GE3451

ENVIRONMENTAL SCIENCES AND SUSTAINABILITY

UNIT - I ENVIRONMENT AND BIODIVERSITY

Definition, scope and importance of environment – need for public awareness. Eco-system and Energy flow– ecological succession. Types of biodiversity: genetic, species and ecosystem diversity– values of biodiversity, India as a mega-diversity nation – hot-spots of biodiversity – threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts – endangered and endemic species of India – conservation of biodiversity: In-situ and ex-situ.

Prepared by
Dr R. Someswaran

INTRODUCTION

What's the use of a beautiful house if you don't have a decent planet to put it on?

Environment belongs to all and is thus important for all. Whatever be the occupation or age of a person, he or she will be affected by environment and will also affect the environment by his or her deeds. Thus, environment is one subject that is actually global in nature. For example,

- Atmosphere has no boundaries and the pollutants produced at one place can be dispersed and transported to another place.
- The river water polluted by industrial or municipal discharge at one point would seriously affect the downstream aquatic life.
- Damage to the forests in a hilly region will have far reaching effect not only on the hills but also on the plains.

This is because environment is a closely and intricately woven network of components and functions. Environmental studies is very important since it deals with the most mundane issues like

1. Safe and clean drinking water,
2. Hygienic living conditions,
3. Clean and fresh air,
4. Fertile land,
5. Healthy food and
6. Development that is sustainable.

There is a need for trained manpower at every level to deal with environmental issues. Environmental law, business administration and environmental engineering are emerging as new career opportunities for environmental protection and management.

Environment:

Descending from the Middle French preposition *environ* "around," *environment*, in its most basic meaning, is "that which surrounds."

When preceded by *the*, it usually refers to the natural world ("please don't litter if you care about *the environment")*

Environment is sum total of water, air and land, inter-relationships among themselves and also with the human beings, other living organisms and property.

Thus, in order to study environment one needs input/information about Biotic and Abiotic components and their interaction.

Mathematics, Statistics and Computer Science serve as effective tools in environmental modeling and management.

Scope:

1. Natural Resources - their conservation and management
2. Ecology and biodiversity
3. Environmental pollution and control
4. Social issues in relation to development and environment
5. Human population and environment

Need for Public Awareness:

Any government at its own level cannot achieve the goals of sustainable development until the public has a participatory role in it. Public participation is possible only when the public is aware about the ecological and environmental issues

- Littering of polythene
- Stubble burning

The public has to be educated about the fact that if we are degrading our environment we are actually harming our ownselves.

It is all the more important to educate the people that some- times the adverse impact of environment are not experienced or noticed until a threshold is crossed.

Ecosystem

Ecology deals with the study of organisms in their natural home interacting with their surroundings. The surroundings or environment consists of other living organisms (biotic) and physical (abiotic) components.

An **ecosystem** is a group of biotic communities of species interacting with one another and with their non-living environment exchanging energy and matter.

In other words, an ecosystem is a chain of interactions between organisms and their environment. The term "Ecosystem" was first coined by A.G.Tansley, an English botanist, in 1935.

Now ecology is often defined as the study of ecosystems.

The ecosystem is thus, a unit or a system which is composed of a number of subunits that are all directly or indirectly linked with each other. They may be freely exchanging energy and matter from outside an open ecosystem or may be isolated from outside a closed ecosystem.

Ecosystem Characteristics

Ecosystems show large variations in their size, structure, composition etc. However, all the ecosystems are characterized by certain basic structural and functional features which are common.

An ecosystem is a structural and functional unit of ecology where the living organisms interact with each other and the surrounding environment.

Structure of the Ecosystem

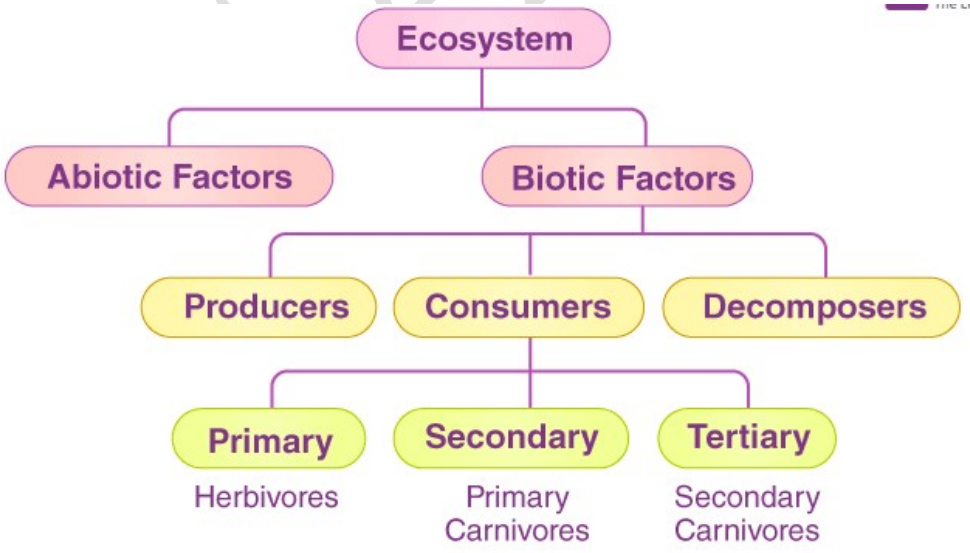
The structure of an ecosystem is characterized by the organization of both biotic and abiotic components. This includes the distribution of energy in our environment. It also includes the climatic conditions prevailing in that particular environment.

The structure of an ecosystem can be split into two main components, namely:

- Biotic Components
- Abiotic Components

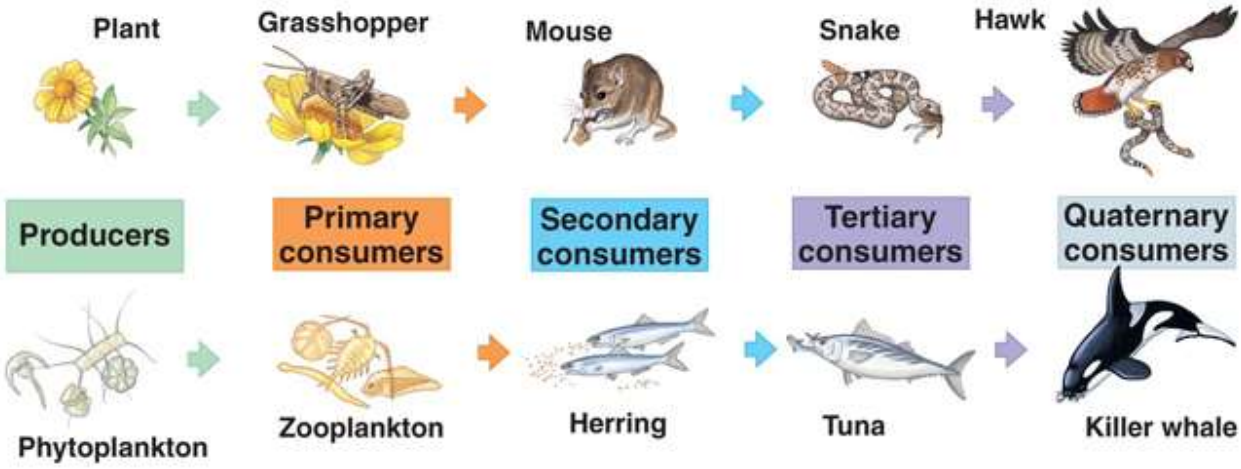
The biotic and abiotic components are interrelated in an ecosystem. It is an open system where the energy and components can flow throughout the boundaries.

Ecology-Definition-Examples-Explanation - YouTube



Biotic Components

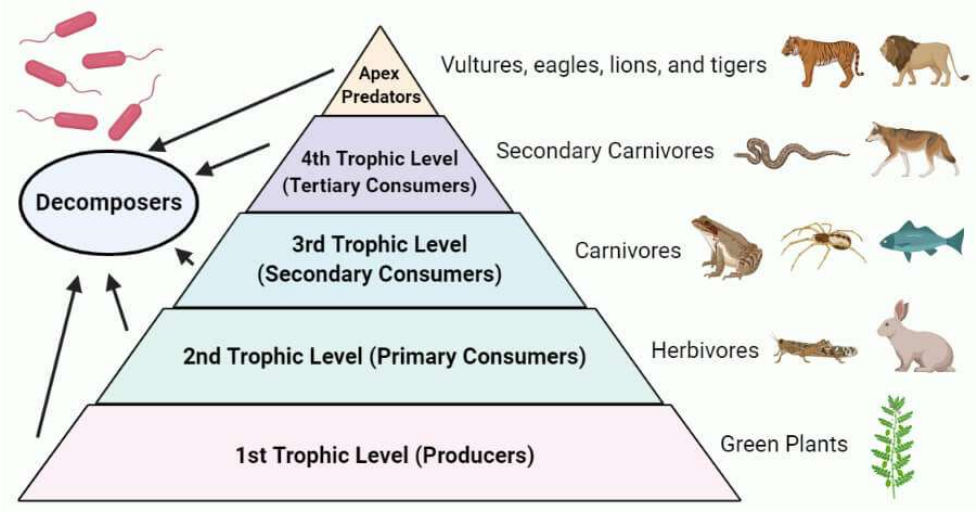
Biotic components refer to all living components in an ecosystem. Based on nutrition, biotic components can be categorized into autotrophs (auto=self, troph=food), heterotrophs and saprotrophs (or decomposers).



- **Producers** They are mainly the green plants, which can synthesize their food themselves by making use of carbon dioxide, water and sunlight through the process of photosynthesis. Consequently, all other organisms higher up on the food chain rely on producers for food.
- **Consumers** or **heterotrophs** are organisms that depend on other organisms for food. Consumers are further classified into primary consumers, secondary consumers and tertiary consumers.
    - ***Primary consumers*** (plant eaters) are always **herbivores** as they rely on producers for food.
    - ***Secondary consumers*** depend on primary consumers for energy. They can either be **carnivores or omnivores.**
    - ***Tertiary consumers*** are organisms that depend on secondary consumers for food. Tertiary consumers can also be carnivores or omnivores.
    - ***Quaternary consumers*** are present in some food chains. These organisms prey on tertiary consumers for energy. Furthermore, they are usually at the top of a food chain as they have no natural predators.
- **Decomposers** include saprophytes such as fungi and bacteria. They directly thrive on the dead and decaying organic matter. Decomposers are essential for the ecosystem as they help in recycling nutrients to be reused by plants.

The trophic level of an organism is the number of steps it is from the point when the food chain begins. A food chain begins at trophic level 1 which involves primary producers. Then it moves on to level 2 which consists of the herbivorous. From then on, the food chain continues to level 3 of the carnivorous organisms. Finally, the food chain ends at level 4 or 5 with the apex predators.

