible on occasions. Plastic bags, containers, tins and glass will often be automatically recycled since they are likely to be scarce commodities in many situations. In most developing countries there exists a strong tradition of recycling leading to lower volumes of waste than in many more developed societies.

Fig:4.2.2 Flowchart representing the processes involved in solid waste management in Urban areas

4.2.5 Zero Waste

Isn't it good if there were no waste at all? How can we do that?

"Zero Waste" is a philosophy of eliminating the generation of materials that have no viable option for end-of-use management. Zero Waste is a goal that is ethical, economical, efficient and visionary, to guide people in changing their lifestyles and practices for sustainable natural cycles, where all discarded materials are designed to become resources for others to use. Zero Waste means designing and managing products and processes to sys-

tematically avoid and eliminate the volume and toxicity of waste conserve and recover all resources, and not burn or bury them. A zero waste approach conserves natural resources and reduces pollution from extraction, manufacturing and disposal. Reducing and reusing means fewer products are made, as people buy less and as products are made to last. Recycling keeps waste out of landfills and incinerators and provides manufacturers with recycled instead of raw materials to make new goods. Effective zero waste programmes also include many different kinds of people such as waste worker cooperatives/ local neighbourhood groups/ universities and governments.

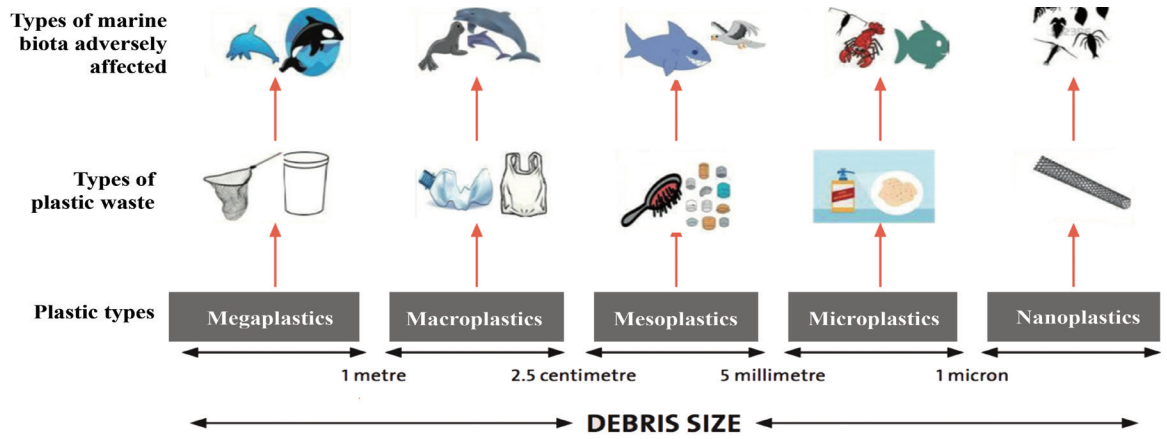
Zero waste programs include all of the following strategies:

- Reusing discards
- Reducing consumption and discards
- The principle of producer accountability (including extended producer responsibility strategies)
- Comprehensive recycling
- Comprehensive composting or bio-digestion of organic materials
- Citizen participation and worker rights
- A ban on waste incineration and illegal dumping
- The systematic reduction of landfilling over time
- Effective policies, regulations, incentives, and financing structures to support these systems

4.2.6 Plastics and micro plastics in the environment

Look around you and find different types of plastics. Are you able to categorise those plastics?

Plastic is an umbrella term that encompasses a wide range of materials made of semi-synthetic or synthetic organic compounds.They arelong chains of polymers comprised of linked repeated units, named "monomers". The International Union of Pure and Applied Chemistry(IUPAC) defines plastics as" polymeric materials that may contain other substances to improve performance and/or reduce costs. Due to their ease of manufacture, low cost, impermeability, and the resistance to chemicals, temperature and light, plastics are used in a wide range of products and have replaced many other materials, such as wood, paper, stone, leather ,metal, glass and ceramic. In the modern world, plastics can be found in components ranging from stationery items to space ships. The smaller particles, frequently classified as particles<5mm, are known as micro plastics, also colloquially referred to as"mermaid`stears" due to their size and the vast array of colours they show. Microplastics come from a variety of sources, including from larger plastic debris that degrades into smaller and smaller pieces. In addition, microbeads, a type of microplastic, are very tiny pieces of manufactured polyethylene plastic that are added as exfoliants to health and beauty products, such as some cleansers and toothpastes. They have become a source of increasing concern both for scientists and the general public because they are a threat to the environment. These tiny particles easily pass-through water filtration systems and end up in the ocean and Great Lakes, posing a potential threat to aquatic life. The health effects of microplastics are yet to be understood fully.



4.2.3 Classification of plastics in the environment

Micro plastics may be classified as primary or secondary, depending on their source.

Primary micro plastics are deliberately manufactured within the millimetric or submillimetric size, and can be found in numerous household items, including personal hygiene products, such as facial cleansers, tooth paste and exfoliating creams. These products are of special concern, as it has been estimated that approximately 6% of all liquid skin-cleaning products sold in the EU, Switzerland and Norway contain micro plastics, of which more than 93% consist of polyethylene (PE).Another key source of primary micro plastics are the raw materials used in the manufacture of plastic items. Inadequate handling, accidental loss, run-off from processing facilities and residues from the production process can lead to the accumulation of primary micro plastics. Micro plastics are also used, to a smaller degree, in medicine, namely as drug vectors. After their use, micro plastics are discharged in domestic waste waters and may reach the environment.

Secondary micro plastics result from the breakdown of larger plastic particles. When exposed to the elements, physical, chemical and biological processes can lead to reduction of the structural integrity of these plastics, leading to their fragmentation. However, this breakdown can also take place before these materials enter the environment, as is the case of synthetic fibres from clothes released during washing cycles or the wear-and-tear of

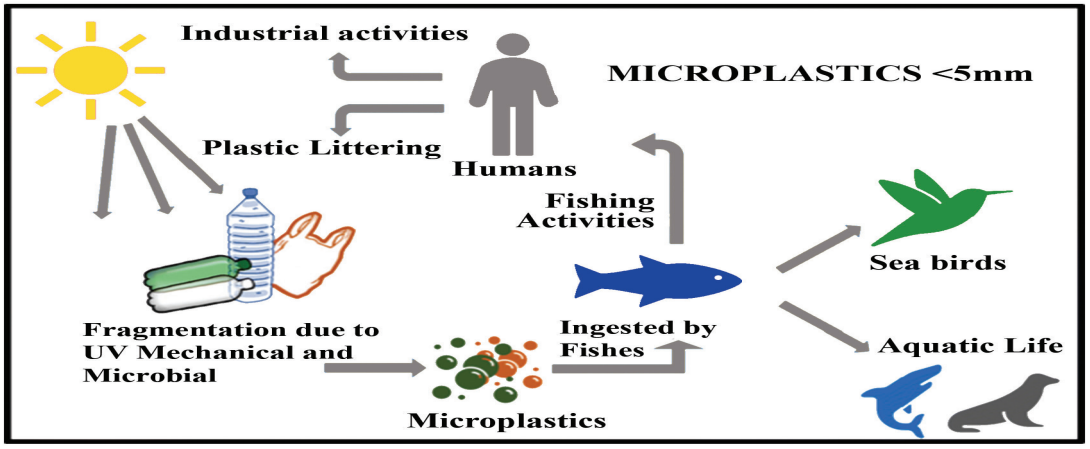


Fig: 4.2.4 Fate of microplastics in the environment

car tyres, which generates minute polymeric fragments.

Micro plastics have been identified across the globe, including in remote locations, from the Arctic, the Antarctic and throughout the water column, from surface to the depths (benthos). Micro plastics are also found in rivers and lakes in agricultural soils, sediments and even in the atmosphere, both in indoor and outdoor environments. Once in the environment, plastics can undergo degradation through abiotic and/ or biotic processes.

4.2.7 Effects of plastics

The interaction of organisms with plastic debris results in a wide range of consequences, both direct and indirect, including the potential occurrence of sub- lethal effects, may be of considerable concern. Broadly, the presence of larger plastic materials in the ocean may result in entanglement and ingestion, potential creation of new habitats, and dispersal via rafting, including transport of invasive species. Entanglement and ingestion frequently cause harm or death. Gathered data appear to suggest that entanglement is far more fatal (79% of all cases) than ingestion (4% of all cases).

Although the increased awareness and focus of research has led to significant advances in the understanding of the behaviour of micro plastics in the environment, there is still much that is undetermined with regard to the ability to accurately forecast the exposure scenarios and predict exposure hot spots. Owing to its small size, micro plastics may be ingested by multiple organisms, such as planktonic and higher organisms, including mammals, birds and fish. Although the exact mechanisms of toxicity of these materials are still not understood, the effects are potentially due to either (1) ingestion-induced stress such as physical blockage, energy expenditure; (2) leakage of chemicals, such as additives, from plastics and; (3) exposure to contaminants adsorbed (and subsequently released) by micro plastics such as persistent organic pollutants (POPs). The direct consequences of the ingestion of micro plastics include obstruction of the digestive tract and internal injury, frequently leading to reduced food consumption and concomitant decreased nutrition. This potentially results in starvation and death. In air -breathing organisms, micro plastics have been described to lodge in gills, which may translate into reduced respiration rates.

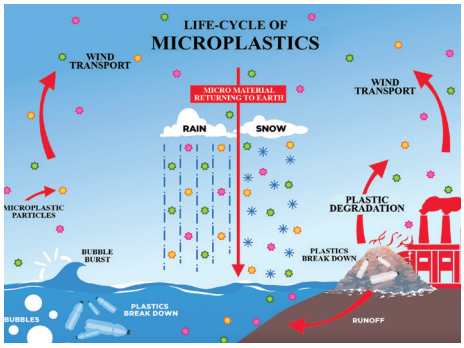


Fig: 4.2.5 Lifecycle of microplastics in the environment

Recap

- Solid waste refers to the range of garbage materials arising from animal and human activities that are discarded as unwanted and useless.
- There are six functional components of the waste management system- Waste

generation, Onsite handling, storage, and processing, Waste collection, Waste transfer and transport, Waste processing and recovery, Disposal.

- There are 2 types of disposal: on-site and off-site.
- On-site disposal includes communal pit disposal, family pit disposal, communal bins etc
- Off-site disposal includes land filling, incineration, composting and recycling.
- Zero waste- The conservation of all resources by means of responsible production, consumption, reuse, and recovery of products, packaging, and materials without burning and with no discharges to land, water, or air that threaten the environment or human health.
- Plastics are long chains polymers comprised of linked repeated units, named 'monomers'.
- The smaller particles, frequently classified as particles<5 mm, are known as micro plastics.
- Primary microplastics are deliberately manufactured within the millimetric or sub millimetric size, and can be found in including personal hygiene products.
- Secondary microplastics result from the break down of larger plastic particles.

Objective Type Questions

1. Mention the best method of disposal of refuse to ensure complete destruction of pathogenic bacteria.
2. What are the major constituent of gases produced from a landfill site?
3. Mention an engineered facility for the disposal of municipal solid waste.
4. What are the key components to zero waste?
5. What is the size of micro-plastics?
6. Does micro-plastics come from cosmetics?
7. How do most micro-plastics end up in the water?

Answers to Objective Type Questions

1. Incineration
2. Carbon dioxide and methane
3. Sanitary landfill
4. Recycling and reusability
5. Smaller than 5 mm
6. Yes
7. Runoff

Self Assessment Questions

1. Describe solid waste.
2. Define Solid Waste Management.
3. Describe the functional elements of Waste Management System.
4. What are the disposal measures of solid wastes?
5. What are communal bins?

6. Define incineration.
7. Describe the process of recycling.
8. Elaborate the concept of 'zero waste'.
9. Write an essay on plastics and microplastics on environment mentioning their effect.

Assignments

1. What are the different types of waste management measures practiced in your house and in your locality?
2. Collect the plastic waste generated from your house and think about the ways in which those can be recycled or reused.

Suggested Reading

1. Christine Costello, in Saving Food, 2019
2. M.R. Kosseva, in Comprehensive Biotechnology (Second Edition), 2011
3. Daniel A. Vallero, in Waste (Second Edition), 2019

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Unit 3
Concept of Global Warming and Climate

Learning Outcomes

- Develops a detailed understanding of global warming
- Gets a brief overview of acid rain, ozone depletion and Green house gases.
- The learner will become aware of the impacts of Climate change on different sectors of the environment.
- Think of solutions to tackle climate change

Prerequisites

What is the current temperature in your place? We hear people complaining of the increasing temperature day by day. Our grandparents tell us that today's temperature is more than that of the temperature during their childhood.

We speak of global warming, ozone layer depletion, green-house effect, climate change and acid rain or acid deposition. The summers have become so hot that we are forced to keep away from the sun from 12pm to3 pm. We read newspaper reports of sunburn deaths.

We have heard the term "acid rain.". It was coined in 1852 by the Scottish chemist Robert Angus Smith, according to the Royal Society of Chemistry. If things are to continue like this, the extinction of living things from the earth is not far remote.

Keywords

Climate change, Global warming, Greenhouse gases, Acid rain, Ozone layer, Aerosols.

Discussion

What is the current temperature in your place? Have you heard from your grandparents that today's temperature is more than that of the temperature during their childhood? Do you know why it happens?

4.3.1 Global Warming and Climate Change

Global warming is considered to be one of the central environmental issues in the recent years. It may prove to be very problematic and disastrous causing severe harm to the biotic and abiotic components of the environment. Nitrogen and oxygen are the main constituents of the atmosphere but the proportion of other gases such as carbon dioxide and carbon monoxide are steadily increasing. Because of the increasing presence of these gases, there is an increase in the global temperature. In other words the earth surface is getting warmer and warmer. Sunlight enters the earth's atmosphere and after hitting the earth's surface gets radiated back into the atmosphere. Here it is absorbed by certain naturally present gases

such as carbon dioxide. This absorption process heats the atmosphere and thus warms the earth's surface. When the gases are present in normal proportions the warming of the earth is normal and their presence is very essential and is responsible for the existence of life on earth. However, when the proportion of these gases increases, these gases allow the sunlight reflect back to the atmosphere, resulting in heat generation. Over a period of time the temperature of the earth will increase gradually. This phenomenon is called as global warming. Global warming is also known as the greenhouse effect because the phenomenon is very similar to what happens in a green house. The effect of this increase in temperature is damaging the environment.

4.3.2 Implications of global warming

1. Global warming can drastically reduce the moisture levels in current fertile zones and turn them subsequently into dry lands and desert.

2. Many countries in the world will suffer from droughts.

3. The agricultural production will be minimized to a significant extent.

4. Global warming will automatically lead to rise in temperature. According to the intergovernmental panel on climatic change set up by the United Nations Environmental Program in 1998, the world is already 0.5 Celsius warmer than the pre-industrial period and this rise in temperature will be an ongoing process.

5. Global warning has a more drastic effect. A rise in temperatures would result in the melting at Polar Regions. This will lead to rise in the sea- levels. Even a 5% rise in sea - level would lead to displacement of millions of people in low tide areas and a number of Small Island nations will disappear totally.

6. Others important effects include global mean surface warming, polar winter surface warm in reduction of sea -ice g, etc.

7. One of the most severe effects of global warming from a human perspective is the creation of 'Climate refugees'. Climate refugees are those people who suffer from climatic conditions such as drought, floods, starvations, displacement etc. These climate refugees therefore signify the most visible symbol of global warming.

4.3.3 Major drivers of climate change (greenhouse gases and aerosols)

Larger emissions of greenhouse gases lead to higher concentrations in the atmosphere. Greenhouse gas concentrations are measured in parts per million, parts per billion, and even parts per trillion. One part per million is equivalent to one drop of water diluted into about 13 gallons of liquid (roughly the fuel tank of a compact car). Each of these gases can remain in the atmosphere for different amounts of time, ranging from a few years to thousands of years. All of these gases remain in the atmosphere long enough to become well mixed.

We will discuss some important greenhouse gases in the atmosphere;

1. Water Vapour

The most abundant greenhouse gas overall, water vapor differs from other greenhouse gases in that changes in its atmospheric concentrations are linked not to human activities directly, but rather to the warming that results from the other greenhouse gases emitted. As the temperature of the atmosphere rises, more water is evaporated from ground storage (rivers, oceans, reservoirs, soil). Because the air is warmer, the absolute humidity can be higher (in essence, the air is able to 'hold' more water when it's warmer), leading to more water vapour in the atmosphere. As a greenhouse gas, the higher concentration of water vapour

the more thermal IR energy radiated from the Earth, thus further warming the atmosphere. The warmer atmosphere can then hold more water vapour and so on and so on. This is referred to as a 'positive feedback loop'.

2. Carbon dioxide

Carbon dioxide (CO_2) is the primary greenhouse gas emitted through human activities. Carbon dioxide is naturally present in the atmosphere and forms part of the Earth's carbon cycle (the natural circulation of carbon among the atmosphere, oceans, soil, plants, and animals). Human activities are altering the carbon cycle–both by adding more $CO_2$to the atmosphere, and by influencing the ability of natural sinks, like forests and soils, to remove and store CO_2 from the atmosphere. While CO_2 emissions come from a variety of natural sources, human-related emissions are responsible for the increase that has occurred in the atmosphere since the industrial revolution. The main human activity that emits $CO_2$is the combustion of fossil fuels (coal, natural gas, and oil) for energy and transportation, although certain industrial processes and land-use changes also emit CO_2. Carbon dioxide is constantly being exchanged among the atmosphere, ocean, and land surface as it is both produced and absorbed by many microorganisms, plants, and animals. However, emissions and removal of CO_2 by these natural processes tend to balance the impacts. Since the Industrial Revolution began around 1750, human activities have contributed substantially to climate change by adding CO_2 and other heat-trapping gases to the atmosphere.

3. Methane

Although methane (CH_4) persists in the atmosphere for far less time than carbon dioxide (about a decade), it is much more potent in terms of the greenhouse effect. Human activities emitting methane include leaks from natural gas systems and the raising of livestock. Methane is also emitted by natural sources such as natural wetlands. In addition, natural processes in soil and chemical reactions in the atmosphere help remove CH_4 from the atmosphere. Methane's lifetime in the atmosphere is much shorter than carbon dioxide (CO_2), but CH_4 is more efficient at trapping radiation than CO_2.The comparative impact of CH_4 is 25 times greater than CO_2 over a 100-year period.

4. Nitrous oxide

Human activities such as agriculture, fuel combustion, wastewater management, and industrial processes are increasing the amount of N_2O in the atmosphere. Nitrous oxide is also naturally present in the atmosphere and forms the Earth's nitrogen cycle, and has a variety of natural sources. Nitrous oxide molecules stay in the atmosphere for an average of 114 years before being removed by a sink or destroyed through chemical reactions. The impact of 1 pound of N_2O on warming the atmosphere is almost 300 times that of 1 pound of carbon dioxide. Globally, about 40 percent of total N_2O emissions come from human activities. Nitrogen takes on a variety of chemical forms throughout the nitrogen cycle, including N_2O. Natural emissions of N_2O are mainly from bacteria breaking down nitrogen in soils and the oceans. Nitrous oxide is removed from the atmosphere when it is absorbed by certain types of bacteria or destroyed by ultraviolet radiation or chemical reactions.

5. Fluorocarbons (FCs)

Unlike many other greenhouse gases, fluorinated gases have no natural sources and only come from human-related activities. They are emitted through their use as substitutes for ozone-depleting substances (e.g., as refrigerants) and through a variety of industrial processes such as aluminium and semiconductor

manufacturing. Many fluorinated gases have very high global warming potentials (GWPs) relative to other greenhouse gases, so small atmospheric concentrations can have disproportionately large effects on global temperatures. They can also have long atmospheric lifetimes in some cases, lasting thousands of years. Like other long-lived greenhouse gases, most fluorinated gases are well-mixed in the atmosphere, spreading around the world after they are emitted. Many fluorinated gases are removed from the atmosphere only when they are destroyed by sunlight in the far upper atmosphere. In general, fluorinated gases are the most potent and longest lasting type of greenhouse gases emitted by human activities. There are four main categories of fluorinated gases—hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphurhexafluoride (SF6), and nitrogen trifluoride (NF3).

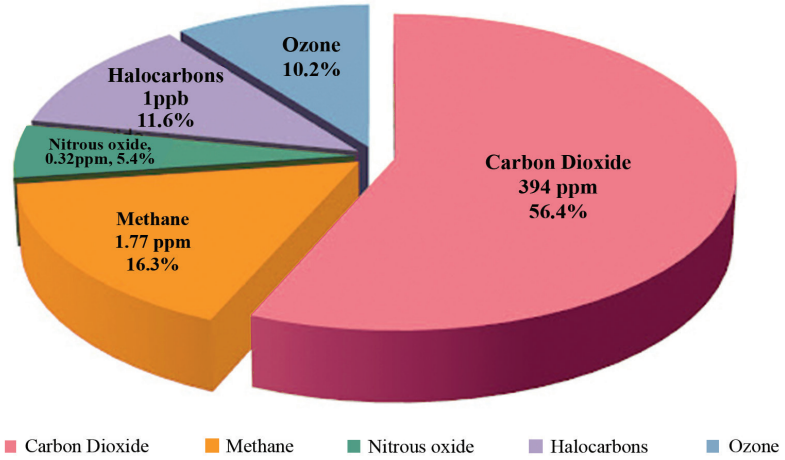

Fig: 4.3.1 Concentration of various GHG gases in the atmosphere

4.3.4 Green House Effect

The greenhouse effect happens when certain gases—known as greenhouse gases—collect in Earth's atmosphere. These gases, which occur naturally in the atmosphere, include carbon dioxide, methane, nitrogen oxide, and fluorinated gases such as chlorofluorocarbons (CFCs).

Due to sun rays, earth surface gets heated. Subsequently it cools and the heat is radiated from the earth to the atmosphere. But CO_2 and other heat absorbing gases take a part of the radiated heat and return it to the earth. This process results in the accumulation of extra heat energy at the surface of the earth. In the last few decades, the amount of heat absorbing gases has remarkably increased and as a result the average temperature of the atmosphere has gone up. This phenomenon is called "Green House Effect". It is clear that gases like CO_2, Chloroflurocarbons, N_2O and CH_4 make a cloud over the earth, which allows the incoming rays of the sun but obstructs the outgoing heat energy from the earth to the atmosphere. There have been numerous warnings in the recent years that the earth's climatic pattern which almost maintained a steady course for centuries has undergone visible changes. This is caused by changes in the composition of global atmosphere which consists of a number of natural and synthetic gases. Any increase in gases which have the ability to absorb infrared radiation reflected will enhance heat - trapping capacity of the earth. In 1961, the English Philospher John

Tyndoll proposed that increased concentration of atmospheric carbon dioxide could raise surface temperature and change the climate. Since then, the concentration of this gas has increased by about 25%. This increase has been caused by various factors. An indiscriminate burning of fossil fuels like coal, oil and natural gases releases huge amounts of gas into the atmosphere. There are more than half a billion vehicles on the road which spew CO_2 and other gases into air. The burning of a large number of oil wells continuously after the gulf war has added tremendous amount of carbon dioxide into the atmosphere. As far as industrial revolution is concerned the main culprits are the developed countries. The industrialized countries are responsible for forcing the pace of global warming, and climatic changes. The entire international community from world leaders and to layman is aware of global warming and its dangers. This could destabilize world food security. There may be massive disruption to agriculture and loss of ecosystem of word wide importance.

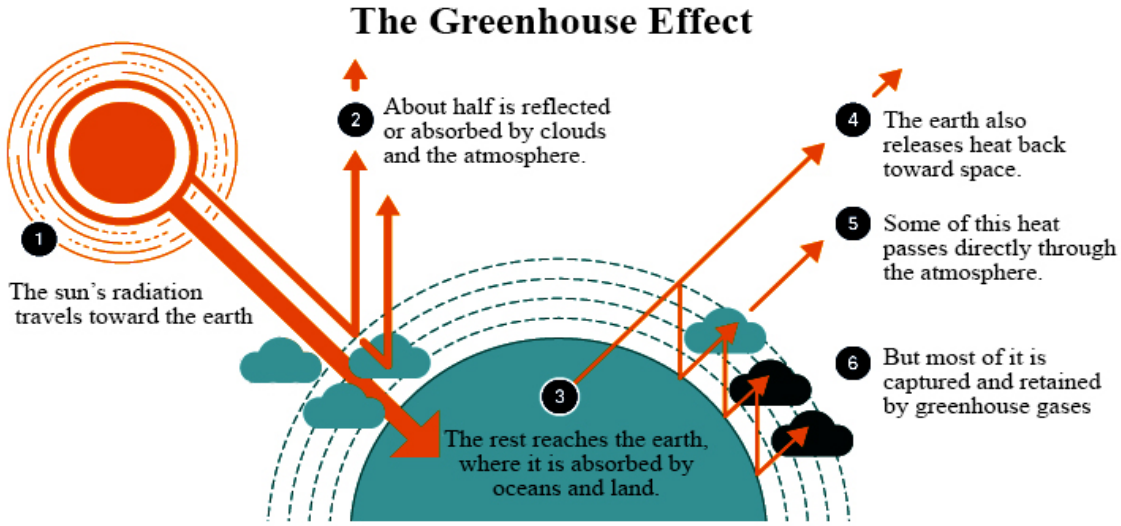

Fig:4.3.2 Greenhouse effect and global warming

4.3.5 Major impacts of climate change on agriculture

Climate change and agriculture are interrelated processes, both of which take place on a global scale. Climate change affects farming in a number of ways, including through changes in average temperatures, rainfall, and climate extremes (e.g. heat waves), changes in pests and diseases, changes in atmospheric carbon dioxide and ground-level ozone concentrations, changes in the nutritional quality of some foods and changes in sea level. Climate change is already affecting agriculture, with effects unevenly distributed across the world.

The accelerating pace of climate change, combined with global population and income growth, threatens food security everywhere. Agriculture is extremely vulnerable to climate change. Higher temperatures eventually reduce yields of desirable crops while encouraging weed and pest proliferation. Pests management becomes less effective, meaning that higher rates of pesticides will be necessary to achieve the same levels of control. Heat wave s can cause extreme heat stress in crops, which can limit yields if they occur during certain times of the plants' life-cycle (pollination, pod or fruit set). Also, heat waves can result in wilted plants (due to elevated transpiration rates) which can cause yield loss if not coun-

teracted by irrigation. Heavy rains that often result in flooding can also be detrimental to crops and to soil structure. Most plants cannot survive in prolonged waterlogged conditions because the roots need to breathe. The overall impacts of climate change on farming are expected to be negative, threatening global food security.

Changes in climate may also impact the water availability and water needs for farming. If temperature increases and more sporadic rainfall events result from global warming, it is possible that irrigation needs could increase in the future. In anticipation of these changes, plant breeders are currently working to develop new varieties of crops that are considered to be drought tolerant, and more adaptable to varying levels of temperature and moisture.

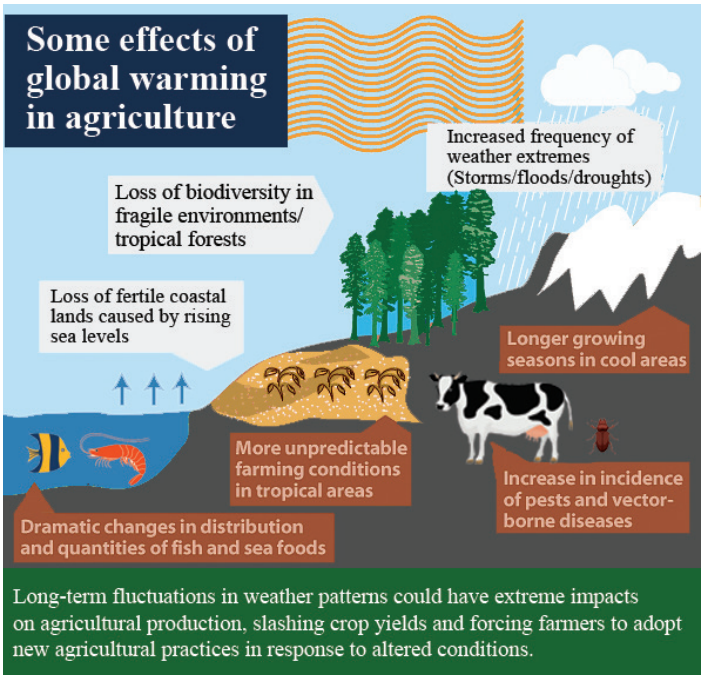

Fig:4.3.3 Impact of climate change on agriculture

4.3.5.1 Impacts on crops

- Higher CO_2 levels can affect crop yields. Some laboratory experiments suggest that elevated CO_2 levels can increase plant growth. However, other factors, such as changing temperatures, ozone, water and nutrient constraints, may counteract these potential increases in yield. For example, if temperature exceeds a crop's optimal level, if sufficient water and nutrients are not available, yield increases may be reduced or reversed. Elevated CO_2 has been associated with reduced protein and nitrogen content in alfalfa and soybean plants, resulting in a loss of quality. Reduced grain and forage quality can reduce the ability of pasture and rangeland to support grazing livestock.
- More extreme temperature and precipitation can prevent crops from growing. Extreme events, especially floods and droughts,

can harm crops and reduce yields. For example, in 2010 and 2012, high night time temperatures affected corn yields across the U.S. Corn Belt, and premature budding due to a warm winter caused $220 million in losses of Michigan cherries.

- Dealing with drought could become a challenge in areas where rising summer temperatures cause soils to become drier. Although increased irrigation might be possible in some places, in other places water supplies may also be reduced, leaving less water available for irrigation when more is needed.
- Many weeds, pests, and fungi thrive under warmer temperatures, wetter climates, and increased CO_2 levels. The ranges and distribution of weeds and pests are likely to increase with climate change. This could cause new problems for farmers' crops previously unexposed to these species.
- Though rising CO_2 can stimulate plant growth, it also reduces the nutritional value of most food crops. Rising levels of atmospheric carbon dioxide reduce the concentrations of protein and essential minerals in most plant species, including wheat, soybeans, and rice. This direct effect of rising CO_2 on the nutritional value of crops represents a potential threat to human health. Human health is also threatened by increased pesticide use due to increased pest pressures and reductions in the efficacy of pesticides.

4.3.5.2 Impacts on livestock

- Heat waves directly threaten livestock. Heat stress affects animals both directly and indirectly. Overtime, heat stress can increase vulnerability to disease, reduce fertility and reduce milk production.
- Drought may threaten pasture and feed supplies. Drought reduces the amount of quality forage available to grazing livestock. Some areas could experience longer, more intense droughts, resulting from higher summer temperatures and reduced precipitation. For animals that rely on grain, changes in crop production due to drought could also become a problem.
- Climate change may increase the prevalence of parasites and diseases that affect livestock.. In areas with increased rainfall, moisture-reliant pathogens could thrive.
- Potential changes in veterinary practices, including an increase in the use of parasiticides and other animal health treatments, are likely to be adopted to maintain livestock health in response to climate-induced changes in pests, parasites, and microbes. This could increase the risk of pesticides entering the food chain or lead to evolution of pesticide resistance, with subsequent implications for the safety, distribution, and consumption of livestock and aquaculture products.
- Increases in carbon dioxide (CO_2) may increase the productivity of pastures, but may also decrease

their quality. Increases in atmospheric CO_2 can increase the productivity of plants on which livestock feed. However, the quality of some of the forage found in pasturelands decreases with higher CO_2. As a result, cattle would need to eat more to get the same nutritional benefits.

4.3.5.3 Impacts on Fisheries

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

4.3.6 Major impacts of climate change on forest

Climate changes directly and indirectly affect the growth and productivity of forests through changes in temperature, rainfall, weather, and other factors. In addition, elevated levels of carbon dioxide have an effect on plant growth. These changes influence complex forest ecosystems in many ways.

4.3.6.1 Impacts on Forest Growth and Productivity

- Warming temperatures generally increase the length of the growing season. It also shifts the geographic ranges of some tree species. Habitats of some types of trees are likely to move north or to higher altitudes. Other species will be at risk locally or regionally if conditions in their current geographic ranges are no longer suitable.
- Climate change will increase the risk of drought in some areas and the risk of extreme precipitation and flooding in others. Increased temperatures alter the timing of snowmelt, affecting the seasonal availability of water. Although many trees are resilient to some degree of drought, increases in temperature could make future droughts more damaging than those experienced in the past. In addition, drought increases wildfire risk, since dry trees and shrubs provide fuel to fires.
- Given sufficient water and nutrients, increases in atmospheric CO_2 may enable trees to be more productive, which may change the distribution of tree species. Growth will be highest in nutrient-rich soils with no water limitation, and will decrease with decreasing fertility and water supply.

4.3.6.2 Impacts of Forest Disturbances

- Climate change could alter the frequency and intensity of forest disturbances such as insect outbreaks, invasive species, wildfires and storms. These disturbances can reduce forest productivity and change the distribution of tree

species. In some cases, forests can recover from a disturbance. In other cases, existing species may shift their range or die out. In these cases, the new species of vegetation that colonize the area create a new type of forest.

- Disturbances can interact with one another, or with changes in temperature and precipitation, to increase risks to forests. For example, drought can weaken trees and make a forest more susceptible to wildfire or insect outbreaks. Similarly, wildfire can make a forest more vulnerable to pests.

4.3.6.3 Impact of Climate Change on Forest Sector

- Change in Supply- Climate change can increase global timber production through location changes of forests, i.e., through a shift towards the poles of the most important for forestry species. Climate change can also accelerate vegetation growth caused by a warmer climate, longer growth seasons, and elevated atmospheric CO_2 concentrations. Changing timber supply will affect the market, generally lowering prices. It will also impact supply for other uses, e.g., enhancing the potential of using various types of wood biomass energy.
- Change in Demand- Some model-based estimates project an increase in biofuel demand during the next 50 years. The use of wood for fuel and biomass energy could dramatically escalate in the face of rising energy prices and new technologies.

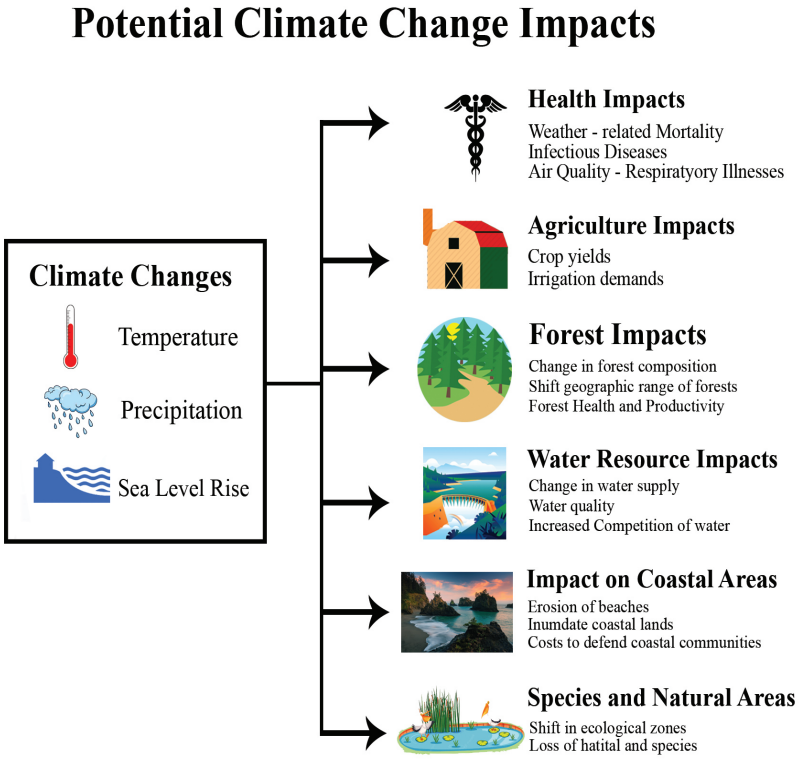

Fig: 4.3.4 Potential impacts of climate change on various environments

4.3.7 Major impacts of climate change on Water resources

Water resources are important to both society and ecosystems. We depend on a reliable, clean supply of drinking water to sustain our health. We also need water for agriculture, energy production, navigation, recreation, and manufacturing. Many of these uses put pressure on water resources, stresses that are likely to be exacerbated by climate change.