Structure & Composition of Ecosystem | Environmental Science | EVS | Letstute - YouTube



(The Trophic level Diagram)

Abiotic Components (non-living component of an ecosystem)

The physical and chemical components of an ecosystem constitute its abiotic structure. It includes air, water, soil, minerals, sunlight, temperature, nutrients, wind, altitude, turbidity, etc. All the biotic components of an ecosystem are influenced by the abiotic components and vice versa.

Abiotic components are sub divided into three categories

1. Atmosphere:
The cover of air that envelopes the earth is known as the atmosphere. The atmosphere extends up to 500 kms from the earth surface. It is essential for all living organism and atmosphere comprises 78% of nitrogen, 21% of oxygen and 1% of other gases.

2. Lithosphere:
The soil and rock components of the earth is called lithosphere.
Functions:
1. Home for human beings and wildlife.
2. Store house of minerals and organic matters.

3. Hydrosphere:
The portion of the earth which is surrounded by water is called hydrosphere. Ocean, lakes, rivers and water vapour constitute hydrosphere. Out of 100% only 3% of water is available as fresh water remaining 97% of water is in Ocean.

Functions:
1. Used for drinking purpose and supports the aquatic life
2. Used for irrigation, power production, industries and transport.

Functions of Ecosystem

Every ecosystem performs under natural conditions in a systematic way. It receives energy from the sun and passes it on through various biotic components and in fact, all life depends upon this flow of energy. Besides energy, various nutrients and water are also required for life processes which are exchanged by the biotic components within themselves and with their abiotic components within or outside the ecosystem. So the functional units of an ecosystem or functional components that work together in an ecosystem are:

- **Productivity –** It refers to the rate of biomass production.
- **Energy flow –** It is the sequential process through which energy flows from one trophic level to another. The energy captured from the sun flows from producers to consumers and then to decomposers and finally back to the environment.
- **Decomposition –** It is the process of breakdown of dead organic material. The top-soil is the major site for decomposition.
- **Nutrient cycling –** In an ecosystem nutrients are consumed and recycled back in various forms for the utilization by various organisms.

Types of Ecosystem

An ecosystem can be as small as an oasis in a desert, or as big as an ocean, spanning thousands of miles. There are two types of ecosystem:

- Terrestrial Ecosystem
- Aquatic Ecosystem

Terrestrial Ecosystem

Terrestrial ecosystems are exclusively land-based ecosystems. There are different types of terrestrial ecosystems distributed around various geological zones. They are as follows:

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

Forest Ecosystem

A forest ecosystem consists of several plants, particularly trees, animals and microorganisms that live in coordination with the abiotic factors of the environment. Forests help in maintaining the temperature of the earth and are the major carbon sink. In a forest ecosystem, big trees are the producers, which are less in number and hence form a narrow base. A larger number of herbivores including birds, insects and several species of animals feed upon the trees (on leaves, fruits, flowers, bark etc.) and form a much broader middle level. The secondary consumers like fox, snakes, lizards etc. are less in number than herbivores while top carnivores like lion, tiger etc. are still smaller in number. So the pyramid is narrow on both sides and broader in the middle

Grassland Ecosystem

In a grassland ecosystem, the vegetation is dominated by grasses and herbs. Temperate grasslands and tropical or savanna grasslands are examples of grassland ecosystems. Grassland ecosystem shows an upright pyramid of numbers. The producers in the grasslands are grasses which are small in size and very large in number. So the producers form a broad base. The herbivores in a grassland are insects while tertiary carnivores are hawks or other birds which are gradually less and less in number and hence the pyramid apex becomes gradually narrower forming an upright pyramid.

Tundra Ecosystem

Tundra ecosystems are devoid of trees and are found in cold climates or where rainfall is scarce. These are covered with snow for most of the year. Tundra type of ecosystem is found in the Arctic or mountain tops. Tundra lands are covered with snow for much of the year, but summer brings bursts of wildflowers. The Arctic tundra, where the average temperature is -34 to -6 degrees Celsius (-30 to 20 degrees Fahrenheit), supports a variety of animal species, including Arctic foxes (*Vulpes lagopus*), polar bears (*Ursus maritimus*), gray wolves (*Canis lupus*). The summer growing season is just 50 to 60 days, when the sun shines up to 24 hours a day.

Desert Ecosystem

Deserts are found throughout the world. These are regions with high evaporation, little rainfall and scarce vegetation. The days are hot, and the nights are cold. The precipitation is less than 25 cm per year. Deserts have little species diversity and consist of drought resistant or drought avoiding plants. Desert plants and animals are having most typical adaptations for conservation of water. Desert animals like insects and reptiles have thick outer coverings to minimize loss of water. They usually live inside burrows where humidity is better and heat is less. Desert soil is rich in nutrients but deficient in water.

Aquatic Ecosystem

Aquatic ecosystems dealing with water bodies and the biotic communities present in them are either freshwater or marine. Freshwater ecosystems are further of standing type (lentic) like ponds and lakes or free-flowing type (lotic), like rivers.

Freshwater Ecosystem

The freshwater ecosystem is an aquatic ecosystem that includes lakes, ponds, rivers, streams and wetlands. These have no salt content in contrast with the marine ecosystem.

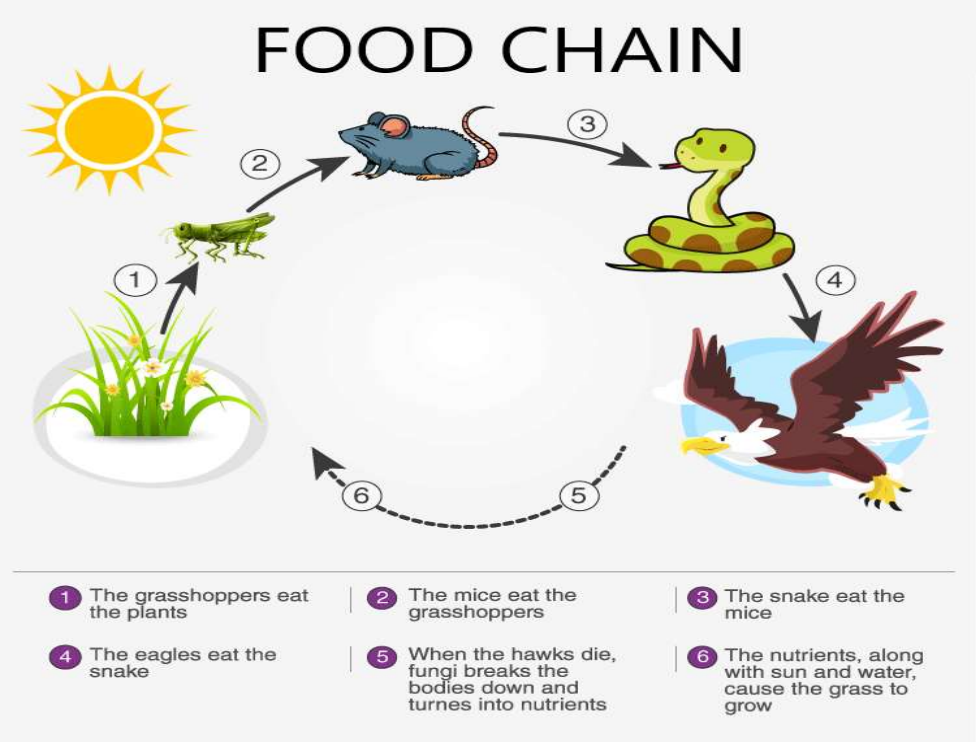
Marine Ecosystem

The marine ecosystem includes seas and oceans. These have a more substantial salt content and greater biodiversity in comparison to the freshwater ecosystem. Oceans provide us iron, phosphorus, magnesium, oil, natural gas, sand and gravel. Oceans are the major sinks of carbon dioxide and play an important role in regulating many biogeochemical cycles and hydrological cycle, thereby regulating the earth's climate.

What is Ecosystem? | Different Types of Ecosystem | Environmental Science | EVS | Letstute - YouTube

Food Chains

All organisms, living or dead, are potential food for some other organism and thus, there is essentially no waste in the functioning of a natural ecosystem. A caterpillar eats a plant leaf, a rat eats the caterpillar, a snake eats the rat, an eagle eats the snake and when they all die, they are all consumed by microorganisms like bacteria or fungi (decomposers) which break down the organic matter and convert it into simple inorganic substances that can again be used by the plants- the primary producers.



Continuous line (——) – Energy flow (unidirectional)

Dashed line (-------) – Nutrient cycle (cyclic process)

Food Web:

Food web is a network of food chains where different types of organisms are connected at different trophic levels, so that there are a number of options of eating and being eaten at each trophic level. A more realistic representation of who eats whom is called a food web. Food web shows how many food chains are connected to each other.

Difference Between Food Chain And Food Web	
Food Chain	**Food Web**
A linear pathway showing the flow of energy	A multitude of networks showing the flow of energy
An organism of higher level trophic feeds on a specific organism of lower trophic level	An organism of a higher trophic level has access to more members of a lower trophic level.
Does not affect the adaptability and competitiveness of organisms.	It has a role in improving the adaptability and competitiveness of an organism.

Ecology: the scientific study of the processes influencing natural life and habitats.

Ecosystem: a natural environment which includes the flora (plants) and fauna (animals) that live and interact within that environment.

Biodiversity: the variety of natural life and habitats on Earth.

ENERGY FLOW IN AN ECOSYSTEM

Flow of energy in an ecosystem takes place through the food chain and it is this energy flow which keeps the ecosystem going. The most important feature of this energy flow is that it is unidirectional or one - way flow. Energy flows from the lowest trophic level (primary producers) to the top (apex predators).

Energy "flows" through the ecosystem in the form of carbon-carbon bonds. When respiration occurs, the carbon-carbon bonds are broken and the carbon is combined with oxygen to form carbon dioxide. This process releases the energy, which is either used by the organism (to move its muscles, digest food, excrete wastes, think, etc.) or the energy may be lost as heat.

All energy comes from the sun, and the ultimate fate of all energy in ecosystems is to be lost as heat. Energy does not recycle.

The flow of energy follows the two laws of Thermodynamics:

Ist law of Thermodynamics states that energy can neither be created nor be destroyed but it can be transformed from one form to another. The solar energy captured by the green plants (producers) gets converted into biochemical energy of plants and later into that of consumers.

IInd law of Thermodynamics states that energy dissipates as it is used or in other words, its gets converted from a more concentrated to dispersed form. As energy flows through the food chain, there occurs dissipation of energy at every trophic level. The loss of energy takes place through respiration, loss of energy in locomotion, running, hunting and other activities. At every level there is about 90% loss of energy and the energy transferred from one trophic level to the other is only about 10%.

ENERGY FLOW | TAMIL | ECOSYSTEM | STD 12 - YouTube

Energy flow models: The flow of energy through various trophic levels in an ecosystem can be explained with the help of various energy flow models.

CHARACTERISTICS of ENERGY FLOW

- **UNIDIRECTIONAL FLOW OF ENERGY:** The most important characteristic is the one-way street along which energy flows. The energy that is captured by the autotrophs does not revert back to solar input; that which passes to the herbivores does not pass back to the autotrophs; and so on.
- **PROGRESSIVE DECREASE IN ENERGY:** In each trophic level there is progressive decrease in energy. This is because at the time of energy transfer from one trophic level to

the other a substantial amount of energy is lost as it is dissipated as heat during metabolic activity.