1. Water Cycle and Water Demand

Warmer temperatures increase the rate of evaporation of water into the atmosphere, in effect increasing the atmosphere's capacity to "hold" water. Increased evaporation may dry out some areas and fall as excess precipitation on other areas. Changes in the amount of rain falling during storms provide evidence that the water cycle is already changing.

2. Water supply

Low water and droughts have severe consequences on most sectors, particularly agriculture, forestry, energy, and drinking water provision. Activities that depend on high water abstraction and use, such as irrigated agriculture, hydropower generation and use of cooling water, will be affected by changed flow regimes and reduced annual water availability. Climate change tends to increase the frequency and intensity of rainfall; there may be an increase in the occurrence of flooding due to heavy rainfall events. Groundwater recharge may also be affected with a reduction in the availability of groundwater for drinking water in some regions.

3. Water Quality

Water quality could suffer in areas experiencing increases in rainfall. Heavy precipitation events could cause problems for the water infrastructure, as sewer systems and water treatment plants are overwhelmed by the increased volumes of water. Heavy downpours can increase the amount of runoff into rivers and lakes, washing sediment, nutrients, pollutants, trash, animal waste, and other materials into water supplies, making them unusable, unsafe, or in need of water treatment.

Freshwater resources along the coastal area face risks from sea level rise. As the sea rises, saltwater moves into freshwater areas. This may force water managers to seek other sources of fresh water, or increase the need for desalination (or removal of salt from the water) for some coastal freshwater aquifers used as drinking water supply.

Drought can cause coastal water resources to become more saline as freshwater supplies from rivers are reduced. Water infrastructure in coastal cities, including sewer systems and wastewater treatment facilities, faces risks from rising sea levels and the damaging impacts of storm surges.

4.3.8 Management options to tackle climate change

1. The global warming is largely the product of industrialized nations and they are the world's largest energy users, CFC producers and consumers, Car manufacturing and use as well as use of nitrogen fertilizers have resulted in global warming and hence the solution is a radical re-thinking of the whole western industrialized lifestyle. However, this solution is almost impossible because it involves a lot of sacrifice by the industrialized world.

2. The immediate solution to reduce global warming is to reduce carbon dioxide emission; this is possible by closing down fossil fuel, power stations and replace by nuclear power.

3. Industrialized nations will assist the developing countries in obtaining data in limiting emissions.

4. All the countries must implement national

strategies to limit their toxic emissions.

5. Countries should be encouraged to recognize climatic changes in the formulation of economic, social and environmental policies.

6. It is necessary to increase public awareness related to environmental problems especially global warming through conscious efforts of education and training.

7. All the countries will co-operate and participate in a continues international research and effort

8. It is necessary to have global environmental ethics to protect the earth from any further exploitation in the nature of development and modernization. Hence environmental movements are necessary in all parts of the world monotony to consume the natural resources but also to share them equitably and fairly. This will sustain earth to a significant extension.

4.3.9 Over view of Acid rains

Acid precipitation has been known for centuries in areas such as London where sulphur discharged by the burning of coal produces toxic smogs. However, the problem did not assume scientific, economic and political prominence until the early 1980s. As it transcends national boundaries, the acid rain problem has become a subject of heated controversy between otherwise friendly neighbours like the US and Canada or Germany and the Scandinavian countries. It has been found that acid precipitation is harmful to trees and other forms of vegetation, causing foliar injury and reduction in growth. The primary reason that acid rain has received attention is its economic impact. The cost to control emission of sulphur compounds from power plants, refineries and smoke generating industries is enormous. The problem of acid rain is more apparent in the parts of the world which are industrialised. The western countries and other developing countries of the world are severely facing this problem. Among Indian cities the possibility of acid rain has increased in Mumbai, Delhi, Kanpur, Bangalore, Ahmedabad and Calcutta. Acid rain has adversely affected the entire ecosystem. Due to acid rain, the mineral balance in forests, rivers, fields and lakes is being disturbed. There is decrease in productivity. The resistance power of the lives at the surface of water has also decreased. The microorganisms have gradually become inactive and it has affected the natural cycles of elements. It has not only affected the human life but also of thousands of species in water. The most important thing is to reduce CO_2, SO_2 and NO_2 gases in the atmosphere to stop acid rain. It should be our endeavour to limit the elements helping acid rain. We must also regulate the spread of the gases in the atmosphere.

4.3.10 Ozone layer depletion

The Earth's atmosphere is composed of several layers. The lowest layer, the troposphere, extends from the Earth's surface up to about 6 miles or 10 km in altitude. Most atmospheric ozone is concentrated in a layer in the stratosphere, about 9 to 18 miles (15 to 30 km) above the Earth's surface. Ozone is a molecule that contains three oxygen atoms. At any given time, ozone molecules are constantly formed and destroyed in the stratosphere. The total amount has remained relatively stable during the decades that it has been measured. It has the potential to absorb around 97-99% of the harmful ultraviolet radiations coming from the sun that can damage life on earth.

Ozone layer depletion is the thinning of the ozone layer present in the upper atmosphere. This happens when the chlorine and bromine atoms in the atmosphere come in contact with ozone and destroy the ozone molecules. One chlorine can destroy 100,000 molecules of ozone. It is destroyed more quickly than it is created. Some compounds release chlorine

and bromine on exposure to high ultraviolet light, which then contributes to the ozone layer depletion. Such compounds are known as Ozone Depleting Substances (ODS).

The ozone-depleting substances that contain chlorine include chlorofluorocarbon, carbon tetrachloride, hydrochlorofluorocarbons, and methyl chloroform, whereas, the ozone-depleting substances that contain bromine are halons, methyl bromide, and hydro bromofluorocarbons. Chlorofluorocarbons are the most abundant ozone-depleting substance. It is only when the chlorine atom reacts with some other molecule, it does not react with ozone.

In the 1970s, concerns about the effects of ozone-depleting substances (ODS) on the stratospheric ozone layer prompted several countries, including the United States, to ban the use of chlorofluorocarbons (CFCs) as aerosol propellants. However, global production of CFCs and other ODS continued to grow rapidly as new uses were found for these chemicals in refrigeration, fire suppression, foam insulation, and other applications. Some natural processes, such as large volcanic eruptions, can have an indirect effect on ozone levels. For example, Mt. Pinatubo's 1991 eruption did not increase stratospheric chlorine concentrations, but it did produce large amounts of tiny particles called aerosols (different from consumer products also known as aerosols). These aerosols increase chlorine's effectiveness at destroying ozone. The aerosols in the stratosphere create a surface on which CFC-based chlorine can destroy ozone. However, the effect from volcanoes is short-lived.

One example of ozone depletion is the annual ozone "hole" over Antarctica that has occurred during the Antarctic spring since the early 1980s. This is not really a hole through the ozone layer, but rather a large area of the stratosphere with extremely low amounts of ozone. The Montreal Protocol was proposed in 1987 to stop the use, production and import of ozone-depleting substances and minimise their concentration in the atmosphere to protect the ozone layer of the earth.

4.3.11 Effects of Ozone Layer Depletion

The depletion of the ozone layer has harmful effects on the environment. Let us see the major effects of ozone layer depletion on man and environment.

Effects on Human Health

The humans will be directly exposed to the harmful ultraviolet radiations of the sun due to the depletion of the ozone layer. This might result in serious health issues among humans, such as skin diseases, cancer, sunburns, cataract, quick ageing and weak immune system.

Effects on Animals

Direct exposure to ultraviolet radiations leads to skin and eye cancer in animals.

Effects on the Environment

Strong ultraviolet rays may lead to minimal growth, flowering and photosynthesis in plants. The forests also have to bear the harmful effects of the ultraviolet rays.

Effects on Marine Life

Planktons are greatly affected by the exposure to harmful ultraviolet rays. These are higher in the aquatic food chain. If the planktons are destroyed, the organisms present in the food chain are also affected.

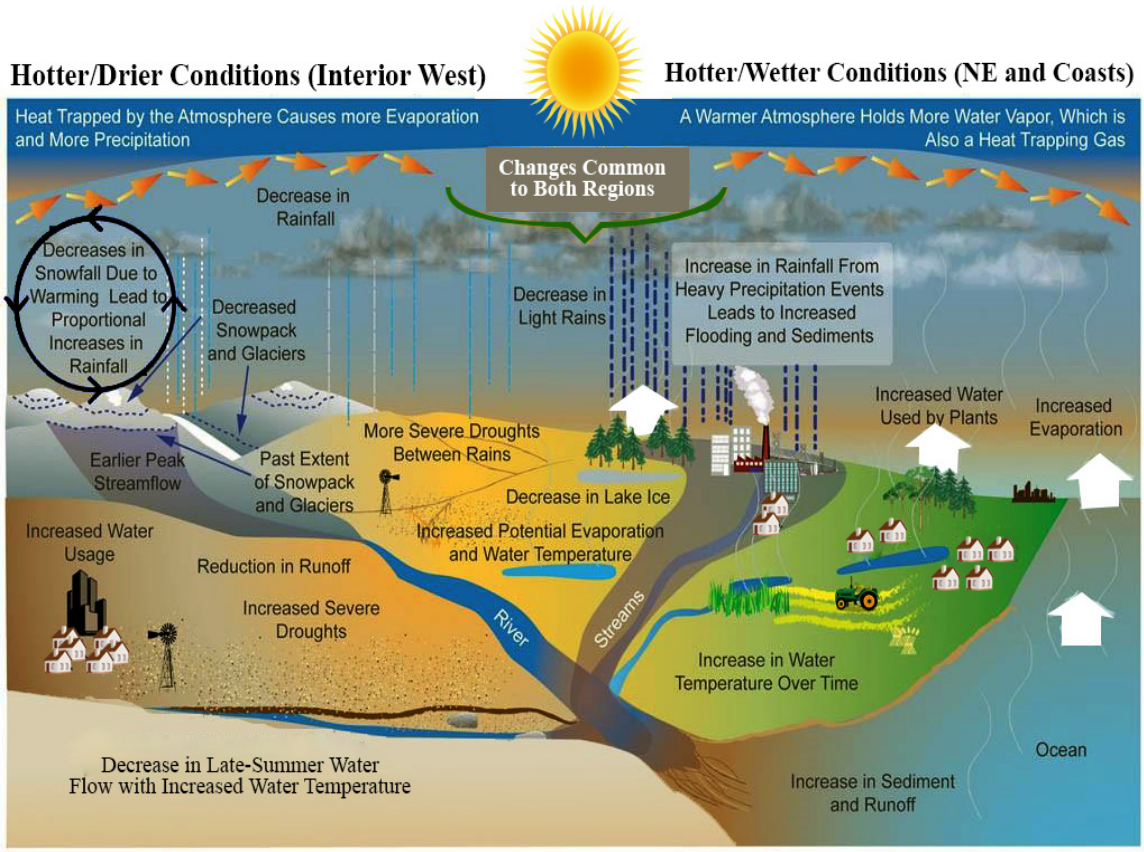

Fig: 4.3.5 Impact of climate change on water resources

Recap

- Global warming is the phenomenon of increasing average air temperatures near the surface of Earth over the past one to two centuries.
- Greenhouse gases- any gas that has the property of absorbing infrared radiation (net heat energy) emitted from Earth's surface and reradiating it back to Earth's surface.
- Larger emissions of greenhouse gases lead to higher concentrations in the atmosphere.
- Major GHGs include water vapour, carbon dioxide, methane, nitrous oxide and fluorocarbons.
- Impact of global warming includes rise in temperature, change in rainfall pattern, more droughts and heat waves, rise in sea level.
- One of the most severe effects of global warming from a human perspective is the creation of "Climate refugees"
- Ozone layer depletion is the thinning of the ozone layer present in the upper atmosphere.
- Those substances that deplete ozone are called as Ozone Depleting Substances

- Acid rain, or acid deposition, is a broad term that includes any form of precipitation with acidic components, such as sulfuric or nitric acid that fall to the ground from the atmosphere in wet or dry forms.
- The term acid rain was coined in 1852 by Scottish chemist Robert Angus Smith, according to the Royal Society of Chemistry.

Objective Type Questions

1. What are the most dangerous ultraviolet rays?
2. What are green house gases?
3. In GHGs which is present in highest quantity in the atmosphere?
4. What does UNFCC stand for?
5. Mention some important GHGs.
6. In which layer of the earth's atmosphere is the ozone layer found?
7. Which gases are the main contributors of acid rain?
8. Who discovered the phenomenon of acid rain?

Answers to Objective Type Questions

1. UVC
2. Any gas that has the property of absorbing infrared radiation emitted from Earth's surface and reradiating it back to Earth's surface.
3. Carbon dioxide
4. United Nations Framework Convention on Climate Change
5. CO_2, Methane, water vapour
6. Stratosphere
7. Sulphur dioxide and nitrogen dioxide
8. Robert A. Smith

Self Assessment Questions

1. Define global warming.
2. What is climate change?
3. Describe the implications of global warming.
4. …….. are people who suffer from climatic conditions such as drought, floods, starvations, displacement etc.
5. Write an essay on major drivers of climate change.

6. Which is the most abundant green house gas?
7. List out the green house gases.
8. Write short note on Green House Effect.
9. Write an essay on the effects of climate change on various sectors.
10. What is acid rain?
11. Write an essay on Ozone Depletion and its effects.

Assignments

1. Prepare a poster illustrating the causes and consequences of global warming in a city.
2. Think of some ways to tackle global warming.

Suggested Reading

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4. Nadine Borduas, Neil M. Donahue, in Green Chemistry, 2018

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2. Houghton, J. (2005) Global Warming. Reports on Progress in Physics, 68, 1343-1403.http://dx.http://dx.doi.org/.org/10.1088/0034-4885/68/6/R02
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Unit 4
Concept and Definition of Carbon Usage

Learning Outcomes

- Learner gets familiarized some key concepts of carbon usage in the environment.
- Gets a general understanding of environmental politics.
- Gets thorough knowledge on EIA.
- Becomes aware about the different processes involved in initiating a new developmental project.

Prerequisites

Now you know about global warming. One of the main reasons for global warming is the excess deposit of Carbon dioxide in the Universe. Have you ever thought that if we could store this carbon, then we could reduce this global warming? Here we have a method called Carbon sequestration - the long-term storage of carbon in plants, soils, geologic formations, and the ocean. Related to this process, we speak of Carbon footprint, carbon credit and Carbon trade. It is also of great importance to be aware of Environmental economics, green economy or green economics, circular economy and Environmental Impact Assessment (EIA).

Keywords

Carbon sequestration, Carbon foot print, Carbon trading, Environmental economics, Green economy, EIA

Discussion

Now you know about global warming. Have you ever thought that if we could store this carbon, we could reduce this global warming?

4.4.1 Carbon sequestration

Carbon sequestration is the long-term storage of carbon in plants, soils, geologic formations, and the ocean. It is one method of reducing the amount of carbon dioxide in the atmosphere with the goal of reducing global climate change and also aims at stabilizing the amounts of the greenhouse gas concentration in the atmosphere, and reducing the human 'carbon footprint'. Thus, carbon capture and sequestration are the processes 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. Carbon sequestration occurs both naturally

and as a result of anthropogenic activities and typically refers to the storage of carbon that has the immediate potential to become carbon dioxide gas.

Carbon dioxide is naturally captured from the atmosphere through biological, chemical, and physical processes. These changes can be accelerated through changes in land use and agricultural practices, such as converting crop and livestock grazing land into land for non-crop fast-growing plants. Artificial processes have been devised to produce similar effects, including large-scale, artificial capture and sequestration of industrially produced carbon dioxide using subsurface saline aquifers, reservoirs, ocean water, ageing oil fields, or other carbon sinks, bio-energy direct air capture when combined with storage.

- Clearly defined, how carbon sinks remove carbon dioxide (CO2) from the Earth's atmosphere is called carbon sequestration.
- Carbon sequestration is both a natural and artificial process by which carbon dioxide is removed from the Earth's atmosphere and then stored in liquid or solid form.
- It is a process of capture and deliberate, whether natural or artificial, storage of CO2 over a long period of time. The initial purpose of doing this is to delay global warming and avoid extreme climate change.
- Other forms of carbon are also stored during this sequestration process.
- It is the removal and storage of carbon from the atmosphere to sinks oceans, soil, forests through physical means and the natural process best known is photosynthesis.

4.4.1.1 Advantages of carbon sequestration

- It makes us plant more trees and preserve forests: Forests and vegetation have been identified to be key players in capturing and storing carbon dioxide, capturing about 25% of all carbon emissions.
- It helps reduce global warming: About 45% of carbon dioxide stays in the atmosphere and the rest is sequestrated naturally by the environment. If more carbon dioxide is pumped into the atmosphere, it creates a blanket-like effect, where more heat is trapped in the atmosphere, resulting in global warming.
- It reduces ocean acidification: About 30% of all carbon dioxide emitted from burning fuels is absorbed by the upper layer of the ocean. This raises the acidity levels of ocean waters, making it harder for marine life to survive, or even build their shells. This eventually affects the fish we eventually eat, which therefore has an indirect effect on humans. Carbon sequestration reduces marine life disturbances and human beings will therefore not be affected by the same
- Helping mitigate carbon dioxide emissions: Technology is advancing daily, to help sequester carbon dioxide from coal-fired power plants and industrial smokestacks, burying it deep in the oceans or within the earth.

4.4.1.2 Disadvantages

- Carbon dioxide may be stored deep underground. At depth, hydrostatic pressure acts to keep it in a liquid state. Reservoir design faults, rock fissures, and tectonic processes may act to release the gas stored into the ocean or atmosphere.
- The use of the technology would add 1–5 cents of cost per kilowatt-hour, according to an estimate made by the panels about climate change. The financial costs of modern coal technology would nearly double.

4.4.1.3 Types of Carbon sequestration

Biological Carbon Sequestration -

It is the storage of carbon dioxide in vegetation such as grasslands or forests, as well as in soils and oceans. What are the biological methods of carbon sequestration?