- **RESPIRATORY LOSS HIGH IN HIGHER TROPHIC LEVELS:** Respiratory loss gets higher and higher in higher trophic levels due to carnivores greater locomotory activity.
- **HIGHER EFFICIENCY OF ASSIMILATION AT HIGHER TRPHIC LEVEL:** In the higher trophic levels there is greater efficiency of energy assimilation.
- **UNUTILISED ENERGY:** In all ecosystems, despite the utilization of energy in various metabolisms by different organisms, large amount of energy always remains in the system as standing crop. This indicates that the ecosystem is under grazed.
- Energy flow in an ecosystem follows the first and second laws of thermodynamics. The energy flow through any trophic level equals the total assimilation at that level, which in turn, equals the production of biomass plus respiratory loss.

MODELS OF ENERGY FLOW

There are basically three types of energy flow models:

- **SINGLE CHANNEL ENERGY FLOW MODEL**
- **Y-SHAPED/ TWO-CHANNEL ENERGY FLOW MODEL**
- **UNIVERSAL MODEL.**

(I) SINGLE CHANNEL ENERGY FLOW MODEL

The single or linear channel energy flow model is one of the first published models pioneered by H. T. Odum in 1956. As can be seen in Fig. 4.4, this model depicts a community boundary and, in addition to light and heat flows, it also includes import, export and storage of organic matter.

Decomposer organisms are placed in a separate box as a means of partially separating the grazing and detritus food chains. Decomposers are actually a mixed group in terms of energy levels and their importance in this energy flow model is overlooked. This model will suffice as long as only the imports and exports are considered.

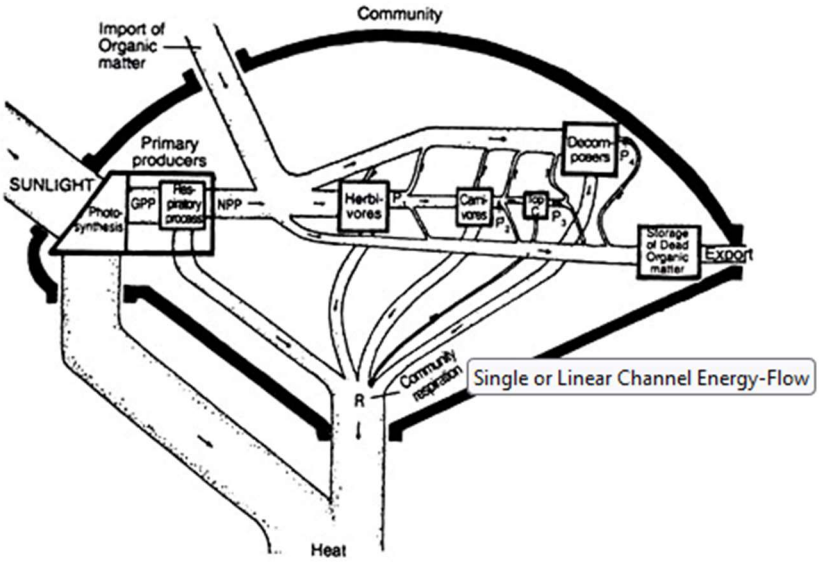


Fig. 4.4 : Single or linear channel energy-flow diagram (P_1, P_2, P_3 and P_4 – secondary production of the indicated level (H. T. Odum, 1956)

BOX-PIPE MODEL:

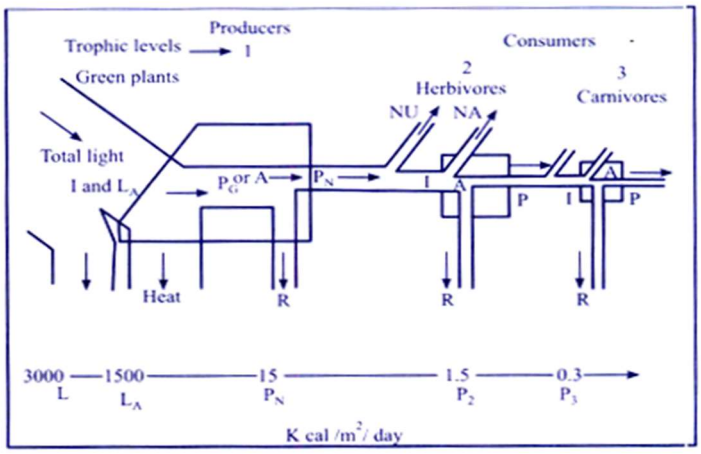


Fig. 1.4 A simplified energy flow diagram depicting three trophic levels

- Box-pipe energy flow model is a very simplified energy flow model of three trophic levels; it was suggested by E.P. Odum in 1953. In such single-channel energy flow model, "boxes" represent the trophic levels (i.e., population mass or biomass) and the "pipes" depict the energy flow in and out of each level.
- Energy inflows balance outflows as required by the first law of thermodynamics, and energy transfer is accompanied by dispersion of energy into unavailable heat (i.e., respiration) as required by the second law.
- From this model it also becomes evident that the energy flow is greatly reduced at each successive trophic level from predators to herbivores and then to carnivores.
- At each transfer of energy from one level to another major part of energy is lost as heat or other form. A closer examination of the diagram reveals that all the energy available to a trophic level is not consumed but a good portion of its left unutilized.

Thus, of the 3000 Kcal of total light falling upon the green plants, approximately 50% (1500 Kcal) is absorbed, of which only 1% (15 Kcal) is converted at first trophic level. Hence net primary production is merely 15 Kcal. Secondary productivity (P_2 and P_3 in fig) tends to be about 10% at successive consumer trophic levels,(i.e., herbivores and carnivores) although efficiency may be sometimes higher, as 20%, at the carnivore level as shown (or P3=0.3 Kcal) in the diagram.

It becomes evident from Figures 1.3 and 1.4 that there is a successive reduction in energy flow at successive trophic levels. Thus shorter the food chain, greater would be the available food energy as with an increase in the length of food chain there is a corresponding more loss of energy.

(II) Y-SHAPED/ TWO-CHANNEL ENERGY FLOW MODEL

- The Y-shaped model further indicates that the two food chains namely the grazing food chain and detritus food chain are in fact, under natural conditions, not completely isolated from one another. The grazing food chain beginning with green plant base going to herbivores and the detritus food chain beginning with dead organic matter acted by microbes, then passing to detrivores and their consumers.
- For instance, dead bodies of small animals that were once part of the grazing food chain become incorporated in the detritus food chain as do the feces of grazing food animals. Functionally, the distinction between the two is of time lag between the direct consumption of living plants and ultimate utilization of dead organic matter. The importance of the two food chains may differ in different ecosystems, in some grazing is more important, in others detritus is major pathway.

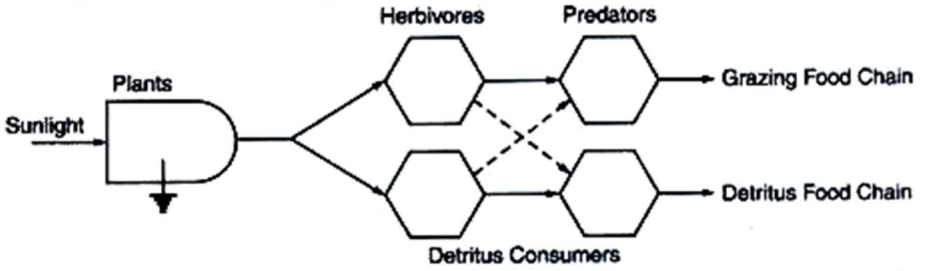


Fig. 3.2. The Y-shaped energy flow model showing linkage between the grazing and detritus food chains

The important point in Y-shaped model is that the two food chains are not isolated from each other. This Y- shaped model is more realistic and practical working model than the single-channel model because,

- ✓ It confirms to stratified structure of ecosystems,
- ✓ It separates the grazing and detritus chains (direct consumption of living plants and utilization of dead organic matter respectively) in both time and space, and

- ✓ That the micro-consumers (absorptive bacteria, fungi) and the macro-consumers (phagotrophic animals) differ greatly size-metabolism relations. (E.P. Odum. 1983).

It must however, be remembered that these models depict the basic pattern of energy flow in ecosystem. In practice, under natural conditions, the organisms are interrelated in a way that several food chains become interlocked results into a complex food web. We have already referred to food webs in grassland and in pond ecosystems. The complexity of food web depends on the length of the food chains.

Thus in nature there operates multi-channel energy flows, but in these the channels belong to either of the two basic food chains i.e., will be either a grazing or a detritus food chain. Interlocking pattern of such several chains in food web of an ecosystem would lead to a multi-channel flow of energy. Thus in practice, under field conditions, we might face difficulties in measuring energetic of ecosystem.

(III) UNIVERSAL MODEL

The universal model is applicable to any living component, which may be plant, animal, microorganism, individual, population or trophic group (E. P. Odum 1968).

The shaded box represents the living, standing crop biomass of the component which should be expressed in calories, so that its relation with rates of energy flow can be established. The total energy input or intake or ingestion varies. For strict autotrophs, it is light, while, for strict heterotrophs, it is organic food.

A key feature of the model is the separation of assimilated energy (A) into the production (P) and respiration ® components. R is the energy that is lost as heat (maintenance energy) and P is the portion transformed to new or different organic matter and is the part that is available to the next trophic level. At the same time, the non-assimilated component (NU-not utilized), such as faeces, enters the detritus food chain. P component is energy that is available to the next trophic level while NU component is energy that is still available at the same trophic level.

This model can be used in two ways:

- ➢ It can represent a species population in which case the appropriate energy inputs and links with other species would be shown as a conventional species oriented food-web diagram, or
- ➢ The model can represent a discrete energy level in which case the biomass and energy channels represent all or parts of many populations supported by same energy source.