- In Oceans- Carbon goes in both directions in the ocean. Oceans absorb roughly 25 percent of carbon dioxide emitted from human activities annually. When carbon dioxide is released into the atmosphere from the ocean, it creates what is called a positive atmospheric flux. A negative flux refers to the ocean absorbing carbon dioxide. Colder and nutrient rich parts of the ocean are able to absorb more carbon dioxide than warmer parts. Therefore, the polar regions typically serve as carbon sinks.
- In soils- Carbon is sequestered in soil by plants through photosynthesis and can be stored as soil organic carbon (SOC). Agro ecosystems can degrade and deplete the SOC levels but this carbon deficit opens up the opportunity to store carbon through new land management practices. Soil can also store carbon as carbonates. Such carbonates are created over thousands of years when carbon dioxide dissolves in water and percolates the soil, combining with calcium and magnesium minerals, forming "caliche" in desert and arid soil.
- In forest- About 25 percent of global carbon emissions are captured by plant-rich landscapes such as forests, grasslands and rangelands. When leaves and branches fall off plants or when plants die, the carbon stored either releases into the atmosphere or is transferred into the soil. Wildfires and human activities like deforestation can contribute to the diminishment of forests as a carbon sink.
- In grasslands: grasslands and rangelands are more reliable areas of storing carbon than forests due to the rapid wildfires and deforestation affecting forests. Grasslands can sequester more carbon underground and when they burn, the carbon stays fixed in the roots and soil instead of in leaves and woody biomass. Granted, forests can store more carbon than grasslands, but in unstable conditions like climate change, grasslands can become more resilient.

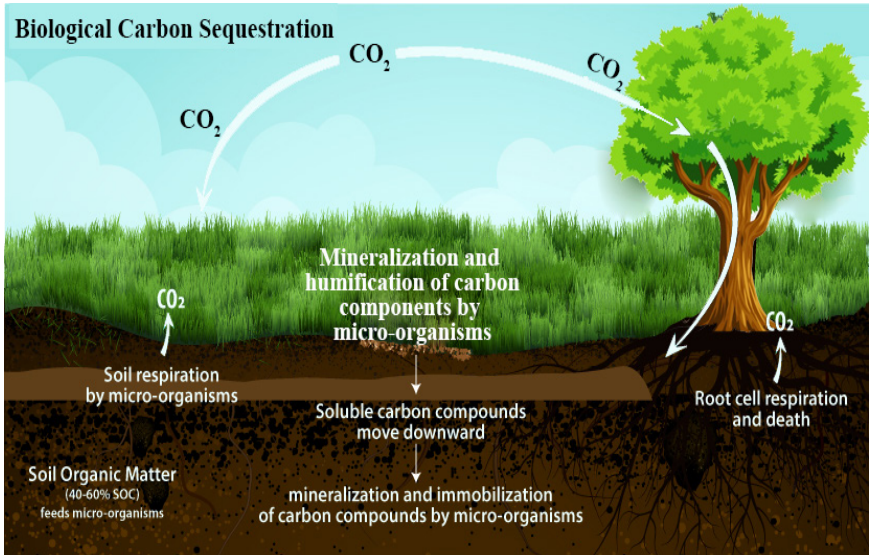

Fig: 4.4.1 Biological Carbon Sequestration

Geological Carbon Sequestration

Geological carbon sequestration is the process of storing carbon dioxide in underground geologic formations, or rocks. Typically, carbon dioxide is captured from an industrial source, such as steel or cement production, or an energy-related source, such as a power plant or natural gas processing facility and injected into porous rocks for long-term storage.

1. Industrial Carbon Sequestration - They capture the carbon in three ways from a power plant, pre-combustion, post-combustion and oxy fuel.

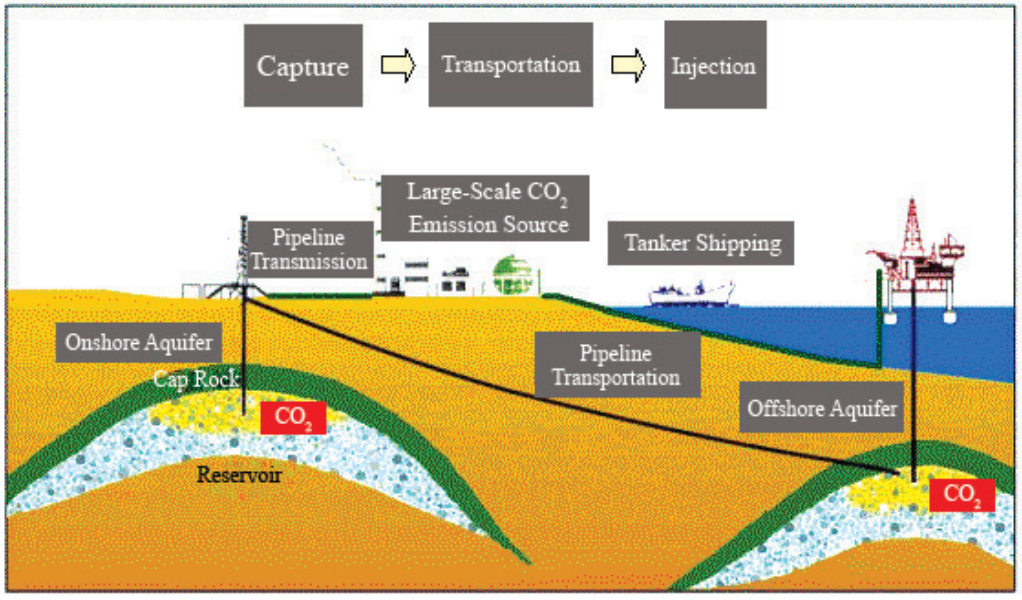

Fig: 4.4.2 Geological Carbon Sequestration

- Pre-combustion: The carbon is captured in power plants before the fuel is burned. The aim is to remove the carbon from coal before it is burned. The coal is reacted with oxygen to produce

synthesis gas, a mixture of carbon monoxide and hydrogen gases.

- Post-combustion: Here, carbon is removed from a power station's output after the fuel has been burned. This means waste gases are captured and scrubbed clean of their carbon dioxide before they travel up smokestacks.
- Oxyfuel or Oxy-combustion: The point is to burn fuel in more oxygen and store all the gases produced as a result.

2. Technological Carbon Sequestration- Uses various technologies to capture CO_2 like:

- Graphene Production:Technology is being used to produce graphene from carbon dioxide as its raw material. Graphene is a technological material, used to create screens for smart phones and other technological devices.
- Direct Air Capture (DAC): A means by which carbon can be captured directly from the air using advanced technology plants. However, this process is energy intensive and expensive. While the techniques such as direct air capture can be effective, they are still too costly to implement on a mass scale.
- Engineered molecules: Scientists are engineering molecules that can change shape by creating new kinds of compounds capable of singling out (distinguishing) and capturing carbon dioxide from the air. The engineered molecules act as a filter, only attracting the element it was engineered to seek.

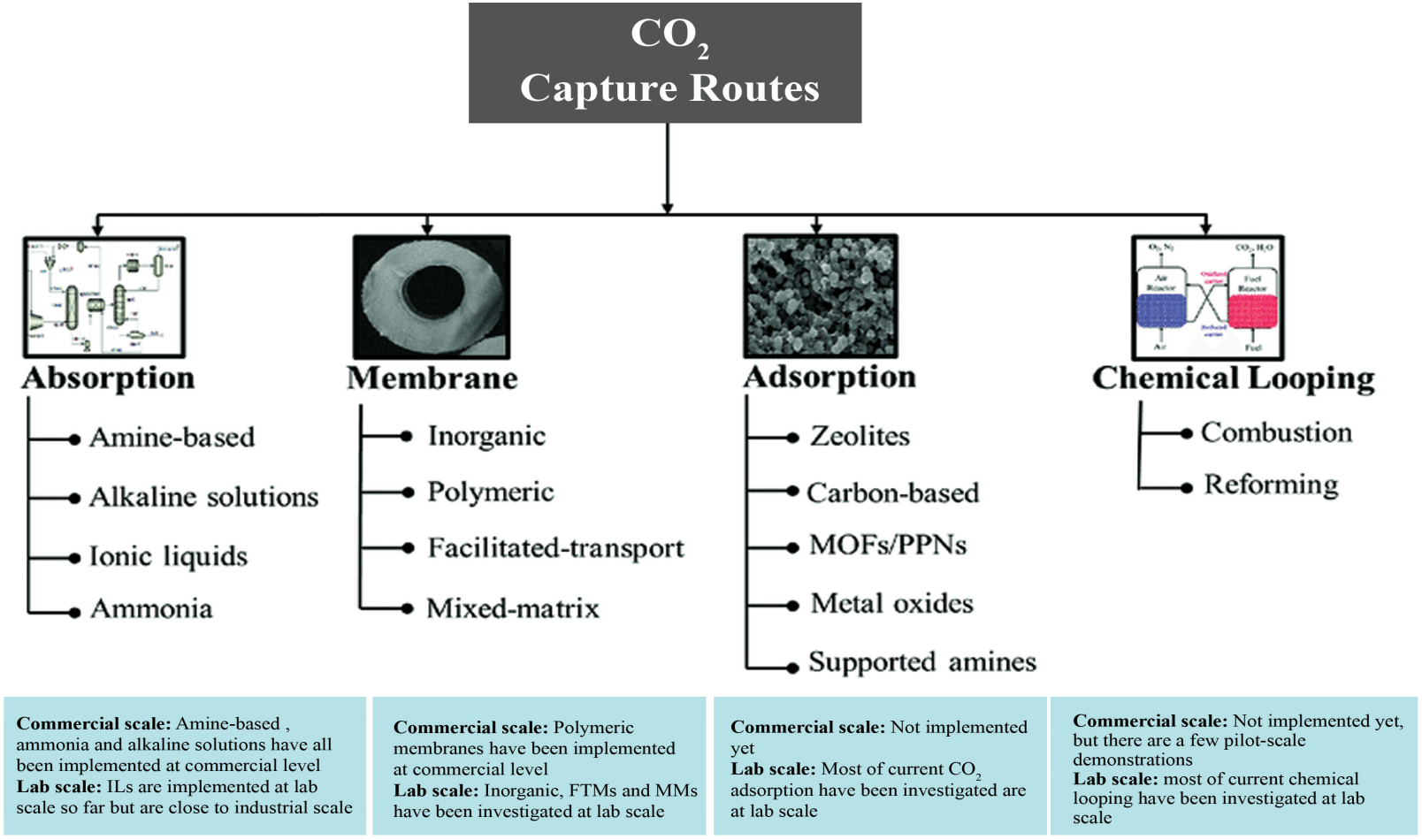

Fig: 4.4.3 Industrial Carbon Sequestration

4.4.2 Carbon footprint

Carbon footprint is the amount of greenhouse gases—primarily carbon dioxide—released into the atmosphere by a particular human activity. A carbon footprint can be a broad measure or be applied to the actions of an individual, a family, an event, an organization, or even an entire nation. It includes direct emissions, such as those that result from fossil-fuel combustion in manufacturing, heating, and transportation, as well as emissions required to produce the electricity associated with goods and services consumed. In addition, the carbon footprint concept also often includes the emissions of other greenhouse gases, such as methane, nitrous oxide, or chlorofluorocarbons (CFCs). It is usually measured as tons of CO_2 emitted per year, a number that can be supplemented by tons of CO_2 equivalent gases, including methane, nitrous oxide, and other greenhouse gases.

According to WHO, a carbon footprint is a measure of the impact your activities have on the amount of carbon dioxide (CO_2) produced through the burning of fossil fuels and is expressed as a weight of CO_2 emissions produced in tonnes.

Carbon footprint calculator

- Many of our daily activities cause emissions of greenhouse gases. Greenhouse gas emissions vary among individuals depending on a person's location, habits, and personal choices.
- The quantity of greenhouse gas emissions from our home electricity use depends on the types of fuel power plant uses to generate the electricity and the amount we use.
- The quantity of greenhouse gases emitted from the furnace and boiler depends on the efficiency of these items, the size and insulation of the house, and the amount and type of fuel used.
- The quantity of emissions from the car or truck depends on how much we drive, what our vehicle's fuel efficiency is, and how we drive (e.g., the amount of time spent idling in traffic).
- In addition, the more recycling we do will reduce the amount of waste sent to landfills, as well as the greenhouse gas emissions that result from processing of raw materials.

4.4.3 Methods of reducing carbon footprint

The following are methods of reducing your carbon footprint:

- Driving more-efficient vehicles (or making sure that your current vehicles are properly maintained),
- Taking public transportation,
- Using energy-efficient appliances,
- Insulating your home to reduce heating and air conditioning costs,
- Consuming food that doesn't require as much transportation, and eating less meat, which has a higher carbon footprint than fruits and vegetables.
- Purchase items with a comparatively low carbon footprint. Some manufacturers have begun assessing and publishing their products' carbon footprints.

- Choose energy-efficient lighting and transition away from incandescent light bulbs
- Individuals and companies can also offset some of their CO_2 emissions by purchasing carbon credits, the money from which can go into projects such as planting trees or investing in renewable energy.

4.4.4 Carbon credit and carbon trading

A carbon credit is a tradable permit or certificate that provides the holder of the credit the right to emit one ton of CO_2 or an equivalent of another greenhouse gas. The main goal for the creation of carbon credit is the reduction of emission of CO_2 and other greenhouse gases from industrial activities to reduce the effect of global warming.

- Carbon credits were devised as a market-oriented mechanism to reduce greenhouse gas emissions.
- Companies get a set number of credits, which decline over time. They can sell any excess to another company.
- Thus, "cap-and-trade" is an incentive to reduce emissions.

Types of credit

- Voluntary Remissions Reduction (VER): A carbon offset that is exchanged in or over the country or voluntary market for credits.
- Certified Emissions reduction (CER): Emission units (credits) created through a regulatory framework with the purpose of offsetting a project's emissions. The main difference between the two is that there is a third party certifying body that regulates the CER as opposed to the VER.

Carbon trade is the buying and selling of credits that permit a company or other entity to emit a certain amount of carbon dioxide. The carbon credits and the carbon trade are authorized by governments with the goal of gradually reducing overall carbon emissions and mitigating their contribution to climate change. Carbon trading is also referred to as carbon emissions trading.

- Carbon trade agreements allow for the sale of credits to emit carbon dioxide between nations as part of an international agreement aimed at gradually reducing total emissions.
- The carbon trade originated with the Kyoto Protocol, a United Nations treaty that set the goal of reducing global carbon emissions and mitigating climate change starting in 2005.
- Various countries and territories have started carbon trading programs—for example, in July 2021, China started a national emissions-trading program.
- Cap and trade, a variation on carbon trade, allows for the sale of emission credits between companies.

These measures are aimed at reducing the effects of global warming but their effectiveness remains a matter of debate.

Carbon Credit and Carbon Trading were created as an answer to the need for controlling emissions (global carbon-dioxide emissions in 2016 were about 36 billion metric tonnes), and as an attempt to reduce the emission of greenhouse and harmful gases coming from industrial activity (industries as power, steel, textile, fertilizer etc. using all fossil fuels – such as coal, oil and natural gas – that are the major materials responsible for greenhouse gas emissions).The Carbon Credits system

was officially formalised in the Kyoto Protocol, while the mechanisms that regulate the Carbon Credits market were established in the Marrakesh Accords. Any government or other regulating body willing to limit the carbon dioxide emissions can issue Carbon Credits. Carbon trading follows the principle of an emissions trading (or cap and trade) approach, i.e., a market-based approach in which economic incentives are given to encourage reductions in the emissions of pollutants. One of the positive aspects of this approach is that organisations can decide to use the emissions trading schemes in a flexible way, finding the best option to meet policy targets. Example- Company A emits less than its target amount of CO_2; this means that Company A has a surplus of Carbon Credits. Company B, on the other hand, emits more than its target amount of hydrocarbon, so either Company B pays a fine or tries to buy Carbon Credits from another company. At this point, Company A and Company B get to an agreement and trade Carbon Credits: Company Asells its surplus to Company B, getting money and a positive image feedback, while Company B buying Carbon Credits from Company A avoids paying a fine.

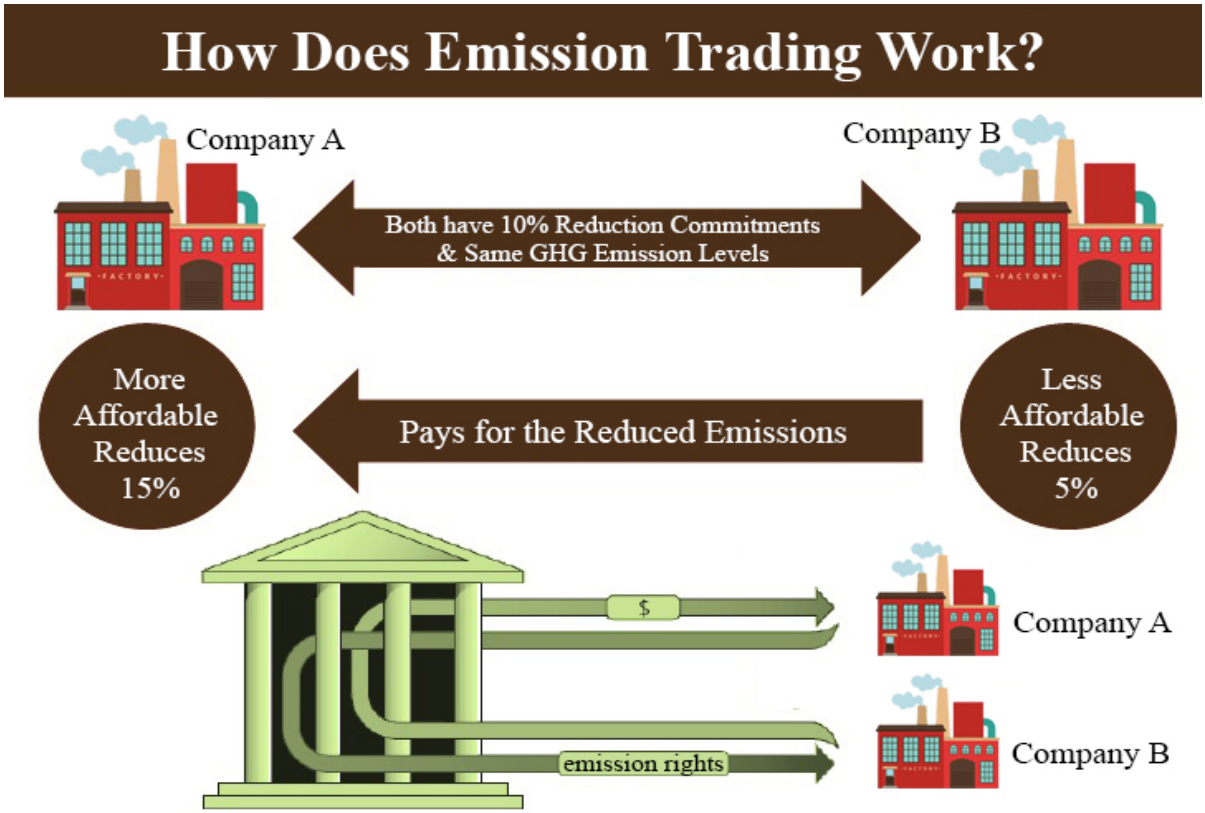

Fig: 4.4.4 Carbon credit and carbon trading methods

4.4.5 The Cap and Trade System

This is how carbon trade works: Each nation is awarded a certain number of permits to emit carbon dioxide up to a certain level. If it does not use up all of its permits it can sell the unused permits to another nation that wants to emit more carbon dioxide than its permits allow. Every year, a slightly smaller number of new permits are awarded to each nation. A cap and trade system is a variation on carbon trade. In this case, the trade, while authorized and regulated by the government, is conduct-

ed between companies. Each company is given a maximum carbon pollution allowance. Unused allowances can be sold to other companies. The goal is to ensure that companies in the aggregate do not exceed a baseline level of pollution. The baseline is reduced annually.