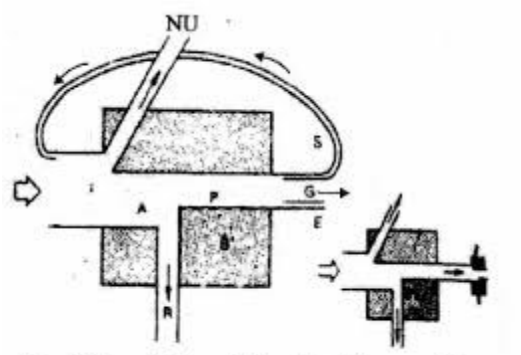


Fig. 40.11 : Universal Model of Energy Flow

NUTRIENT CYCLING

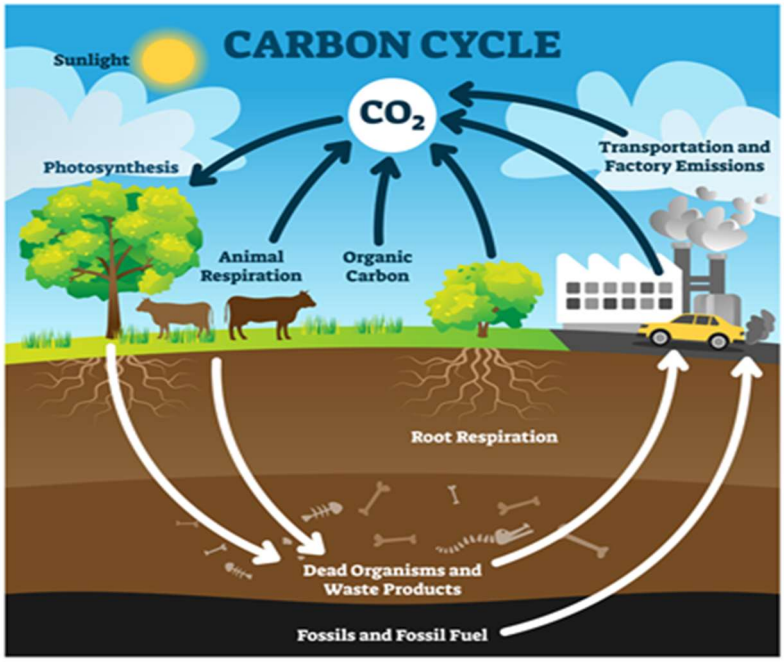
Besides energy flow, the other important functional attribute of an ecosystem is nutrient cycling. Nutrients like carbon, nitrogen, sulphur, oxygen, hydrogen, phosphorus etc. move in circular paths through biotic and abiotic components and are therefore known as biogeochemical cycles.

How nutrient cycling differs from energy flow? The energy flow refers to the transfer of energy from one trophic level to another in the food chain and food web. It is unidirectional and energy is lost from one trophic level to another in the form of heat. Sunlight is the ultimate energy source.

The nutrient cycle is a system where energy and matter are transferred between living organisms and non-living parts of the environment. This occurs as animals and plants consume nutrients found in the soil, and these nutrients are then released back into the environment via death and decomposition.

Carbon Cycle

The atmospheric carbon dioxide is virtually the only source of carbon. The carbon cycle is the process through which carbon elements are interchanged between the biosphere, geosphere, hydrosphere, and atmosphere in the Earth. The complete carbon cycle looks like the figure below:

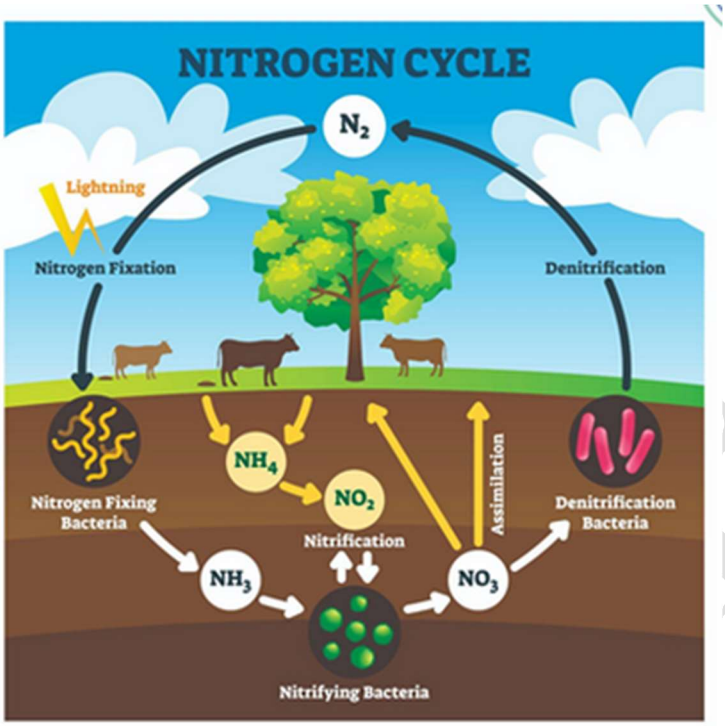


Steps involved in the process of the carbon cycle:

1. Carbon present in the atmosphere is absorbed by the plants through photosynthesis.
2. All living organisms release carbon dioxide by respiration.
3. The carbon that is present in the plants is transferred to herbivores animals when they eat plants. Carnivores also get carbon through different food chains.
4. Dead bodies of animals and dead parts of plants decay (decompose), and carbon is transferred back to the soil.
5. Some amount of carbon that is not transferred to the soil is buried deep and forms fossil fuels. Carbon enters back to the atmosphere as carbon dioxide gas when these fossil fuels are burned.

Nitrogen Cycle

Nitrogen is also one of the important components in life. However, though Nitrogen is the most abundant gas present in the atmosphere, living organisms cannot utilize it in its elemental form. Therefore, Nitrogen must be converted into ammonia and other nitrogen compounds like nitrites and nitrates to be used by living organisms. This process of conversion is named Nitrogen Fixation. This process is carried out by various soil microorganisms in different steps.

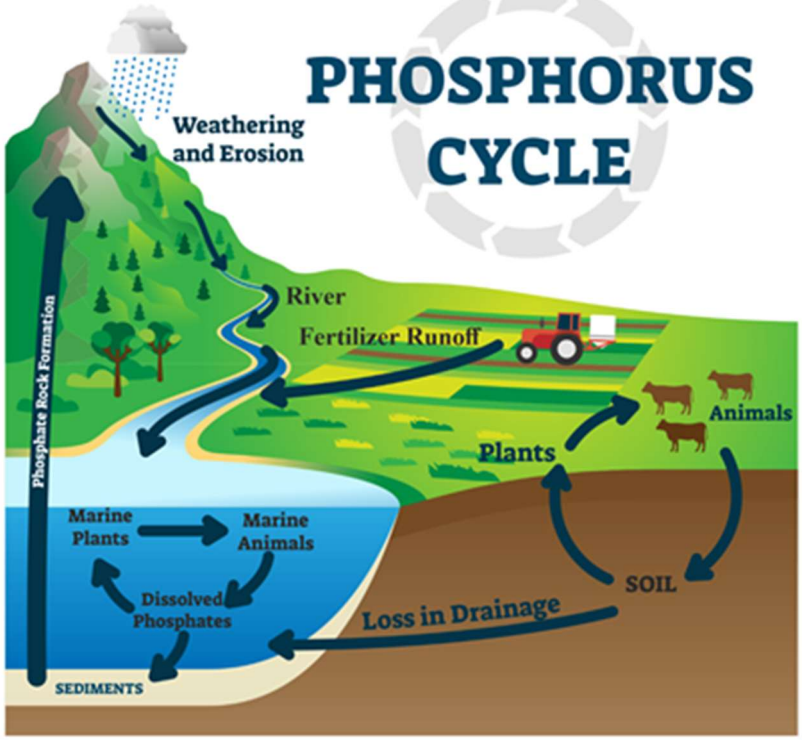


Steps involved in the process of the Nitrogen cycle:

1. Nitrogen-fixing bacteria fix atmospheric nitrogen into ammonia, and nitrifying bacteria present in the soil convert ammonia into nitrate, which is absorbed by the plants. This process is called Nitrogen fixation.
2. Atmospheric Nitrogen is converted into nitrates by the process of assimilation and lightning by plants.
3. Decomposers like bacteria present in the soil break down complex proteins and acids of decaying organic matter.
4. During the process of denitrification, denitrifying bacteria converts ammonia, nitrates into nitrogen. Free nitrogen gas is released into the atmosphere.

Phosphorus Cycle

Phosphorus is found in the soil in various forms like phosphate of rock, calcium, and iron or aluminium phosphate, fluorapatite, etc. Like many other mineral elements, Phosphorus also arrives in the oceans and settles down as sediment. A large proportion of Phosphorus percolates down to deep layers of soil. Biological processes like the formation of teeth and bones also keep Phosphorus locked up for some time.



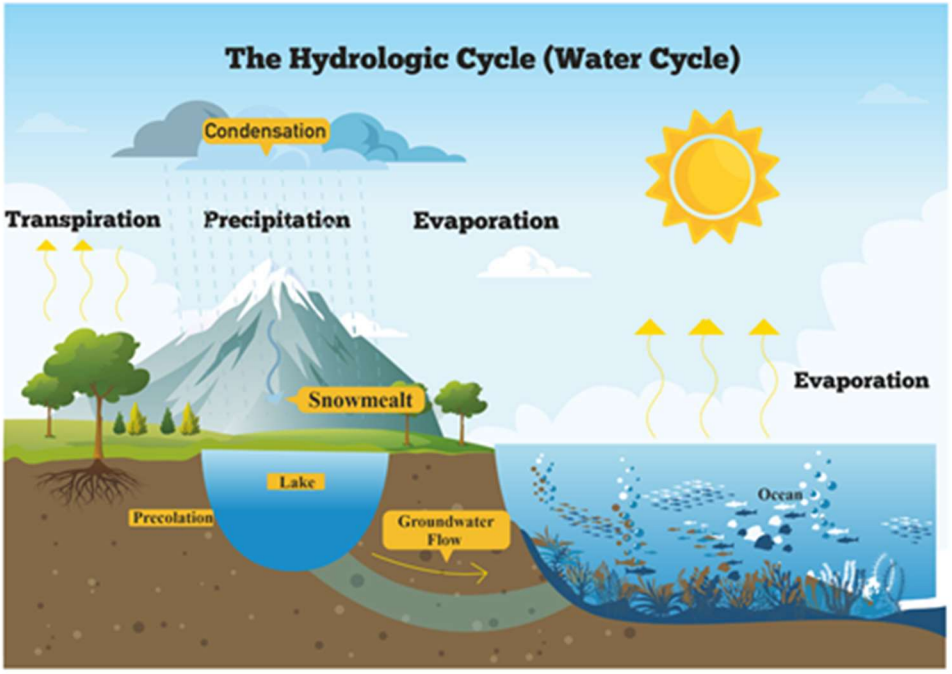
Hydrologic or Water Cycle

Water plays a vital role in the existence of life. The exchange of water between atmosphere, land, sea, and living organisms and their habitats is achieved through the water cycle. The water cycle or hydrologic cycle involves various steps like evaporation, transpiration, cloud formation, and precipitation. The following diagram illustrates the steps involved in the water cycle.

The steps involved in the process of water or hydrologic cycle are:

1. Transfer of Water from the Earth takes place in the form of water vapour in the atmosphere by evaporation and transpiration. Evaporation occurs when water reaches its boiling point.
2. Water present in the lakes, oceans and other water reservoirs is converted into vapours through **evaporation**. **Transpiration** occurs from the surface of the plants.

3. After the water is converted into vapours, the vapours are converted back into liquid form due to the increase in temperature; this process is called **condensation**.
4. These tiny droplets of water fall down due to Earth's gravity which is called **precipitation**.
5. Water falling on the ground in the form of rain fills the water bodies, which is called runoff or stored as groundwater.