Carbon Credits are bought, on a voluntary basis, by any country or company interested in lowering its carbon footprint. The Kyoto Protocol divides countries into two groups according to the level of their economy: industrialised and developing economies. The first group operates in an emissions trading market, assigning to each country a certain emissions standard to meet. If, for example, a country emits less than its permitted amount of CO_2, it can sell the surplus credits to other countries that do not meet their emissions level goals established by the Kyoto Protocol. This buying and selling of Carbon Credits is regulated by a legal contract called ERPA (Emission Reduction Purchase Agreement). There is also another mechanism, called Clean Development Mechanism and specifically addressed to developing countries, that issues Carbon Credits for supporting sustainable development initiatives (those Carbon Credits are called Certified Emission Reduction, or CER).

Carbon credits can be traded on both private and public markets. Current rules of trading allow the international transfer of credits. The prices of credits are primarily driven by the levels of supply and demand in the market. Due to the differences in the supply and demand in different countries, the prices of the credits fluctuate. The carbon funds provide small investor with the opportunity to enter the market. Buyers and sellers can also use an exchange platform to trade, which is like a stock exchange for carbon credits. In some cases, though, it can happen that it is more economic to pay a fine than to buy Carbon Credits due to their high price.

4.4.6 Environmental Economics

Environmental economics is a sub discipline of economics that applies the values and tools of mainstream economics to allocate environmental resources more efficiently. On the political stage, environmental issues are usu ally placed at odds with economic issues; environmental goods, such as clean air and clean water, are commonly viewed as priceless and not subject to economic consideration. Environmental economists perform studies to determine the theoretical or empirical effects of environmental policies on the economy. This field of economics helps users design appropriate environmental policies and analyse the effects and merits of existing or proposed policies.

- Environmental economics is an evolving discipline that developed as a result of environmental damage caused by economic activities and the pursuit of sustainable development.
- It is concerned with the design of environmental policies and their implementation.
- Environmental economics deals with a number of issues, such as inefficient natural resource allocation, market failure, negative externalities, and management of public goods.
- The approach can either be prescriptive or incentive-based.
- The two main challenges to environmental economics are its transnational nature and its impact on various moving parts of a society.

4.4.7 Origins of Environmental Economics

The origins of environmental economics date back to the 1960s, when industrialization was experiencing a boom, particularly in the western world, and pollution from industrial activity became an increasing concern. Environmental activism also started to increase due to the perceived negative consequences of environmental degradation. The world became aware of rapid economic growth and its consequences to the environment.

Environmental economists see the environment as a form of natural capital that provides amenities and life support functions to the earth's inhabitants. Environmental economics was premised on the neoclassical approach dealing with issues such as inefficient natural resource allocation, market failure, negative externalities, and management of public goods.

As the movement developed over time, other intricate details on the relationship between the environment and the economy became apparent. The study brought about powerful environmental arguments and propositions, which gave rise to contemporary environmental policies and regulations around the world. It led to the establishment of new environmental bodies – chief among them, the United Nations Environment Programme (UNEP) in 1972.10. What are the biological methods of carbon sequestration?

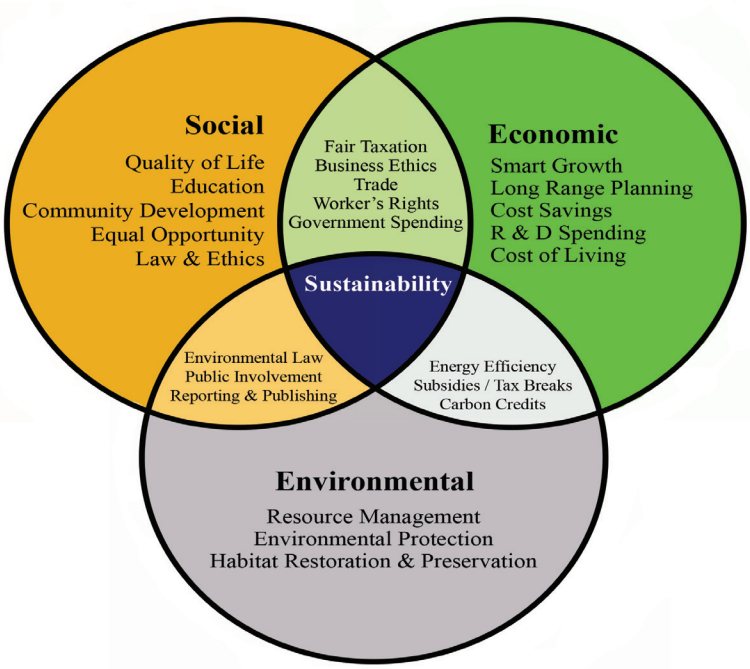

Fig: 4.4.5 Interlinking of environment with social, economic and sustainability aspects.

Environmental economics encompasses the following concepts:

1. Sustainable Development

Sustainable development is defined by UNEP as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." The concept analyses the role of economic development in supporting sustainable development. The four basic components of sustainable development are economic growth, environmental protection, social equity, and institutional capacity.

2. Market Failure

Market failure occurs if the functioning of a perfect market is compromised; hence, it is unable to efficiently allocate scarce resources at a given price as conditions for laws of demand and supply are not met. An example can be an environmental goods such as clean oceans. It is difficult to price the value of clean seas and oceans, and there exist no markets for clean water bodies where it is traded depending on the degree of cleanliness. It is a standard case of market failure.

3. Externalities

Externalities are inadvertent unintentional consequences of economic activity that affect people over and above those directly involved in it. Externalities are also another form of market failure. They can either be negative or positive.,A negative externality creates unplanned outcomes that are harmful to the environment or directly to the general public. An example can be pollution through industrial production, which results in unclean air and water and other health risks. The polluting entities may not incur any costs to address the pollution, even though their activities harm the environment and negatively affect the surrounding community. A positive externality is a benefit to other people not directly involved in its generation. A community nature park can benefit people outside the community who visit family and friends in the area and would not have contributed to its development. People who benefit from an economic resource without contributing to its establishment are called "free riders."

4. Valuation

Valuation is an important aspect of environmental economics, as it helps to evaluate a variety of options in managing challenges with the use of environmental and natural resources. The valuation of ecological resources is a complex process, as it is difficult to assign value to intangible benefits, such as clean air and an unpolluted environment.

Resources that offer multiple benefits are difficult to value – for example, mountains may prevent flooding, provide scenic beauty, direct river flow patterns, and provide fertile soil for agriculture. Environmental resources can be assigned values depending on use and non-use methods. It is easier to assign value to a product in use by observing what consumers are willing to pay.

Opportunity cost pricing, replacement cost, and hedonic pricing techniques can be employed in the "use" method. The contingent valuation technique is used for the "non-use" method by measuring what consumers are willing to pay for a product they do not use or enjoy.

- Green economics refers to an economics discipline that focuses on devising an approach that promotes harmonious economic interactions between humans and nature.
- It has a broad canvas that incorporates means of interaction with nature to the methodology for goods production and social justice.
- It is closely related to ecological economics but is different from it because it is a holistic approach that includes political advocacy of sustainable solutions.

5. Cost-Benefit Analysis

Cost-benefit analysis (CBA) involves weighing the benefits arising from a policy against the perceived benefits. Hence, the best policy

is one in which there is the greatest surplus of benefits over costs.

CBA starts with a base policy where no changes are made to the status quo. A time horizon is selected where the perceived costs and benefits are expected to be realized. Benefits are instances where human well-being is improved, and costs decrease human well-being. Costs and benefits to be realized in the future are discounted using a discount factor to cater to the time value of money. Benefits include extra income, improved quality of life, clean water, and beaches, and costs include opportunity costs, internal and external costs, and externalities.

4.4.8 Green Economy

Green economy or green economics is a methodology of economics that supports the harmonious interaction between humans and nature and attempts to meet the needs of both simultaneously.

The term green economy was first coined in a pioneering 1989 report for the Government of the United Kingdom by a group of leading environmental economists, entitled Blueprint for a Green Economy. Green economic theories encompass a wide range of ideas, all dealing with the interconnected relationship between people and the environment. Green economists assert that the basis for all economic decisions should be in some way tied to the ecosystem and that natural capital and ecological services have economic value.

In many ways, green economics is closely related to ecological economics in the way that it views natural resources as having measurable economic value and in how they focus on sustainability and justice. But when it comes to the application of these ideas, advocates of green economics are more politically focused. Green economists advocate a full cost accounting system in which the entities (government, industry, individuals, etc.) who do harm to or neglect natural assets are held liable for the damage they do.

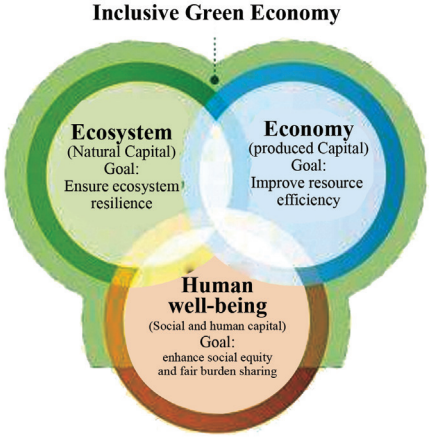

Fig: 4.4.6 Represention of green economy

4.4.9 Circular Economy

The circular economy is a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. In this way, the life cycle of products is extended.In practice, it implies reducing waste to a minimum. When a product reaches the end of its life, its materials are kept within the economy wherever possi-

ble. These can be productively used again and again, thereby creating further value.

According to the World Economic Forum, "A circular economy is an industrial system that is restorative or regenerative by intention and design. It replaces the end-of-life concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse and return to the biosphere, and aims for the elimination of waste through the superior design of materials, products, systems, and business models."

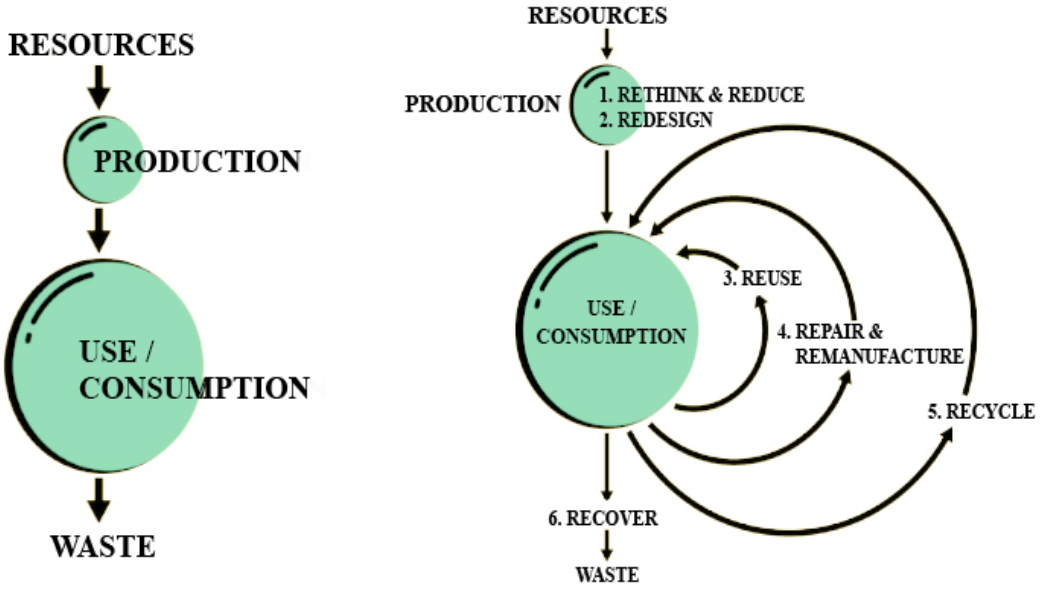

Fig: 4.4.7 Diagram representing linear and circular economy

4.4.10 Principles of circular economy

First, at its core, a circular economy aims to design out waste. Waste does not exist: products are designed and optimized for a cycle of disassembly and reuse. These tight component and product cycles define the circular economy and set it apart from disposal and even recycling, where large amounts of embedded energy and labour are lost.

Second, circularity introduces a strict differentiation between consumable and durable components of a product. Unlike today, consumables in the circular economy are largely made of biological ingredients or 'nutrients' that are at least non-toxic and possibly even beneficial, and can safely be returned to the biosphere, either directly or in a cascade of consecutive uses. Durables such as engines or computers, on the other hand, are made of technical nutrients unsuitable for the biosphere, such as metals and most plastics. These are designed from the start for reuse, and products subject to rapid technological advance are designed for upgrade.

Third, the energy required to fuel this cycle should be renewable by nature, again to decrease resource dependence and increase systems resilience.

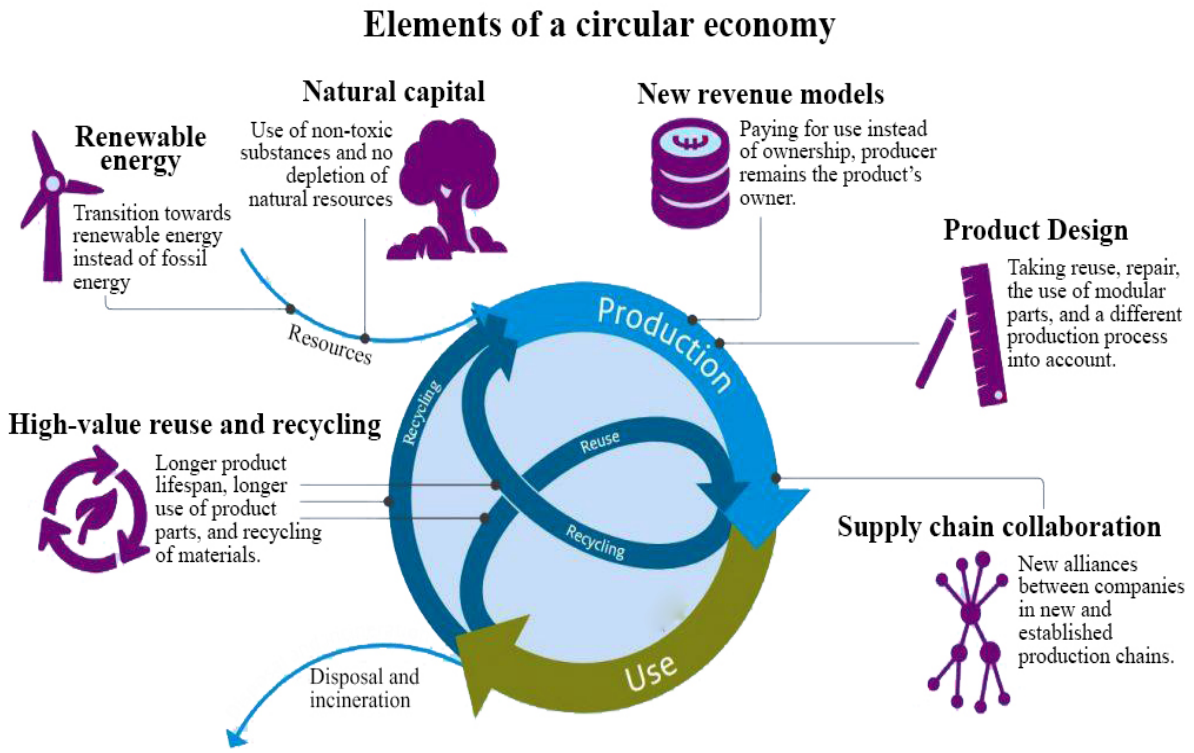

Fig 4.4.8 Elements of circular economy

4.4.11 Environmental Impact Assessment

Consider you have to initiate a new work for your class. What are the things you will consider?

Environmental Impact Assessment (EIA) is a process of evaluating the likely environmental impacts of a proposed project or development, taking into account inter-related socio-economic, cultural and human-health impacts, both beneficial and adverse. UNEP defines Environmental Impact Assessment (EIA) as a tool used to identify the environmental, social and economic impacts of a project prior to decision-making. It aims to predict environmental impacts at an early stage in project planning and design, find ways and means to reduce adverse impacts, shape projects to suit the local environment and present the predictions and options to decision-makers.

EIA systematically examines both beneficial and adverse consequences of the project and ensures that these effects are taken into account during project design. It helps to identify possible environmental effects of the proposed project, proposes measures to mitigate adverse effects and predicts whether there will be significant adverse environmental effects, even after the mitigation is implemented. By considering the environmental effects of the project and their mitigation early in the proj-

ect planning cycle, environmental assessment has many benefits, such as protection of environment, optimum utilisation of resources and saving of time and cost of the project. Properly conducted EIA also lessens conflicts by promoting community participation, informing decision makers, and helping lay the base for environmentally sound projects. Benefits of integrating EIA have been observed in all stages of a project, from exploration and planning, through construction, operations, decommissioning, and beyond site closure.

4.4.12 The EIA Process

The stages of an EIA process will depend upon the requirements of the country or donor. However, most EIA processes have a common structure and the application of the main stages is a basic standard of good practice. However, the EIA process is cyclical with interaction between the various steps.

- Screening: The project plan is screened for scale of investment, location and type of development and if the project needs statutory clearance.
- Scoping: The project's potential impacts, zone of impacts, mitigation possibilities and need for monitoring.
- Collection of baseline data: Baseline data is the environmental status of study area.
- Impact prediction: Positive and negative, reversible and irreversible and temporary and permanent impacts need to be predicted which presuppose a good understanding of the project by the assessment agency.
- Mitigation measures and EIA report: The EIA report should include the actions and steps for preventing, minimizing or by passing the impacts or else the level of compensation for probable environmental damage or loss.
- Public hearing: On completion of the EIA report, public and environmental groups living close to project site may be informed and consulted.
- Decision making: Impact Assessment Authority along with the experts consult the project-in-charge along with consultant to take the final decision, keeping in mind EIA and EMP (Environment Management Plan).
- Monitoring and implementation of environmental management plan: The various phases of implementation of the project are monitored.
- Assessment of Alternatives, Delineation of Mitigation Measures and Environmental Impact Assessment Report: For every project, possible alternatives should be identified, and environmental attributes compared. Alternatives should cover both project location and process technologies. Once alternatives have been reviewed, a mitigation plan should be drawn up for the selected option and is supplemented with an Environmental Management Plan (EMP) to guide the proponent towards environmental improvements.
- Risk assessment: Inventory analysis and hazard probability and index also form part of EIA procedures.

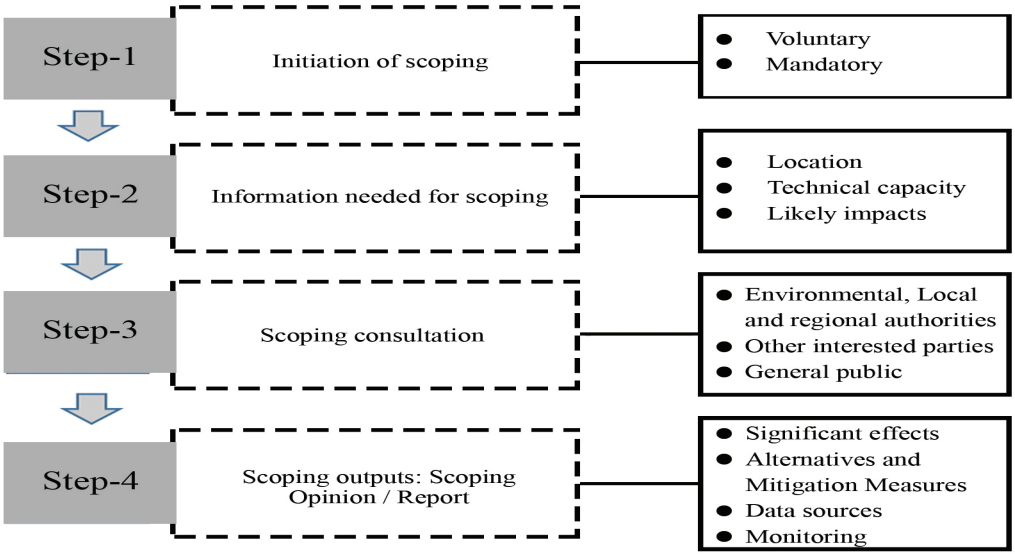

Fig: 4.4.9 Different stages of Scoping

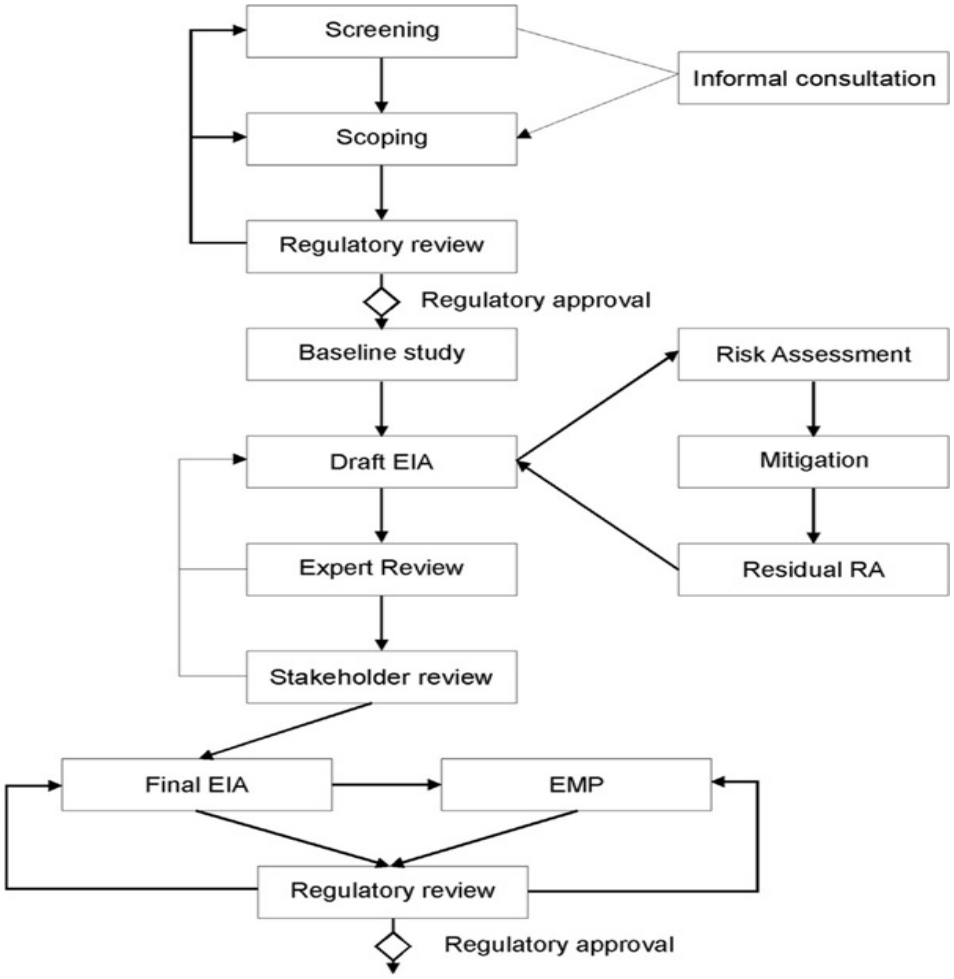

Fig: 4.4.10 Different stages of EIA process

Stakeholders in the EIA Process

- Those who propose the project
- The environmental consultant who prepares EIA on behalf of project proponent
- Pollution Control Board (State or National)
- Public has the right to express their opinion
- The Impact Assessment Agency
- Regional centre of the MoEFCC

Importance of EIA

- EIA links environment with development for environmentally safe and sustainable development.
- EIA provides a cost-effective method to eliminate or minimize the adverse impact of developmental projects.
- EIA enables the decision makers to analyse the effect of developmental activities on the environment well before the developmental project is implemented.
- EIA encourages the adaptation of mitigation strategies in the developmental plan.
- EIA makes sure that the developmental plan is environmentally sound and within the limits of the capacity of assimilation and regeneration of the ecosystem.

Shortcomings of EIA Process

➔Applicability:

There are several projects with significant environmental impacts that are exempted from the notification either because they are not listed in schedule I, or their investments are less than what is provided for in the notification.

➔Composition of expert committees and standards:

It has been found that the team formed for conducting EIA studies is lacking the expertise in various fields such as environmentalists, wildlife experts, Anthropologists and Social Scientists.

➔Public hearing:

1. Public comments are not considered at an early stage, which often leads to conflict at a later stage of project clearance.
2. A number of projects with significant environmental and social impacts have been excluded from the mandatory public hearing process.
3. The data collectors do not pay respect to the indigenous knowledge of local people.

➔Quality of EIA:

One of the biggest concerns with the environmental clearance process is related to the quality of EIA report being carried out.

➔Lack of Credibility:

There are many cases of fraudulent EIA studies where erroneous data has been used, same facts used for two totally different places etc.

Often, and more so for strategic industries such as nuclear energy projects, the EMPs are kept confidential for political and administrative reasons.

Details regarding the effectiveness and implementation of mitigation measures are often not provided.

Emergency preparedness plans are not discussed in sufficient detail and the information not disseminated to the communities.

Recap

- Carbon sequestration is the long-term storage of carbon in plants, soils, geologic formations, and the ocean.
- It is one method of reducing the amount of carbon dioxide in the atmosphere. There are 4 different types of carbon sequestration methods.
- Carbon footprint is the amount of greenhouse gases released into the atmosphere by a particular human activity.
- A carbon credit is a tradable permit or certificate that provides the holder of the credit the right to emit one ton of CO2 or an equivalent of another greenhouse gas.
- Carbon trade is the buying and selling of credits that permit a company or other entity to emit a certain amount of carbon dioxide.
- Environmental economics is a sub discipline of economics that applies the values and tools of mainstream macroeconomics and microeconomics to allocate environmental resources more efficiently.
- Green economy or green economics is a methodology of economics that supports the harmonious interaction between humans and nature and attempts to meet the needs of both simultaneously.
- The circular economy is a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible.
- Environmental Impact Assessment (EIA) is a tool used to identify the environmental, social and economic impacts of a project prior to decision-making.
- The different processes in EIA are Screening, Scoping. Baseline study, Impact prediction. Impact assessment, Mitigation, Producing the environmental impact statement, EIS review

Objective Type Questions

1. Out of different types of fabrics available in the market, which fabric may have lower carbon footprint?
2. How can you minimize your carbon footprint?
3. What is the best way to reduce our carbon footprint?
4. What is 3Es in Environmental economics?
5. What is green economy?
6. What are the three pillars of sustainable development?
7. EIA commenced in which year?
8. How many stages are there in EIA?
9. What does C2C in environmental science stand for?

Answers to Objective Type Questions

1. Cotton (because it is organic and biodegradable)
2. Buy things from a farmer's market just near your area going on foot.
3. Use less and buy less.
4. Energy, Economy and Environment
5. A green economy is a low carbon, resource efficient and socially inclusive economy.
6. The three pillars of sustainable development are energy, economy and environment
7. 1960s
8. 4 stages. They are local level, regional level, national level and global level.
9. Cradle to Cradle

Self Assessment Questions

1. Define carbon sequestration.
2. What are the advantages of Carbon Sequestration?
3. Comment on the disadvantages of Carbon Sequestration.
4. Write an essay on Carbon Sequestration and its effects.
5. Discuss Carbon Footprint.
6. Comment on the method of reducing Carbon Footprint.
7. Describe carbon credit and carbon trading.
8. What are the types of carbon credit?
9. Describe cap and trade system.
10. Write an essay on environmental economics.
11. Describe green economy and circular economy.
12. Write an essay on EIA and EIA process.

Assignments

1. Prepare a poster illustrating the cause and consequences of global warming in a city.
2. Think of some ways to tackle global warming.
3. Find out your and your family's carbon footprint of a day
4. Identify a local project which is planned to be commissioned in your locality and prepare a baseline data.

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Unit 5
A Brief Overview of Prominent Natural Disasters in India

Learning Outcomes

- Learns to distinguish natural and man-made disasters
- Imbibes awareness related to its impact, consequences, prevention and mitigation
- Gets a general understanding of some natural disasters.

Prerequisites

We are hit by natural disasters time and again. These disasters bring about unprecedented havoc reducing humanity to mere helpless and hapless creatures. Landslides, earthquakes, Cyclones, Hurricanes and rainstorms are frequent. Floods have become a common occurrence and there several types of floods, the prominent being, river flood, coastal flood, storm surge, inland flood and flash flood.The word "seismograph" has now become familiar. We all know that it is an instrument used to measure the intensity of earthquakes.

Another curious word is Bulbul - a severe cyclonic storm that struck West Bengal in 2019. It is also interesting to observe that we speak of the "eye of a cyclone".

Keywords

Natural disasters, Man-made disasters, Earthquake, Landslide, Cyclone, Flood

Discussion

Mention some of the natural disasters. How are they caused? Are there any methods to prevent them?

4.5.1 Landslide

A landslide, also called landslip, is defined as the movement of a mass of rock, debris, or earth down a slope. Landslides are a type of "mass wasting," which denotes any downslope movement of soil and rock under the direct influence of gravity. They can happen suddenly or more slowly over long periods of time. Landslides are caused by disturbances in the natural stability of a slope. They can accompany heavy rains or follow droughts, earthquakes, or volcanic eruptions. Landslides occur when gravitational and other types of shear stresses within a slope exceed the shear strength (resistance to shearing) of the materials that form the slope.

Fig: 4.5.1 A landslide occurrence in South Asia

Shear stresses can be built up within a slope by a number of processes. These include over steepening of the base of the slope, such as by natural erosion or excavation, and loading of the slope, such as by an inflow of water, a rise in the groundwater table, or the accumulation of debris on the slope's surface. Short-term stresses, such as those imposed by earthquakes and rainstorms, can likewise contribute to the activation of landslides. Landslides can also be activated by processes that weaken the shear strength of a slope's material. Shear strength is dependent mainly on two factors: frictional strength, which is the resistance to movement between the slope material's interacting constituent particles, and cohesive strength, which is the bonding between the particles. Coarse particles such as sand grains have high frictional strength but low cohesive strength, whereas the opposite is true for clays, which are composed of fine particles. Another factor that affects the shear strength of a slope-forming material is the spatial disposition of the sediment fabric. Some materials with a loose, open sediment fabric will weaken if they are mechanically disturbed or flooded with water. An increase in water content, resulting from either natural causes or human activity, typically weakens sandy materials through the reduction of interparticle friction and weakens clays through the dissolution of interparticle cements, the hydration of clay minerals, and the elimination of interparticle (capillary) tension.

When the force of gravity acting on a slope exceeds the resisting forces of a slope, the slope will fail and a landslide occurs. External factors can lead to landslides happening, including:

- heavy rainfall leading to saturation of the ground
- erosion of the base of a slope
- changes to the material's strength through weathering

Why do landslides happen?

A landslide may occur because the strength of the material is weakened. This reduces the power of the 'glue' that cements the rock or soil grains together. Located on a slope, the rock is then no longer strong enough to resist the forces of gravity acting upon it.

Several factors can increase a slope's susceptibility to a landslide event.

- Water: Adding water to the material on a slope makes a landslide more likely to happen. This is because water adds weight, lowers the strength of the material and reduces friction, making it easier for material to move downslope.
- Erosion processes: If the bottom of a slope is continually eroded, for example by the sea or a river, the slope will eventually become too steep to hold itself up.
- Slope angle (steepness of slope): The slope angle is a key factor as far as landslides are concerned. Any change to this makes it steeper (such as coastal erosion) increases the likelihood of a landslide.
- Rock type: the type of rocks in the slope, and their combination, can increase the chance of a landslide.
- Grain shape: the shape of the grains that make up a rock can affect the risk of a landslide.
- Jointing and orientation of bedding planes.
- Arrangement of the rock layers.
- Weathering processes: eg- freeze-thaw reduces the cohesion ('stickiness') between the rock grains.
- Vegetation: Vegetation helps bind material together; removing veg-

etation increases the chance of a landslide.

- Flooding.
- Volcanoes and earthquake activity nearby.
- Human activity: Mining, traffic vibrations or urbanisation change surface water drainage patterns.

4.5.2 Types of landslides

Landslides are generally classified by type of movement (slides, flows, spreads, topples, or falls) and type of material (rock, debris, or earth). Sometimes more than one type of movement occurs within a single landslide, and, because the temporal and spatial relationships of these movements are often complex, their analysis often requires detailed interpretation of both landforms and geological sections, or cores.

1. Slides- Rockslides and other types of slides involve the displacement of material along one or more discrete shearing surfaces. The sliding can extend downward and outward along a broadly planar surface (a translational slide), or it can be rotational along a concave-upward set of shear surfaces (a slump). A translational slide typically takes place along structural features, such as a bedding plane or the interface between resistant bedrock and weaker overlying material. If the overlying material moves as a single, little-deformed mass, it is called a block slide. A translational slide is sometimes called a mud slide when it occurs along gently sloping, discrete shear planes in fine-grained rocks (such as fissured clays) and the displaced mass is fluidized by an increase in pore water pressure. In a rotational slide the axis of rotation is roughly parallel to the contours of the slope. The movement near the head of the slide is largely downward, exposing a steep head scarp, and movement within the displaced mass takes place along internal slip planes, each tending to tilt backward. Over time, upslope ponding of water by such back-tilted blocks can enlarge the area of instability, so that a stable condition is reached only when the slope is reduced to a very low gradient.