ECOLOGICAL SUCCESSION

Ecological succession is the process by which natural communities replace (or "succeed") one another over time. For example, when an old farm field in the midwestern U.S. is abandoned and left alone for many years, it gradually becomes a meadow, then a few bushes grow, and eventually, trees completely fill in the field, producing a forest.

Each plant community creates conditions that subsequently allow different plant communities to thrive. For example, early colonizers like grasses might add nutrients to the soil, whereas later ones like shrubs and trees might create cover and shade. Succession stops temporarily when a "climax" community forms; such communities remain in relative equilibrium until a disturbance restarts the succession process.

The whole sequence of communities which are transitory are known as **Seral stages or seres** whereas the community establishing first of all in the area is called a **pioneer community.**

Ecological successions starting on different types of areas or substrata are named differently as follows:

(i) Hydrarch or Hydrosere: Starting in watery area like pond, swamp, bog
(ii) Mesarch: starting in an area of adequate moisture.
(iii) Xerarch or Xerosere: Starting in a dry area with little moisture.
(iv) Lithosere: starting on a bare rock
(v) Psammosere: starting on sand
(vi) Halosere: starting on saline soil

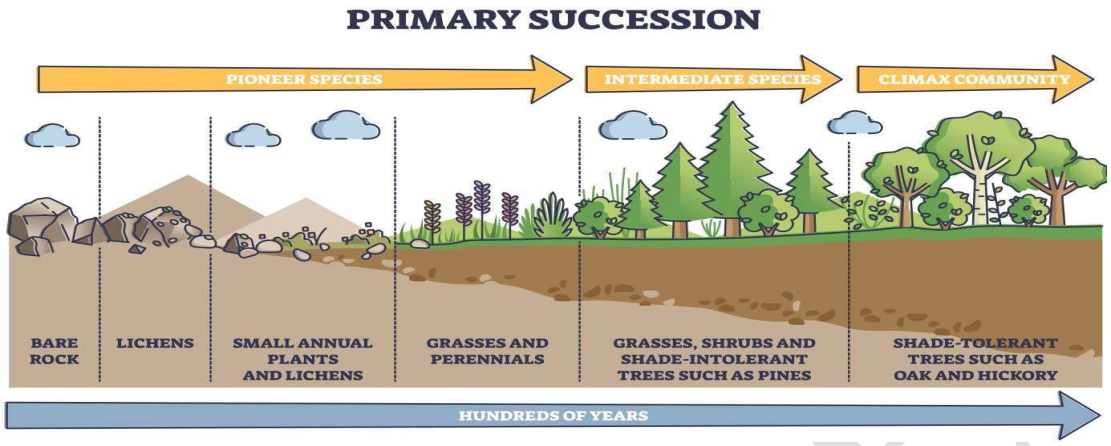
Process of Succession:
The process of succession takes place in a systematic order of sequential steps as follows:

(i) Nudation: It is the development of a bare area without any life form. The bare area may be caused due to landslides, volcanic eruption etc. (topographic factor), or due to drought, glaciers, frost etc. (Climatic factor), or due to overgrazing, disease outbreak, agricultural/ industrial activities (biotic factors).
(ii) Invasion: It is the successful establishment of one or more species on a bare area through dispersal or migration, followed by ecesis or establishment. Dispersal of the seeds, spores etc. is brought about by wind, water, insects or birds. Then the seeds germinate and grow on the land. As growth and reproduction start, these pioneer species increase in number and form groups or aggregations.
(iii) Competition and coaction: As the number of individuals grows there is competition, both inter-specific (between different species) and intra-specific (within the same species), for space, water and nutrition. They influence each other in a number of ways, known as coaction.
(iv) Reaction: The living organisms grow, use water and nutrients from the substratum, and in turn, they have a strong influence on the environment which is modified to a large extent and this is known as reaction. The modifications are very often such that they become unsuitable for the existing species and favor some new species, which replace them. Thus, reaction leads to several seral communities.
(v) Stabilization: The succession ultimately culminates in a more or less stable community called climax which is in equilibrium with the environment. The climax community is characterized by maximum biomass and symbiotic (mutually beneficial) linkages between organisms and are maintained quite efficiently per unit of available energy

There are two major types of ecological succession:

- ***Primary succession***
- ***Secondary succession.***

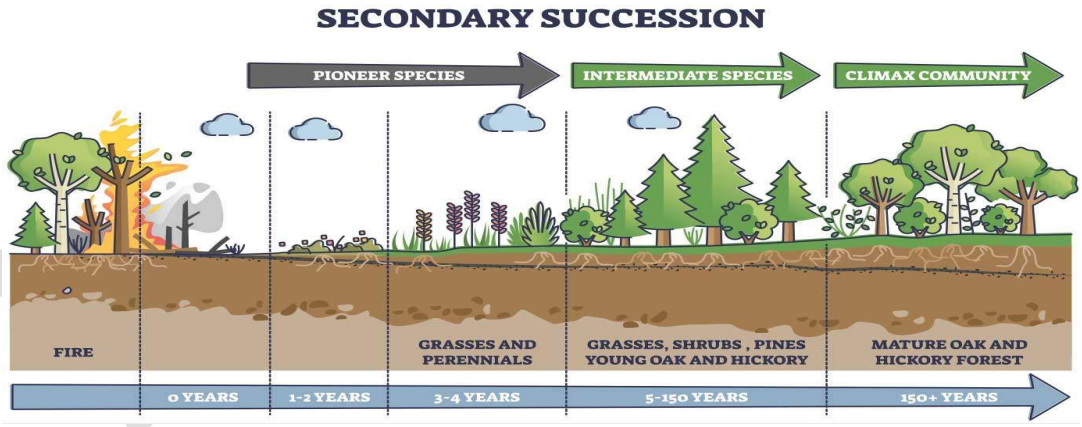
Primary succession happens when a new patch of land is created or exposed for the first time. This can happen, for example, when lava cools and creates new rocks, or when a glacier retreats and exposes rocks without any soil. During primary succession, organisms must start from scratch. First, lichens might attach themselves to rocks, and a few small plants able to live without much soil might appear. These are known as “pioneer species.”



(**Primary succession** begins when no plant life is present on the landscape, such as after a lava flow or glacial retreat. Over centuries, soil forms and deepens and successive communities of plants grow)

Gradually, the decomposition of those plants contributes to soil formation, and more and larger plants begin to colonize the area. Eventually, enough soil forms and enough nutrients become available such that a ***climax community***, like a forest, is formed. If the site is disturbed after this point, secondary succession occurs.

Secondary succession happens when a climax community or intermediate community is impacted by a disturbance. This restarts the cycle of succession, but not back to the beginning—soil and nutrients are still present.



(Secondary succession begins after a disturbance, like a fire. Crucially, some soil and nutrients remain present—fire, in fact, may help recycle those nutrients.)

For example, after a forest fire that kills all the mature trees on a particular landscape, grasses might grow, followed by shrubs and a variety of tree species, until eventually the community that existed before the fire is present again.

What is a climax community?
A climax community is the "endpoint" of succession within the context of a particular climate and geography.

What is an example of ecological succession?
Ecological succession can occur in many contexts and over many time spans.

In Hawaii and Iceland, primary succession occurs on lava flows where new land has formed; in Canada's Athabasca Dunes, it happens when new sand is deposited along a lakeshore; in the Andes, it occurs when glaciers retreat.

In many regions, secondary succession occurs where wildfires have destroyed conifer forests, or where former agricultural land is reverting to meadow or scrubland.

Ecological Succession-Primary and Secondary - YouTube

BIODIVERSITY

Bio – Life

Diversity - Variety

Biodiversity is all the different kinds of life you'll find in one area—the variety of animals, plants, fungi, and even microorganisms like bacteria that make up our natural world. Each of these species and organisms work together in ecosystems, like an intricate web, to maintain balance and support life. Biodiversity supports everything in nature that we need to survive: food, clean water, medicine, and shelter.

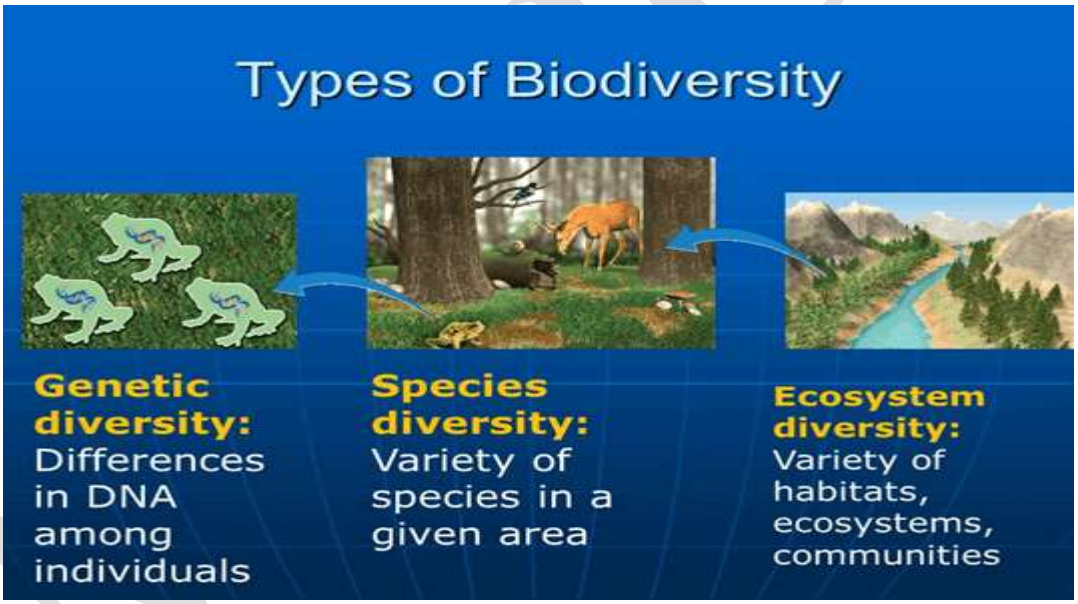
Importance of Biodiversity

Biodiversity is a crucial part of any ecosystem and plays a vital role in ecosystems' function and services. An environment rich in biodiversity is essential for supporting human life. Due to an ever-increasing population, the demand for food and energy production is also increasing, leading to a degradation, fragmentation and loss of natural habitats. With this decrease in biodiversity and degradation of ecosystems, the natural environment becomes less productive, less resilient and adaptable, and is at real risk of sustaining long term damage or collapse.

Types of Biodiversity

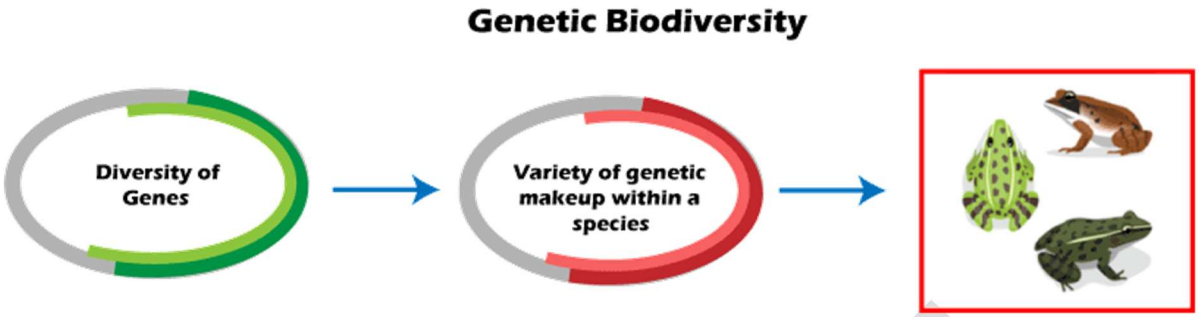
There are the following three different types of biodiversity:

- Genetic Biodiversity
- Species Biodiversity
- Ecosystem Biodiversity



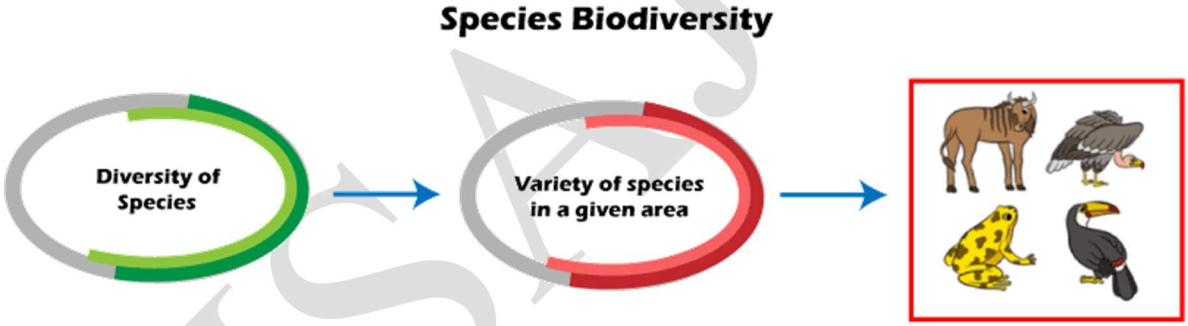
Genetic Biodiversity:

Genes are the basic units of hereditary information transmitted from one generation to other. When the genes within the same species show different versions due to new combinations, it is called genetic variability. For example, all rice varieties belong to the Genes are the basic units of hereditary information transmitted from one generation to other. That is why every human is different from another. Similarly, the species of rice, wheat, maize, barley, etc., have different varieties.



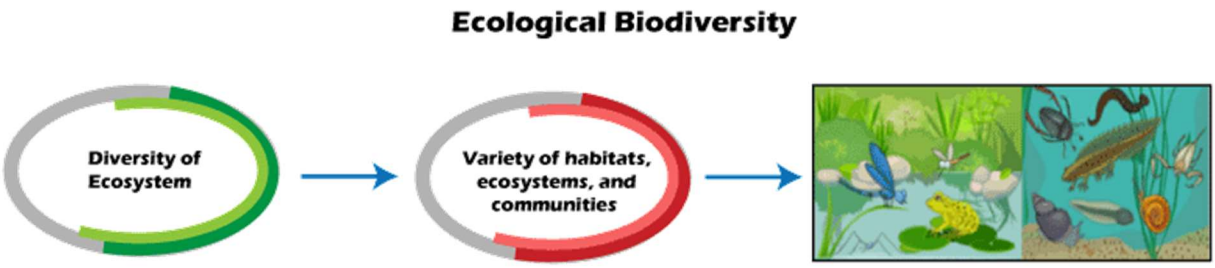
Species diversity

Species diversity refers to the variety of different types of species found in a particular area. It is the biodiversity at the most basic level. It includes all the species ranging from plants to different microorganisms. As species diversity is seen in natural and agricultural ecosystems, the total numbers of different species of plants and animals located in an area form this type of diversity. It is believed that there are about 5-10 million species in the world; however, only 1.75 million of those species have been named scientifically so far on Earth. Some areas have more species than others. Areas with more species diversity are generally referred to as 'hotspots' of diversity.



Ecological Biodiversity:

An ecosystem is a collection of living and non-living organisms and their interaction with each other. Ecological biodiversity refers to the variations in the plant and animal species living together and connected by food chains and food webs. It is the diversity observed among the different ecosystems in a region. Diversity in different ecosystems like deserts, rainforests, mangroves, etc., include ecological diversity.



VALUE 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, erosion control and local flood reduction. Food, clothing, housing, energy, medicines are all resources that are directly or indirectly linked to the biological variety present in the biosphere.

- **Consumptive use value:** These are direct use values where the biodiversity product can be harvested and consumed directly e.g. fuel, food, drugs, fibre etc . A straight consumptive use is the direct utilization of timber, food, fuelwood 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 prospects etc.

- **Productive use value:** This category comprises of marketable goods. 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 for use in farming and plantation programs or to develop better live stock. 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 rich storehouse from which to develop new products. For the agricultural scientist, the biodiversity is the basis for developing better crops. A variety of industries, like 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 called “biological prospecting”.

- **Social values:** Social value of biodiversity prospecting motivated habitat conservation in some areas, as traditional societies valued it as a resource. 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 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, landlessness, and increased vulnerability to drought and floods.

- **Ethical and moral values:** Ethical values related to biodiversity conservation are based on the importance of protecting all forms of life against illegal activities like cloning of animals, smuggling of valuable biodiversity instances, bio-piracy, illicit trade etc. In India, several generations have preserved nature through local traditions. However, immediate benefit rather than ethics appears to be modern man’s objective.

- **Aesthetic value:** Aesthetic value is a judgment of value based on the appearance of an object and the emotional responses it evokes. Biodiversity is a direct source of pleasure and aesthetic satisfaction – its contribution to quality of life, outdoor recreation and scenic enjoyment. They provide opportunities for recreational activities such as hiking, canoeing, bird watching, river rafting, rock climbing, trekking, parasailing, bird watching and nature photography. The designing of thousands of new horticultural species, wild life conservation, landscape luxury, national parks, zoological and botanical gardens, snake, crocodile, butterfly parks, and biotechnologically manipulated novel curios species added to the existing aesthetics.

- **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 greatest use in the future. Important ecosystem services and uses for plants and animals are still unknown and await discovery. It becomes valuable if targets are based on policy of obtaining wealth from wastes.

Value of Biodiversity | Ecosystem and Biodiversity Services | EVS | Environmental Studies - YouTube

Indian Biodiversity:

India ranks 10th among the plant rich countries of the world, 11th in terms of number of endemic species of higher vertebrates and 6th among the centers of diversity and origin of agricultural crops. The total number of living species identified in our country is 150,000. Out of a total of 25 biodiversity hot-spots in the world, India possesses two, one in the north-east region and one in the Western Ghats. Indian is also one of the 17 mega-biodiversity countries in the world.

REGIONAL OR LOCAL BIODIVERSITY:

Biodiversity at regional level is better understood by categorizing species richness into four types, based upon their spatial distribution as discussed below

(i) **Point richness** refers to the number of species that can be found at a single point in a given space.
(ii) **Alpha (α-) richness** refers to the number of species found in a small homogeneous area
(iii) **Beta (β-) richness** refers to the rate of change in species com-position across different habitats.
(iv) **Gamma (γ-) richness** refers to the rate of change across large landscape gradients

INDIA AS A MEGA-DIVERSITY NATION

Mega diversity:

Like economic wealth, biological wealth is not distributed evenly across the globe. Some countries hold vast amounts of the world's plants and animals. In fact, seventeen of the world's nearly 200 countries hold over 70% of the earth's biodiversity. These countries are labeled "Megadiverse".

Countries list:

They are Australia, Brazil, China, Colombia, the Democratic Republic of the Congo, Ecuador, India, Indonesia, Madagascar, Malaysia, Mexico, Papua New Guinea, Peru, Philippines, South Africa, United States, and Venezuela.

India is one of the **17 megadiversity countries in the world**. The Ministry of Environment and Forests, Govt. of India (2000) records 47,000species of plants and 81,000 species of animals which is about 7% and 6.5% respectively of global flora and fauna.

Endemism: Species which are restricted only to a particular area are known as endemic. India shows a good number of endemic species. About 62% of amphibians and 50% of lizards are endemic to India. Western Ghats are the site of maximum endemism.

Center of origin: A large number of species are known to have originated in India. Nearly 5000 species of flowering plants had their origin in India. From agro-diversity point of view also our country is quite rich. India has been the center of origin of 166 species of crop plants and 320 species of wild relatives of cultivated crops, thereby providing a broad spectrum of diversity of traits for our crop plants.

Marine diversity: Along 7500 km long coastline of our country in the mangroves, estuaries, coral reefs, back waters etc. there exists a rich biodiversity. More than 340 species of corals of the world are found here. The marine diversity is rich in mollusks, crustaceans (crabs etc.), polychaetes and corals. Several species of Mangrove plants and seagrasses (Marine algae) are also found in our country.

Indian forests cover 64.01 million hectares having a rich biodiversity of plants in the Trans-Himalayan, north-west, west, central and eastern Himalayan forests, western ghats, coasts, deserts, Gangetic plains, deccan plateau and the Andaman, Nicobar and Lakshadweep islands. Due to very diverse climatic conditions there is a complete rainbow spectrum of biodiversity in our country.

HOT SPOTS OF BIODIVERSITY

Areas which exhibit high species richness as well as high species endemism are termed as hot spots of biodiversity. The term was introduced by Myers (1988). There are 25 such hot spots of biodiversity on a global level out of which four are present in India, namely the Eastern Himalayas

and Western Ghats and Two of hotspots lie in India extending into neighboring countries namely, Indo-Burma region (covering Eastern Himalayas) and Western Ghats - Sri Lanka region.

According to Myers et al. (2000) an area is designated as a hotspot when it contains at least 0.5% of the plant species as endemics. About 40% of terrestrial plants and 25% of vertebrate species are endemic and found in these hotspots.

a) Eastern Himalayas: They display an ultra-varied topography that fosters species diversity and endemism. There are numerous deep and semi-isolated valleys in Sikkim which are extremely rich in endemic plant species. In an area of 7298 Km^2 of Sikkim about 4250 plant species are found of which 60% are endemic.

Recent studies have shown that North East India along with its contiguous regions of Burma and Chinese provinces of Yunnan and Schezwan is an active center of organic evolution and is considered to be the cradle of flowering plants. Out of the world's recorded flora 30% are endemic to India of which 35,000 are in the Himalayas.

(b) Western Ghats: It extends along a 17,000 Km^2 strip of forests in Maharashtra, Karnataka, Tamil Nadu and Kerala and has 40% of the total endemic plant species. 62% amphibians and 50% lizards are endemic to Western Ghats. Forest tracts upto 500 m elevation covering 20% of the forest expanse are evergreen while those in 500-1500 m range are semi-evergreen. The major centers of diversity are Agastyamalai Hills and Silent Valleyóthe New Amambalam Reserve Basin. It is reported that only 6.8% of the original forests are existing today while the rest has been deforested or degraded, which raises a serious cause of alarm, because it means we have already lost a huge proportion of the biodiversity.