2. Flows- A type of landslide in which the distribution of particle velocities resembles that of a viscous fluid is called a flow. The

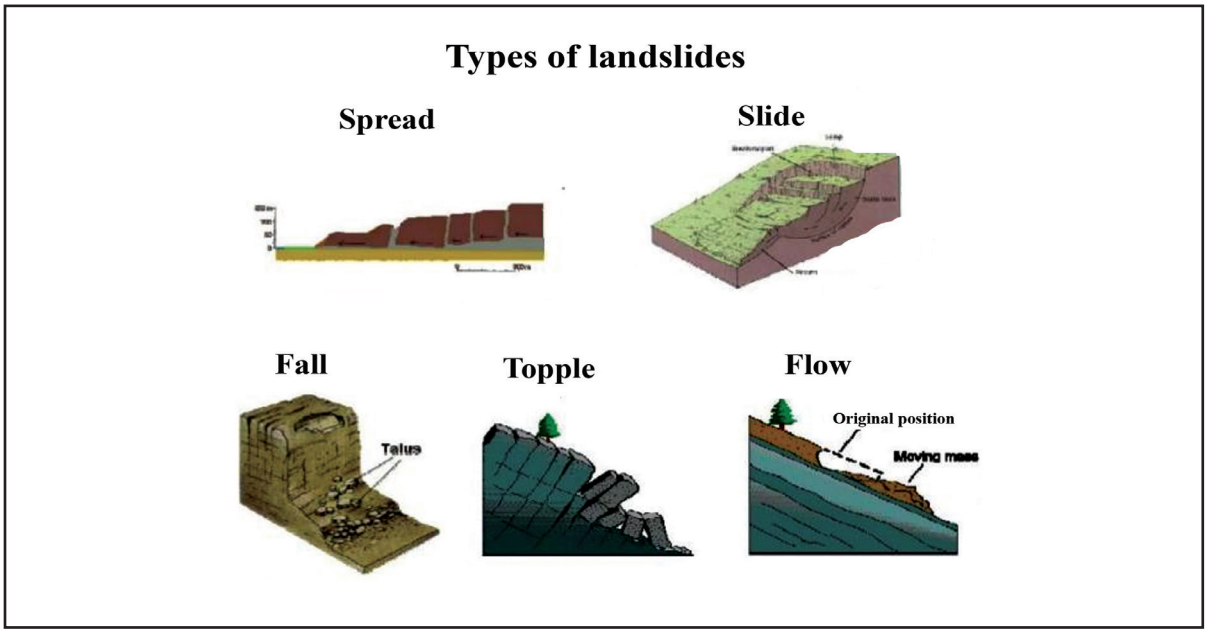

Fig: 4.5.2 Types of landslides

most important fluidizing agent is water, but trapped air is sometimes involved. Contact between the flowing mass and the underlying material can be distinct, or the contact can be one of diffuse shear. The difference between slides and flows is gradational, with variations in fluid content, mobility, and type of movement, and composite slide movement and flow movement are common.

3. Spreads- A spread is the complex lateral movement of relatively coherent earth materials resting on a weaker substrate that is subject to liquefaction or plastic flow. Coherent blocks of material subside into the weaker substrate, and the slow downslope movement frequently extends long distances as a result of the retrogressive extension from the zone of origin, such as an eroding riverbank or coastline. Spreads occur as the result of liquefaction caused by water saturation or earthquake shock in such substrates as loess, a weakly cemented wind-lain silt.

4. Toppling - Rotation of a mass of rock, debris, or earth outward from a steep slope face is called toppling. This type of movement can subsequently cause the mass to fall or slide.

4.5.3 Landslide mitigation and prevention

Landslides pose a recurrent hazard to human life and livelihood in most parts of the world, especially in some regions that have experienced rapid population and economic growth. Hazards are mitigated mainly through precautionary means, by restricting or even removing populations from areas with a history of landslides, by restricting certain types of land use where slope stability is in question, and by installing early warning systems based on the monitoring of ground conditions such as strain in rocks and soils, slope displacement, and groundwater levels. There are also various direct methods of preventing landslides; these include modifying slope geometry, using chemical agents to reinforce slope material, installing structures such as piles and retaining walls, grouting rock joints and fissures, diverting debris pathways, and rerouting surface and underwater drainage. Such direct methods are constrained by cost, landslide magnitude and frequency, and the size of human settlements at risk.

4.5.4 Flood

Do you remember the Chennai floods of 2016, Kerala floods of 2018 and 2019? Do you know how they were caused?

A flood is an overflow of water that submerges land that is usually dry. Floods can happen during heavy rains, when ocean waves come on shore, when snow melts quickly, or when dams or levees break. Damaging flooding may happen with only a few inches of water, or it may cover a house to the rooftop. Floods can occur within minutes or over a long period, and may last days, weeks, or longer. Floods are the most common and widespread of all weather-related natural disasters.

4.5.4.1 Causes of Flood

Flood is usually a result of natural causes. It may also be caused by man-made factors. It causes huge damage to life and property. There are many different causes leading to flooding.

1. Massive Rainfall

Drainage systems and the effective infrastructure design aid during heavy rains. They help the drainage of excess water into reservoirs in an easy way. But in cases of heavy rainfall, the systems stop working. Thus flood is caused.

2. Overflowing of the Rivers

The people living along the river always have a risk of life from the overflowing of the riv-

ers. To prevent such a situation, a string of dams are built. However, if these dams are not managed properly, they may cause flooding and huge damage.

3.Collapsed Dams

In the event of huge rainfall, the dams built begin to collapse, thus, causing the flood situation to become critical for the people living around.

4.Snowmelt

At the time of the high melting of snow due to heavy precipitation and other factors, the situation of flooding arises. Adopting sustainable measures for heavy precipitation can help in dealing with the flooding situation.

5.Deforestation

Trees prevent soil erosion and also the loss of crops. The vegetation is also enriched as a result of more and more trees. This also blocks the massive flow of rain, thus preventing flooding.

6.Climate change

The climatic changes caused due to human practices also add to the risk of flooding. Human beings cut trees in large numbers, thus affecting the process of photosynthesis. Increased level of carbondioxide in the atmosphere cause changes in climate, posing threats of natural disasters like floods etc.

7.Emission of Greenhouse Gases

The burning of fossil fuels, industrial influences and pollution are depleting the level of the ozone layer and increasing the level of greenhouse gases, thus becoming a major cause of man-made flooding.

8.Other Factors

Broken supply lines cause the outflow of water but lead to less damage. There is water flow from the washing machine and overflow from dishwashers worsening the situation. The lack of proper sewage systems adds to the destruction of this natural disaster.

4.5.4.2 Types of Flooding

There are five types of floods. They include:

1. River Flood-A River flood occurs when water levels rise over the top of river banks. This flooding can happen in all rivers and stream channels. This includes everything from small streams to the world's largest rivers. River floods can happen suddenly or slowly. Sudden river flooding events occur more often on smaller rivers, rivers with steep valleys, rivers that flowmuch of their length over impermeable terrain, and normally dry channels. On the other hand, low-rising river floods typically occur in large rivers with large catchment areas.

Causes of River FloodingRiver flooding typically happens for four reasons. They are:

- Excessive rain from tropical storm systems making landfall
- Persistent thunderstorms over the same area for extended periods
- Combined rainfall and snowmelt

Fig: 4.5.3 River Flooding observed in Kerala during 2018 flood

2. Coastal Flooding

This type of flood occurs when land is submerged by sea water.

Causes of Coastal Flooding

Coastal flooding is typically a result of a combination of sea tidal surges, high winds, and barometric pressure.These conditions typically come from storms at sea like:

• Tropical cyclones

• Tsunami

• Higher-than-average tides

Fig 4.5.4 A Ruined House in Coastel Flood

3. Storm surge- Storm surge is an abnormal rise in water level in coastal areas over and above the regular astronomical tide. Storm surge is an extremely dangerous form of flooding. It can flood large coastal areas at the same time. It can also cause flooding very quickly. Extreme flooding occurs when storm surge happens at the same time as high tide. This can cause storm tides to reach over 20 feet.

Causes of Storm Surge

Storm surge is always a result meteorological storms that cause higher than normal tides on the coast. There are three parts of a storm that create this surge. They are:

• Wind

• Waves

• Low atmospheric pressure

Fig: 4.5.5 Storm Surge

4. Inland Flood- An inland flood is flooding that occurs inland or not in a coastal area. Therefore, coastal flooding and storm surge are not inland floods.

Causes of Inland Flooding

- Rainfall is almost always to blame for inland floods. Rain causes inland flooding in two ways. It can happen with steady rainfall over several days or it can happen because of a short and intense period of rainfall.
- Snowmelt also causes inland floods, although rainfall is a more common cause.
- Another way inland flooding happens is when water ways get blocked by debris, ice, or dams.

Inland floods are often worse in urban areas because there isn't anywhere for the water to go. The following urban features can create urban flooding or make inland floods worse:

- Paved roads and streets
- Low-capacity drainage equipment
- Dense buildings
- Low amounts of green space

Fig 4.5.6 Inland flooding observed in US

5. Flash Flood- A flash flood is flooding that begins within 6 hours, and often within 3 hours, of heavy rainfall (or other cause).

Causes of Flash Floods

Flash floods can happen for several reasons. Most flash floods happen after extremely intense rainfall from severe thunderstorms over a short period of time (normally 6 hours or less). Flash floods also happen when dams break, when levees fail, or when an ice jam releases a large amount of water. There are two key elements to determine flash flooding is

a) Rainfall rate

b) Rainfall duration

4.5.5 Cyclones

Cyclones are caused by atmospheric disturbances around a low-pressure area distinguished by swift and often destructive air circulation. Cyclones are usually accompanied by violent storms and bad weather. Or in other words, Cyclones are large revolving tropical storms caused by winds blowing around a central area of low atmospheric pressure. In the southern hemisphere these tropical storms are called cyclones and rotate in a clockwise direction, while in the northern hemisphere cyclones are called hurricanes or typhoons and rotate in an anti-clockwise direction.

Cyclones are classified as: (i) tropical cyclones. (ii) extra tropical cyclones (also called temperate cyclones)

Tropical Cyclones - Cyclones that form closer to the Equator (i.e., at latitudes 10° to 25° north and south over the oceans) are known as tropical cyclones, typhoons or hurricanes and are much smaller in diameter. They form an intense circular storm that originates over warm tropical oceans and is characterized by low atmospheric pressure, high winds, and heavy rain. Tropical cyclones are the progeny of ocean and atmosphere, powered by the heat from the sea; and driven by easterly trades and temperate westerlies, high planetary winds and their own fierce energy. They develop in the regions between the Tropics of Capricorn and Cancer. Tropical cyclones are large-scale weather systems developing over tropical or subtropical waters, where they get organized into surface wind circulation. Drawing energy from the sea surface and maintaining its strength as long as it remains over warm water, a tropical cyclone generates winds that exceed 119 km (74 miles) per hour.

Extra tropical Cyclones- Extratropical cyclone, also called wave cyclone or mid-latitude cyclone, a type of storm system formed in middle or high latitudes, in regions of large horizontal temperature variations called frontal zones. Extratropical cyclones present a contrast to the more violent cyclones or hurricanes of the tropics. In high and middle latitudes a number of extratropical cyclones normally exist around the globe at any given time. These storms tend to form in preferred locations and follow typical paths, although exceptions to these typical patterns often occur.

4.5.6 Earthquake

Earth quake refers to any sudden shaking of the ground caused by the passage of seismic waves through Earth's rocks. Seismic waves are produced when some form of energy stored in Earth's crust is suddenly released, usually when masses of rock straining against one another suddenly fracture and "slip." The surface where they slip is called the fault or fault plane. The location below the earth's surface where the earthquake starts is called the hypocentre, and the location directly above it on the surface of the earth is called the epicentre.

While the edges of faults are stuck together, and the rest of the block is moving, the energy that would normally cause the blocks to slide past one another is being stored up. When the force of the moving blocks finally overcomes the friction of the jagged edges of the fault and it unsticks, all that stored up energy is released. The energy radiates outward from the fault in all directions in the form of seismic waves like ripples on a pond. The seismic waves shake the earth as they move through it, and when the waves reach the earth's surface, they shake the ground.

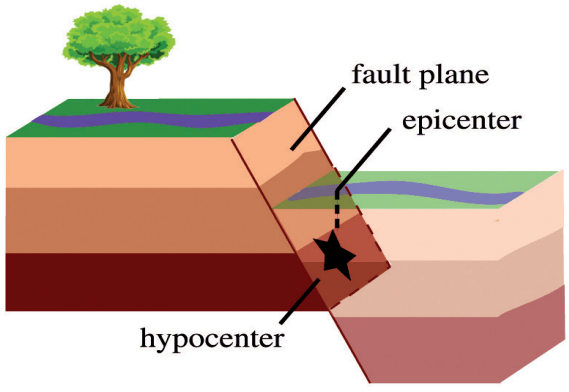

Fig: 4.5.7 A normal (dip-slip) fault is an inclined fracture where the rock mass above an inclined fault moves down

Earthquakes are recorded by instruments called seismographs. The recording they make is called a seismogram. The seismograph has a base that sets firmly in the ground, and a heavy weight that hangs free. When an earthquake causes the ground to shake, the base of the seismograph shakes too, but the hanging weight does not. Instead, the spring or string that it is hanging from absorbs all the movement. The difference in position between the shaking part of the seismograph and the motionless part is what is recorded. Scientists then use a method called triangulation to determine exactly where the earthquake was (see image below). It is called triangulation because a triangle has three sides, and it takes three seismographs to locate an earthquake.

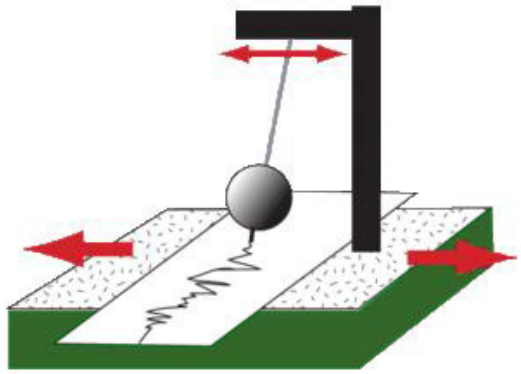

Fig: 4.5.8 The seismograph shows how the instrument shakes with the earth below it

4.5.7 Earthquake waves

When an earthquake occurs, it releases waves of energy, which are known as Seismic waves. It is like the ripples created in water when you throw a stone in it. Seismic waves are like those ripples which can travel through the inside of the earth, as well as on the surface.

P waves, S waves, and Surface waves

Body waves are those waves that travel through the earth. They originate at the epicentre of the earthquake and travel through

the earth at amazing speeds. There are two types of body waves namely,

- P waves
- S waves

Surface waves are those waves that travel on the surface of the earth. The destruction caused by earthquakes is primarily done by these waves.

P waves and S waves

P waves or Primary waves are the first waves to hit the seismographs when an earthquake strikes. They are longitudinal waves which means that the direction of motion and propagation are the same.

- S waves also called secondary waves and shear waves, are the second waves to hit the seismographs. They are transverse waves, which means that the motion is perpendicular to the direction of wave propagation. S waves can only travel through solids and scientists have been successful in mapping the interior of the earth by studying the routes of these waves.

Recap

- Landslide is defined as the movement of a mass of rock, debris, or earth down a slope.
- Short-term stresses, such as those imposed by earthquakes and rainstorms, can likewise contribute to the activation of landslides.
- A flood is an overflow of water that submerges land that is usually dry.
- There are natural and manmade factors of flood.
- Types of floods include- river flood, coastal flood, storm surge, inland flood and flash flood.
- Cyclones are large revolving tropical storms caused by winds blowing around a central area of low atmospheric pressure.
- The centre of a cyclone which is usually cloudless and calm is called “The Eye” of a cyclone with no rain and very light winds.
- An Earthquake can be defined as any sudden shaking of the ground caused by the passage of seismic waves through Earth’s rocks.
- The location below the earth’s surface where the earthquake starts is called the hypocentre, and the location directly above it on the surface of the earth is called the epicentre.
- Earthquakes are recorded by instruments called seismographs.

Objective Type Questions

1. Define Landslide?
2. Why do so many landslides occur near mountains, rather than in flat areas?
3. Define flash flood.
4. How do you measure the size of a flood?
5. What are the environmental consequences of flood?
6. What is an Eye of a cyclone?
7. Name the severe cyclonic storm that struck West Bengal in 2019?
8. What is the tropical cyclones in the Atlantic called?
9. In which oceans are Earthquakes most frequent in?

Answers to Objective Type Questions

1. Landslide can be defined as the movement of a mass of rock, debris, or earth down a slope.
2. Mountains are big hills which allow the dirt to slide down them quickly.
3. Flash floods are those which occur suddenly and unexpectedly and for a short duration
4. The size of a flood can be measured by the highest level that water in a waterway reaches, referred to as the 'peak water level' or 'flood peak'.
5. Dispersal of weed species, soil erosion, release of pollutants etc.
6. The low pressure area at the centre of a cyclone
7. Bulbul
8. Hurricanes
9. Pacific Ocean

Assignments

1. Identify the flood prone locations in your area and come up with suitable measures to prevent and mitigate the ill effects of flood.
2. Make a detailed report on the impacts of 2018 and 2019 Kerala flood.

Suggested Reading

1. Abhaya S. Prasad, Louis Hugo Francescutti, in International Encyclopedia of Public Health (Second Edition), 2017
2. L.M. Lee, in Encyclopedia of the Anthropocene, 2018
3. Rongxing Guo, in Cross-Border Resource Management (Fourth Edition), 2021

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Unit 6
Important Acts and Rules for the Conservation of Environment

Learning Outcomes

- Learns about, understanding and awareness related to environmental conservation process.
- Gets familiarised with the scope and concept of environmental law
- Learns to inculcate healthy personal and social attributes towards environment

Prerequisites

Life on Earth has become highly challenging. Humanity has made the life of all the creatures in the Universe very dangerous. We have destroyed water bodies and forest reservoirs. Many species have become extinct.

There have been protests and agitations against such greedy and violent acts of mankind. This has forced the governments and organisations across the globe to pass laws against indiscriminate killing of animals and birds.

All of us are familiar with The National Board for Wildlife, The National Tiger Conservation Authority. Wildlife Protection Act 1972, The Environment Protection Act, 1986, The Water Prevention and Control of Pollution Act, 1974, The Washington Convention, etc,.

Let us also learn about sanctuary-- a place of refuge where injured, abandoned, and abused wildlife is allowed to live in peace in their natural environment without any human intervention.

Keywords

Air act, Water act, Wildlife conservation, Sanctuaries, National Parks, Environmental Protection Act

Discussion

You must be aware of various rules and regulations existing in India. But have you ever thought of any law related to environmental issues?

4.6.1 Wildlife Protection Act, 1972

This Act provides for the protection of the country's wild animals, birds, and plant species, in order to ensure environmental and ecological security. Among other things, the

Act lays down restrictions on hunting many animal species. The Act was last amended in the year 2006.