Global Biodiversity Hotspots | Hotspots of India |EVS | Environmental Studies - YouTube

THREATS TO BIODIVERSITY

Extinction or elimination of a species is a natural process of evolution. In the geologic period the earth has experienced mass extinctions. During evolution, species have died out and have been replaced by others. However, the rate of loss of species in geologic past has been a slow process, keeping in view the vast span of time going back to 444 million years. The process of extinction has become particularly fast in the recent years of human civilization. Major causes and issues related to threats to biodiversity:

1) LOSS OF HABITAT:

Destruction and loss of natural habitat is the single largest cause of biodiversity loss. Billions of hectares of forests and grasslands have been cleared over the past 10,000 years for conversion into agriculture lands, pastures, settlement areas or development projects. These natural forests

and grasslands were the natural homes of thousands of species which perished due to loss of their natural habitat. Severe damage has been caused to wetlands thinking them to be useless ecosystems. The unique rich biodiversity of the wetlands, estuaries and mangroves are under the most serious threat today. The wetlands are destroyed due to draining, filling and pollution thereby causing huge biodiversity loss.

2) POACHING:

Illegal trade of wildlife products by killing prohibited endangered animals i.e. poaching is another threat to wildlife. Despite international ban on trade in products from endangered species, smuggling of wildlife items like furs, hides, horns, tusks, live specimens and herbal products worth crores per year continues. The trading of such wild life products is highly profit making for the poachers who just hunt these prohibited wild life and smuggle it to other countries mediated through a mafia. Do not purchase furcoat, purse or bag, or items made of crocodile skin or python skin. You will certainly help in preserving biodiversity by doing so.

3) MAN-WILDLIFE CONFLICTS:

Human-wildlife conflict is when encounters between humans and wildlife lead to negative results, such as loss of property, livelihoods, and even life. Defensive and retaliatory killing may eventually drive these species to extinction. Instances of man animal conflicts keep on coming to lime light from several states in our country. In Sambalpur, Orissa 195 humans were killed in the last 5 years by elephants. In retaliation the villagers killed 98 elephants and badly injured 30 elephants.

Biodiversity : Threats to Biodiversity - YouTube

3.1. CAUSES OF MAN-ANIMAL CONFLICTS:

The root causes of these conflicts are discussed below:

(i) Dwindling habitats of tigers, elephants, rhinos and bears **due to shrinking forest cover** compels them to move outside the forest and attack the field or sometimes even humans. Human encroachment into the forest areas raises a conflict between man and the wildlife, perhaps because it is an issue of survival of both.

(ii) Usually the **ill, weak and injured animals have a tendency to attack man**. Also, the female tigress attacks the human if she feels that her newborn cubs are in danger. But the biggest problem is that if human-flesh is tasted once then the tiger does not eat any other animal.

At the same time, it is very difficult to trace and cull the man-eating tiger and in the process many innocent tigers are also killed.

(iii) Earlier, **forest departments used to cultivate paddy, sugarcane etc. within the sanctuaries** when the favourite staple food of elephants i.e. bamboo leaves were not available. Now due to lack of such practices the animals move out of the forest in search of food. It may be noted that, One adult elephant needs 2 quintals of green fodder and 150 kg of clean water daily and if it is not available, the animal strays out.

(iv) Very often the villagers put electric wiring around their ripe crop fields. The **elephants get injured, suffer in pain and turn violent**.

(v) Earlier there used to be wild-life corridors through which the wild animals used to migrate seasonally in groups to other areas. **Due to development of human settlements in these corridors, the path of wildlife has been disrupted** and the animals attack the settlements.

(vi) The cash compensation paid by the government in lieu of the damage caused to the farmers' crop is not enough. In Mysore, a farmer gets a compensation of Rs. 400/- per quintal of expected yield while the market price is Rs. 2400/- per quintal. The agonized farmer therefore gets revengeful and kills the wild animals.

3.2. REMEDIAL MEASURES TO CURB THE CONFLICT:

(i) Tiger Conservation Project (TCP) has made provisions for making available vehicles, tranquillizer guns, binoculars and radio sets etc. to tactfully deal with any imminent danger.

(ii) Adequate crop compensation and cattle compensation scheme must be started, along with substantial cash compensation for loss of human life.

(iii) Solar powered fencing should be provided along with electric current proof trenches to prevent the animals from straying into fields.

(iv) Cropping pattern should be changed near the forest borders and adequate fodder, fruit and water should be made available for the elephants within forest zones.

(v) Wild life corridors should be provided for mass migration of big animals during unfavorable periods. About 300 km^2 area is required for elephant corridors for their seasonal migration.

(vi) In Similipal Sanctuary, Orissa there is a ritual of wild animal hunting during the months of April-May for which forest is burnt to flush out the animals. Due to massive hunting by people, there is a decline in prey of tigers and they start coming out of the forest in search of prey. Now there is WWF-TCP initiative to curb this ritual in Orissa.

ENDANGERED SPECIES OF INDIA

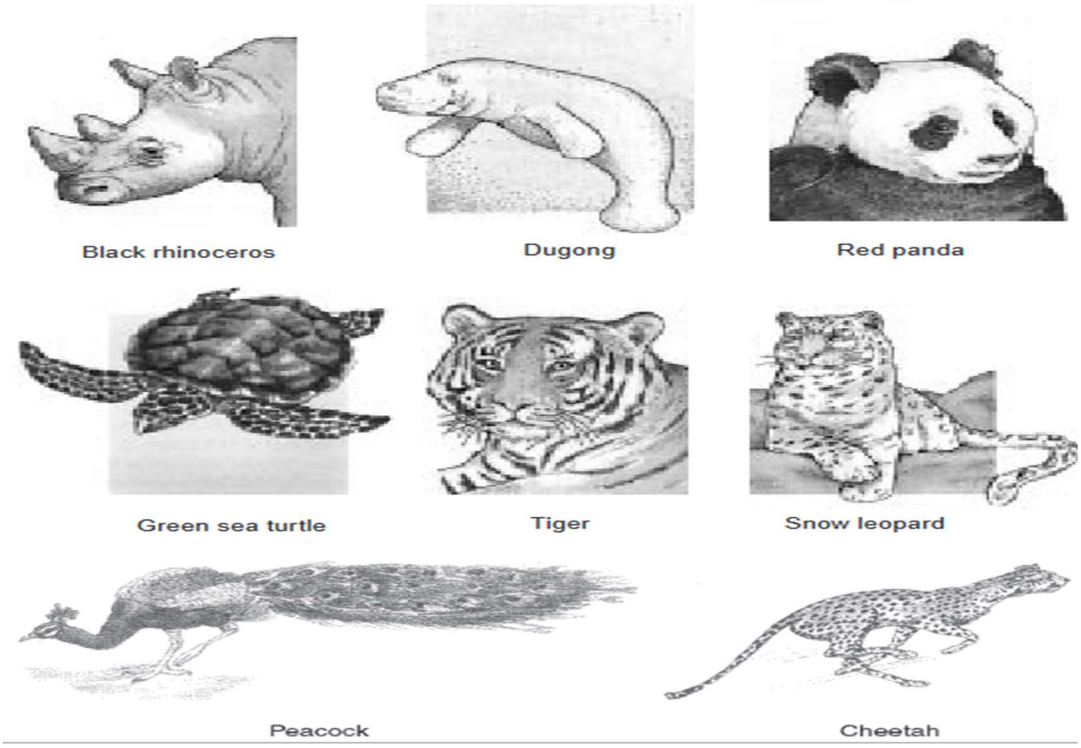
The Red Data Book is referred to as the public document that records the information about all rare and endangered species of plants, animals, and fungi existing within the boundary

of a state or territory. It can be considered as a catalogue of species facing the risk of extinction.

An endangered species is an animal or plant that's considered at risk of extinction. In India, nearly 450 plant species have been identified in the categories of endangered, threatened or rare. Existence of about 150 mammals and 150 species of birds is estimated to be threatened while an unknown number of species of insects are endangered.

A few species of endangered reptiles, birds, mammals and plants are given below:

(a) Reptiles : Gharial, green sea turtle, tortoise, python
(b) Birds : Great Indian bustard, Peacock, Pelican, Great Indian Hornbill, Siberian White Crane
(c) Carnivorous : Indian wolf, red fox, Sloth bear, red panda, Mammals tiger, leopard, striped hyena, Indian lion, golden cat, desert cat, dugong
(d) Primates : Hoolock gibbon, lion-tailed macaque, Nilgiri langur, Capped monkey, golden monkey
(e) Plants : A large number of species of orchids, Rhododendrons, medicinal plants like Rauvolfia serpentina, the sandal wood tree Santalum, Cycas beddonei etc.



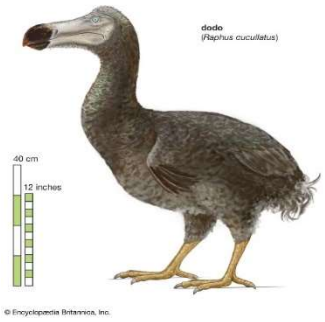
1) A species is said to be **extinct** when it is not seen in the wild for 50 years at a stretch e.g. Dodo, passenger pigeon.
2) A species is said to be **endangered** when its number has been reduced to a critical level or whose habitats, have been drastically reduced and if such a species is not protected and conserved, it is in immediate danger of extinction.

3) A species is said to be in **vulnerable** category if its population is facing continuous decline due to overexploitation or habitat destruction. Such a species is still abundant, but under a serious threat of becoming endangered if causal factors are not checked.
4) Species which are not endangered or vulnerable at present, but are at a **risk** are categorized as rare species.
5) These taxa are usually localized within restricted areas i.e. they are usually **endemic**. Sometimes they are thinly scattered over a more extensive area.

Extinct species:

1. Passenger Pigeon: The passenger pigeon or wild pigeon is an extinct species of pigeon that was endemic to North America. Its common name is derived from the French word passenger, meaning "passing by", due to the migratory habits of the species.

2. Dodo: The *dodo* (Raphus cucullatus) is an extinct flightless bird that was endemic to the island of Mauritius, which is east of Madagascar in the Indian Ocean.



ENDEMIC SPECIES OF INDIA

India has two biodiversity hot spots and thus possesses a large number of endemic species. Out of about 47,000 species of plants in our country 7000 are endemic. Thus, Indian subcontinent has about 62% endemic flora, restricted mainly to Himalayas, Khasi Hills and Western Ghats. Some of the important endemic flora include orchids and species like

- Sapria himalayana,
- Uvaria lurida,
- Nepenthes khasiana,
- Pedicularis perroter etc.

A large number out of a total of 81,000 species of animals in our country is endemic.

The western ghats are particularly rich in amphibians (frogs, toads etc.) and reptiles (lizards, crocodiles etc.). About 62% amphibians and 50% lizards are endemic to Western Ghats.

- Different species of monitor lizards (Varanus),
- reticulated python and
- Indian Salamander and
- Viviparous toad
- Nectophhryne

are some important endemic species of our country.