Constitutional Provisions for the Wildlife Act Article 48A of the Constitution of India directs the States to protect and improve the environment and safeguard wildlife and forests. This article was added to the Constitution by the 42nd Amendment in 1976.

Article 51A imposes certain fundamental duties on the people of India. One of them is to protect and improve the natural environment including forests, lakes, rivers, and wildlife and to have compassion for living creatures.

4.6.2 History of wildlife protection legislation in India

The first such law was passed by the British Indian Government in 1887 called the Wild Birds Protection Act, 1887. The law sought to prohibit the possession and sale of specified wild birds that were either killed or captured during a breeding session.

A second law was enacted in 1912 called the Wild Birds and Animals Protection Act. This was amended in 1935 when the Wild Birds and Animals Protection (Amendment) Act 1935 was passed.

During the British Raj, wildlife protection was not accorded a priority. It was only in 1960 that the issue of protection of wildlife and the prevention of certain species from becoming extinct came into the force.

4.6.3 Salient Features of Wildlife Protection Act

The following Salient Features of Wildlife Protection Act

- This Act provides for the protection of a listed species of animals, birds, and plants, and also for the establishment of a network of ecologically-important protected areas in the country.
- The Act provides for the formation of wildlife advisory boards, wildlife wardens, specifies their powers and duties, etc.
- It helped India become a party to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).
- CITES is a multilateral treaty with the objective of protecting endangered animals and plants.
- It is also known as the Washington Convention and was adopted as a result of a meeting of IUCN members.
- For the first time, a comprehensive list of the endangered wildlife of the country was prepared.
- The Act prohibited the hunting of endangered species.
- Scheduled animals are prohibited from being traded as per the Act's provisions.
- The Act provides for licenses for the sale, transfer, and possession of some wildlife species.
- It provides for the establishment of wildlife sanctuaries, national parks etc.
- Its provisions paved the way for the formation of the Central Zoo Authority. This is the central body responsible for the oversight of zoos in India. It was established in 1992.
- The Act created six schedules which gave varying degrees of protection to classes of flora and fauna.
- Schedule I and Schedule II (Part II) get absolute protection, and offences under these schedules

attract the maximum penalties.

- The schedules also include species that may be hunted.

The National Board for Wildlife was constituted as a statutory organization under the provisions of this Act.

- This is an advisory board that offers advice to the central government on issues of wildlife conservation in India.
- It is also the apex body to review and approve all matters related to wildlife, projects of national parks, sanctuaries, etc.
- The chief function of the Board is to promote the conservation and development of wildlife and forests.
- It is chaired by the Prime Minister.

The Act also provided for the establishment of the National Tiger Conservation Authority.

- It is a statutory body of the Ministry of Environment, Forest and Climate Change with an overall supervisory and coordination part, performing capacities as given in the Act.
- Its mandate is to strengthen tiger conservation in India.
- It gives statutory authority to Project Tiger which was launched in 1973 and has put the endangered tiger on a guaranteed path of revival by protecting it from extinction.

4.6.4 Protected Areas under the Wildlife Protection Act

There are five types of protected areas as provided under the Act. They are described below.

1. Sanctuaries: "Sanctuary is a place of refuge where injured, abandoned, and abused wildlife is allowed to live in peace in their natural environment without any human intervention." They are naturally-occurring areas where endangered species are protected from poaching, hunting, and predation.

- Here, animals are not bred for commercial exploitation. The species are protected from all sorts of disturbance.
- Animals are not allowed to be captured or killed inside the sanctuaries.
- A wildlife sanctuary is declared by the State government by a Notification. Boundaries can be altered by a Resolution of the State Legislature.
- Human activities such as timber harvesting, collecting minor forest products, and private ownership rights are permitted as long as they do not interfere with the animals' well-being. Limited human activity is permitted.
- They are open to the general public. But people are not allowed unescorted. There are restrictions as to who can enter and/or reside within the limits of the sanctuary. Only public servants (and his/her family), persons who own immovable property inside, etc. are allowed. People using the highways which pass through sanctuaries are also allowed inside.
- Boundaries of sanctuaries are not generally fixed and defined.
- Biologists and researchers are permitted inside so that they can study the area and its inhabitants.
- The Chief Wildlife Warden (who is the authority to control, manage and maintain all sanctuaries)

may grant permission to persons for entry or residence in the sanctuary for the study of wildlife, scientific research, photography, the transaction of any lawful business with persons residing inside, and tourism.

- Sanctuaries can be upgraded to the status of a 'National Park'.

2. National Parks: "National Parks are the areas that are set by the government to conserve the natural environment."

- A national park has more restrictions as compared to a wildlife sanctuary.
- National parks can be declared by the State government by Notification. No alteration of the boundaries of a national park shall be made except on a resolution passed by the State Legislature.
- The main objective of a national park is to protect the natural environment of the area and biodiversity conservation.
- The landscape, fauna, and flora are present in their natural state in national parks.
- Their boundaries are fixed and defined.
- Here, no human activity is allowed.
- Grazing of livestock and private tenurial rights are not permitted here.
- Species mentioned in the Schedules of the Wildlife Act are not allowed to be hunted or captured.
- No person shall destroy, remove, or exploit any wildlife from a National Park or destroy or damage the habitat of any wild animal or deprive any wild animal of its habitat within a national park.
- They cannot be downgraded to the status of a 'sanctuary'.

Examples: Bandipur National Park in Karnataka

3. Conservation Reserves: The State government may declare an area (particularly those adjacent to sanctuaries or parks) as conservation reserves after consulting with local communities.

4. Community Reserves: The State government may declare any private or community land as a community reserve after consultation with the local community or an individual who has volunteered to conserve the wildlife.

5. Tiger Reserves: These areas are reserved for the protection and conservation of tigers in India. They are declared on the recommendations of the National Tiger Conservation Authority.

The amended Wildlife Act does not allow any commercial exploitation of forest produce in both wildlife sanctuaries and national parks, and local communities are allowed to collect forest produce only for their bona fide requirements.

4.6.5 Air (Prevention and Control of Pollution) Act of 1981

The Air (Prevention and Control of Pollution) Act of 1981, or the Air Act, in short, was a law passed by the Parliament of India to prevent and control the harmful effects of air pollution in India. This act is seen as the first concrete step taken by the government of India to combat air pollution.

Decisions were taken at the United Nations Conference on the Human Environment held in Stockholm in June, 1972, in which India participated, to take appropriate steps for the preservation of the natural resources of the earth which, among other things, include the preservation of the quality of air and control of

air pollution and whereas it is considered necessary to implement the decisions aforesaid in so far as they relate to the preservation of the quality of air and control of air pollution.

Short title, extent and commencement

1. This Act may be called the Air (Prevention and Control of Pollution) Act, 1981.

2. It extends to the whole of India.

3. It shall come into force on such a date as the Central Government may, by notification in the official Gazette, appoint.

The Act clearly states and explain each and every term very precisely: air pollutant, air pollution, approved appliances, approved fuel, automobile, central board, chimney, control equipment, emission, industrial plant, member, occupier, prescribed, state board.

Definitions under the Air Act

The following are the definitions under the Air (Prevention and Control of Pollution) Act.

- Section 2(a) defines 'air pollutants' as any solid liquid or gaseous substance which may cause harm to or damage the environment, humans, plants, animals or even damage property. A 1987 amendment to the act also added 'noise' in the list of harmful substances.

  The air act defines 'air pollution' as the presence of any dangerous pollutant that makes the air unbreathable.
- Section 2 (g) of the Act also set up the Central Pollution Control Board (CPCB) whose powers extended to the whole of India. To carry out the directives of the CPCB the act also called for the setting up of the State Pollution Control Board (SPCB) for the individual states of India.

4.6.6 The Environment Protection Act, 1986

The Environment Protection Act, 1986 (the "Environment Act") provides for the protection and improvement of the environment. The Environment Protection Act establishes the framework for studying, planning and implementing long-term requirements of environmental safety and laying down a system of speedy and adequate response to situations threatening the environment. It is an umbrella legislation designed to provide a framework for the coordination of central and state authorities established under the Water Act, 1974 and the Air Act.

Under the Environment Act, the Central Government is empowered to take measures necessary to protect and improve the quality of environment by setting standards for emissions and discharges of pollution in the atmosphere by any person carrying on an industry or activity; regulating the location of industries; management of hazardous wastes, and protection of public health and welfare. From time to time, the Central Government issues notifications under the Environment Act for the protection of ecologically-sensitive areas or issues guidelines for matters under the Environment Act.

In case of any non-compliance or contravention of the Environment Act, or of the rules or directions under the said Act, the violator will be punishable with imprisonment up to five years or with fine up to Rs 1,00,000, or with both. In case of continuation of such violation, an additional fine of up to Rs 5,000 for every day during which such failure or contravention continues after the conviction for the first such failure or contravention, will be levied. If the violation continues beyond a period of one year after the date of conviction, the offender shall be punishable with imprisonment for a term which may extend to seven years.

Short Title, Extent and Commencement of the Act

1. This Act may be called the Environment (Protection) Act, 1986.

2. It extends to the whole of India.

3. It shall come into force on such date as the Central Government may, by notification in the Official Gazette, appoint and different dates may be appointed for different provisions of this Act and for different areas.

The Act clearly states and explain each and every term very precisely like environment, environmental pollutants, environmental pollution, handling, hazardous substance, occupier, prescribed.

General Powers of the Central Government

Power of Central Government to take measures to protect and improve environment.

1. Subject to the provisions of this Act, the Central Government shall have the power to take all such measures, as it deems necessary or expedient for the purpose of protecting and improving the quality of the environment.

2. Planning and execution of a nationwide programme for the prevention, control and abatement of environmental pollution;

3. Laying down standards for the quality of environment in its various aspects;

4. Laying down standards for emission or discharge of environmental pollutants from various sources.

5. Restriction of areas in which any industries, operations or processes or class of industries, operations or processes shall not be carried out or shall be carried out subject to certain safeguards;

6. Laying down procedures and safeguards for the handling of hazardous substances;

7. Examination of such manufacturing processes, materials and substances as are likely to cause environmental pollution;

8. Carrying out and sponsoring investigations and research relating to problems of environmental pollution;

9. Inspection of any premises, plant, equipment, machinery, manufacturing or other processes, materials or substances and giving, by order, of such directions touch authorities, officers or persons as if may consider necessary to take steps for the prevention, control and abatement of environmental pollution;

10. Preparation of manuals, codes or guides relating to the prevention, control and abatement of environmental pollution.

4.6.7 Water (Prevention and Control of Pollution) Act, 1974

The Water Prevention and Control of Pollution Act, 1974 (the "Water Act") has been enacted to provide for the prevention and control of water pollution and to maintain or restore wholesomeness of water in the country. It further provides for the establishment of Boards for the prevention and control of water pollution with a view to carry out the aforesaid purposes. The Water Act prohibits the discharge of pollutants into water bodies beyond a given standard, and lays down penalties for non-compliance. At the Centre, the Water Act has set up the CPCB which lays down standards for the prevention and control of water pollution. At the State level, SPCBs function under the direction of the CPCB and the State Government.

Further, the Water (Prevention and Control of Pollution) Cess Act was enacted in 1977 to provide for the levy and collection of a cess on water consumed by persons operating and carrying on certain types of industrial activities. This cess is collected with a view to augment the resources of the Central Board and the State Boards for the prevention and con-

trol of water pollution constituted under the Water (Prevention and Control of Pollution) Act, 1974. The Act was last amended in 2003.

Short title, application and commencement

1. This Act may be called the Water (Prevention and Control of Pollution) Act, 1974.

2. It applies in the first instance to the whole of the States of Assam, Bihar, Gujarat, Haryana, Himachal Pradesh, Jammu and. Kashmir, Karnataka, Kerala, Madhya Pradesh, Rajasthan, Tripura and West Bengal and the Union Territories; and it shall apply to such other State which adopts this Act by resolution passed in that behalf under clause (1) of the article 252 of the Constitution.

Recap

- Wildlife Protection Act 1972 - This Act provides for the protection of the country's wild animals, birds, and plant species, in order to ensure environmental and ecological security.
- It is also known as the Washington Convention and was adopted as a result of a meeting of IUCN members.
- The National Board for Wildlife was constituted as a statutory organization under the provisions of this Act.
- The Act also provided for the establishment of the National Tiger Conservation Authority.
- Sanctuary is a place of refuge where injured, abandoned, and abused wildlife is allowed to live in peace in their natural environment without any human intervention.
- National Parks are the areas that are set by the government to conserve the natural environment.
- The Air (Prevention and Control of Pollution) 1981 empowers the central and state pollution control boards to meet with grave emergencies of air pollution.
- Air pollutants are any solid liquid or gaseous substance which may cause harm or damage the environment, humans, plants, animals or even damage property.
- The Environment Protection Act, 1986 (the "Environment Act") provides for the protection and improvement of environment.
- The Water Prevention and Control of Pollution Act, 1974 (the "Water Act") has been enacted to provide for the prevention and control of water pollution and to maintain or restore wholesomeness of water in the country.

Objective Type Questions

1. What is environmental degradation?
2. When was the Air Prevention and Control of Pollution Act of the parliament of India passed?
3. When was the Water prevention and Control of pollution Act of the Parliament of India passed?
4. When was the Environmental Protection Act of the Parliament of India came into force?
5. Write the full form of CITES.
6. Define Sanctuary.

Answers to Objective Type Questions

1. The overall degradation of environmental attributes.
2. 29 March 1981
3. 23 March 1974
4. 19 November 1986
5. Convention on International Trade in Endangered Species of Wild Fauna and Flora
6. Sanctuary is a place of refuge where injured, abandoned, and abused wildlife is allowed to live in peace in their natural environment without any human intervention.

Assignment

1. What are the violations in the environmental laws which you have observed in your locality? Make a detailed list of such practices.

Suggested Reading

1. Ricardo Beiras, in Marine Pollution, 2018
2. Daniel A. Vallero, in Environmental Systems Science, 2021
3. Oladele A. Ogunseitan, in Encyclopedia of Environmental Health (Second Edition), 2019

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1. Dernbach, John C., and Joel A. Mintz. "Environmental Laws and Sustainability: An Introduction." *Sustainability 3*, no. 3 (March 23, 2011): 531–40. https://doi.org/10.3390/su3030531.

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3. https://www.ipcc.ch/
4. www.heritage.enviro.com
5. https://sustainabledevelopment.un.org/
6. https://www.unido.org/
7. https://www.cseindia.org/

Model Question Paper
Set-01

SREENARAYANAGURU OPEN UNIVERSITY

QP CODE : ……

Reg. No : ……..
Name : ……..

FIRST SEMESTER ABILITY ENHANCEMENT COMPULSORY COURSE
EXAMINATION- B21ES01AC- ENVIRONMENTAL STUDIES(CBCS - UG)
2022-23 - Admission Onwards

Time: 3 Hours **Max Marks: 70**

SECTION A

Answer any ten questions. Each carries one mark

1. The organisms that thrive on dead and decaying matter are called …… (Re)
2. Rainfall range of tropical moist deciduous forests is ……. (Re)
3. The percentage of freshwater on the surface of earth which serves the needs of lives is ……. (Re)
4. The kind of erosion occurring in natural depression is ……. (Un)
5. Management and integration of trees, crops and/or livestock on the same plot of land is called ……. (Un)
6. Ecological pyramids were developed by …… (Re)
7. What is the expansion of NFT?
8. In general, species diversity …… as we move from the equator to the poles (Un)
9. Using gums derived from forest trees represent …… values of biodiversity (Un)
10. How many biodiversity hotspots are there in India? (Re)
11. Species which are vulnerable to extinction in the near future is called ……. (Re)
12. Areas designed to protect natural environment is ……. (Un)
13. Stone workers are likely to develop …… (Re)
14. …… is a vector-borne disease (Un)
15. Sunderlal Bahuguna is associated with …… (Re)

(10 x 1 = 10 Marks)

SECTION B

Answer any ten questions. Each carry two marks

16. List out four Environment Conservation activities (Re)
17. How can you say that human activities are among the reasons for climate change? (An)
18. Define Sustainable Development. (Re)

19. Continuous cultivation of a crop leads to deficiency of soil of certain minerals? What is the solution? How is it done? (Un)
20. What are the targets of climate action? (Re)
21. What do you mean by Environmental Equity? (Un)
22. What is a sanitary landfill? (Re)
23. Define Carbon foot print (Re)
24. Write some threats faced by natural resources. (Re)
25. Comment on the threats faced by forests. (Un)
26. What is water logging? (Re)
27. What are the environmental effects of mineral extraction? (Re)
28. What are the methods of conversion of sunlight to electric power? (Re)
29. What is food chain? What are the types of food chains? (Un)
30. Distinguish between weather and climate. (Un)

(10x 2 = 20 Marks)

SECTION C

Answer any five questions. Each carry four marks

31. Comment on the negative effects of incineration (An)
32. Plants produce carbohydrates using carbon dioxide in the presence of sunlight. Are there any problems to crops if the levels of CO2 are very high? Justify your answer. (Un)
33. Why is it said that public participation is an essential stage in EIA? What benefit does it give to the project proponent? (Ap)
34. Express your view on the statement "Biocentrism as well as Ecocentrism essentially come under anthropocentrism" (Ap)
35. Write a short note on circular economy with an example. (Un)
36. Do large dams pose environmental hazard? Justify your answer. (An)
37. What are the salient features of Air Act 1981? (Re)
38. Comment on earth quate waves (Re)
39. Write short notes on carbon credit and carbon trading (Un)
40. Elaborate on the concept of zero waste (Un)

(5 x 4 = 20 Marks)

SECTION D

Answer any two questions. Each carry ten marks

41. Some recent studies reported the presence of microplastics in blood and in mother's milk. What are microplastics? How are they formed? What are their effects on environment? (An)
42. Why developmental projects are required to do an Environmental Impact Assessment (EIA) before it is implemented? What is Environmental Impact Assessment? What are the stages of EIA? (Un)
43. Keeping the 2018 and 2019 Kerala floods in mind, comment on the causes and effects of floods. (An)
44. Write an essay on the major drivers of climate change (Un)

(2 x 10 = 20 Marks)

Regional Centres

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