CONSERVATION OF BIODIVERSITY

The enormous value of biodiversity due to their genetic, commercial, medical, aesthetic, ecological and optional importance emphasizes the need to conserve biodiversity. A number of measures are now being taken the world over to conserve biodiversity including plants and wildlife. There are two approaches of biodiversity conservation:

(A) In situ conservation (within habitat): This is achieved by protection of wild flora and fauna in nature itself. e.g. Biosphere Reserves, National Parks, Sanctuaries, Reserve Forests etc. At present we have 7 major Biosphere reserves, 80 National Parks, 420 wild-life sanctuaries and 120 Botanical gardens in our country covering 4% of the geographic area.

The Biosphere Reserves conserve some representative ecosystems as a whole for long-term in situ conservation. In India we have Nanda Devi (U.P.), Nokrek (Meghalaya), Manas (Assam), Sunderbans (West Bengal), Gulf of Mannar (Tamil Nadu), Nilgiri (Karnataka, Kerala, Tamil Nadu), Great Nicobars and Similipal (Orrisa) biosphere Reserves. Within the Biosphere reserves we may have one or more National Parks. For example, Nilgiri Biosphere Reserve has two National Parks viz Bandipur and Nagarhole National Park.

A National Park is an area dedicated for the conservation of wildlife along with its environment. It is also meant for enjoyment through tourism but without impairing the environment. Grazing of domestic animals, all private rights and forestry activities are prohibited within a National Park. Each National Park usually aims at conservation specifically of some particular species of wildlife along with others.

Table 4.5. Some important National parks in India

Name of National Park	State	Important Wildlife
Kaziranga	Assam	One horned Rhino
Gir National Park	Gujarat	Indian Lion
Dachigam	J & K	Hangul
Bandipur	Karnataka	Elephant
Periyar	Kerala	Elephant, Tiger
Kanha	M.P.	Tiger
Corbett	U.P.	Tiger
Dudwa	U.P.	Tiger
Ranthambore	Rajasthan	Tiger
Sariska	Rajasthan	Tiger

Wildlife sanctuaries are also protected areas where killing, hunting, shooting or capturing of wildlife is prohibited except under the control of highest authority. However, private ownership rights are permissible and forestry operations are also permitted to an extent that they do not affect the wildlife adversely.

For plants, there is one gene sanctuary for Citrus (Lemon family) and one for pitcher plant (an insect eating plant) in Northeast India. For the protection and conservation of certain animals, there have been specific projects in our country e.g. Project Tiger, Gir Lion Project, Crocodile Breeding Project, Project Elephant, Snow Leopard Project etc.

Table 4.6. Some Important Wildlife Sanctuaries of India

Name of Sanctuary	State	Major Wild Life
Ghana Bird Sanctuary	Rajasthan	300 species of birds (including migratory)
Hazaribagh Sanctuary	Bihar	Tiger, Leopard
Sultanpur Bird Sanctuary	Haryana	Migratory birds
Nal Sarovar Bird Sanctuary	Gujarat	Water birds
Abohar Wildlife Sanctuary	Punjab	Black buck
Mudamalai Wildlife Sanctuary	Tamil Nadu	Tiger, elephant, Leopard
Vedanthangal Bird Sanctuary	Tamil Nadu	Water birds
Jaldapara Wild Life Sanctuary	W. Bengal	Rhinoceros, elephant, Tiger
Wild Ass Sanctuary	Gujarat	Wild ass, wolf, nilgai, chinkara

(B) Ex situ conservation (outside habitats) this is done by establishment of gene banks, seed banks, zoos, botanical gardens, culture collections etc.

This type of conservation is mainly done for conservation of crop varieties, the wild relatives of crops and all the local varieties with the main objective of conserving the total genetic variability of the crop species for future crop improvement or afforestation programmes. In India, we have the following important gene bank/seed bank facilities:

(i) National Bureau of Plant Genetic Resources (NBPGR) is located in New Delhi. Here agricultural and horticultural crops and their wild relatives are preserved by ***cryo-preservation*** of seeds, pollen etc. by using liquid nitrogen at a temperature as low as -196^0C. Varieties of rice, pearl millet, Brassica, turnip, radish, tomato, onion, carrot, chilli, tobacco, poppy etc. have been preserved successfully in liquid nitrogen for several years without losing seed viability.

(ii) National Bureau of Animal Genetic Resources (NBAGR) located at Karnal, Haryana. It preserves the semen of domesticated bovine animals.

(iii) National Facility for Plant Tissue Culture Repository (NFPTCR) for the development of a facility of conservation of varieties of crop plants/trees by tissue culture. This facility has been created within the NBPGR. The G-15 countries have also resolved to set up a network of gene banks to facilitate the conservation of various varieties of aromatic and medicinal plants for which India is the networking coordinator country.

Conservation of Biodiversity | Threats to Biodiversity | EVS | Environmental Studies - YouTube

Book:

1. Anubha Kaushik and C. P. Kaushik's "Perspectives in Environmental Studies", 6th Edition, New Age International Publishers ,2018.
(Perspectives in Environmental Studies (gbcramgarh.in)

UNIT II ENVIRONMENTAL POLLUTION

Causes, Effects and Preventive measures of Water, Soil, Air and Noise Pollutions. Solid, Hazardous and E-Waste management. Case studies on Occupational Health and Safety Management system (OHASMS). Environmental protection, Environmental protection acts.

Prepared by
Dr R.Someswaran

Environmental pollution can, therefore, be defined as any undesirable change in the physical, chemical or biological characteristics of any component of the environment (air, water, soil), which can cause harmful effects on various forms of life or property.

Learn about Pollution | Environment Defilement | Cartoon - YouTube

Environmental pollution, the addition of any substance (solid, liquid, or gas) or any form of energy (such as heat, sound, or radioactivity) to the environment at a rate faster than it can be dispersed, diluted, decomposed, recycled, or stored in some harmless form. The major kinds of pollution, usually classified by environment, are air pollution, water pollution, and land pollution.

WATER POLLUTION

Water pollution can be defined as alteration in physical, chemical or biological characteristics of water making it unsuitable for designated use in its natural state

I. SOURCES OF WATER POLLUTION:

Water is an essential commodity for survival. We need water for drinking, cooking, bathing, washing, irrigation, and for industrial operations. Most of water for such uses comes from rivers, lakes or groundwater sources. Water has the property to dissolve many substances in it, therefore, it can easily get polluted.

Pollution of water can be caused by

- Point sources or
- Non-point sources.

Point sources are specific sites near water which directly discharge effluents into them. Major point sources of water pollution are industries, power plants, underground coal mines, offshore oil wells etc.

The discharge from non-point sources is not at any particular site, rather, these sources are scattered, which individually or collectively pollute water. Surface run-off from agricultural fields, overflowing small drains, rain water sweeping roads and fields, atmospheric deposition etc. are the non-point sources of water pollution.

Ground water pollution: Ground water forms about 6.2% of the total water available on planet earth and is about 30 times more than surface water (streams, lakes and estuaries). Ground water seems to be less prone to pollution.

Potential sources of ground water pollution. Septic tanks, industry (textile, chemical and tanneries), deep well injection, mining etc. are mainly responsible for ground water pollution, which is irreversible. Ground water pollution with arsenic, fluoride and nitrate are posing serious health hazards.

Surface water pollution: The major sources of surface water pollution are:

1. Sewage: Pouring the drains and sewers in fresh water bodies causes water pollution. The problem is severe in cities.

2. Industrial effluents: Industrial wastes containing toxic chemicals, acids, alkalis, metallic salts, phenols, cyanides, ammonia, radioactive substances, etc. are sources of water pollution. They also cause thermal (heat) pollution of water.

3. Synthetic detergents: Synthetic detergents used in washing and cleaning produce foam and pollute water.

4. Agrochemicals: Agrochemicals like fertilizers (containing nitrates and phosphates) and pesticides (insecticides, fungicides, herbicides etc.) washed by rain-water and surface run-off pollute water.
5. Oil: Oil spillage into sea-water during drilling and shipment pollute it.

II. EFFECTS OF WATER POLLUTION:
Following are some important effects of various types of water pollutants:

- **Oxygen demanding wastes:** Organic matter which reaches water bodies is decomposed by micro-organisms present in water. For this degradation oxygen dissolved in water is consumed.
- Lower DO may be harmful to animals especially fish population. Oxygen depletion (deoxygenation) helps in release of phosphates from bottom sediments and causes eutrophication.
- **Nitrogen and Phosphorus Compounds (Nutrients):** Addition of compounds containing nitrogen and phosphorus helps in the growth of algae and other plants which when die and decay consume oxygen of water.
- **Toxic Compounds:** Pollutants such as heavy metals, pesticides, cyanides and many other organic and inorganic compounds are harmful to aquatic organisms. Some of these substances like pesticides, methyl mercury etc. move into the bodies of organisms. These substances tend to accumulate in the organisms body. This process is called **bioaccumulation**. The concentration of these toxic substances builds up at successive levels of food chain. This process is called **bio magnification**.
- **Pathogens:** Many wastewaters especially sewage contain many pathogenic (disease causing) and non-pathogenic micro-organisms and many viruses. Water borne diseases like cholera, dysentery, typhoid, jaundice etc. are spread by water contaminated with sewage.
- **Nitrate in stomach** partly gets changed into nitrites which can produce cancer-causing products in the stomach.
- **Excess of fluoride** in drinking water causes defects in teeth and bones called fluorosis.

III. CONTROL OF WATER POLLUTION:
It is easy to reduce water pollution from point sources by legislation. However, due to absence of defined strategies it becomes difficult to prevent water pollution from non-point sources. The following points may help in reducing water pollution from non-point sources.

- It is important to dispose-off waste carefully and not to dump it directly into water bodies, without proper waste treatment.
- Industries should treat their wastes carefully before disposing of chemicals and other materials into water bodies directly. Sewage treatment plants and wastewater treatment plants in industries are established to treat the water used so it can be safely mixed into the river streams. It also enables water recycling.
- Using natural fertilizers and pesticides as substitutes for chemical ones is good for plants and water.
- Chemical processes such as coagulation, ion exchange method, reverse osmosis, etc. will greatly reduce the level of water pollution.
- Lastly, it is better to reduce the consumption of water in our daily activities and reuse water whenever possible to reduce the overall level of pollution.

SOIL POLLUTION

Soil is the upper layer of the earth crust which is formed by weathering of rocks. Organic matter in the soil makes it suitable for living organisms.

I. SOURCES OF SOIL POLLUTION

Dumping of various types of materials especially domestic and industrial wastes causes soil pollution.

Domestic wastes include garbage, rubbish material like glass, plastics, metallic cans, paper, fibres, cloth rags, containers, paints, varnishes etc. Leachates from dumping sites and sewage tanks are harmful and toxic, which pollute the soil.

Industrial wastes are the effluents discharged from chemical industries, paper and pulp mills, tanneries, textile mills, steel industries, distilleries, refineries, pesticides and fertilizer industries, pharmaceutical industries, food processing industries, cement industries, thermal and nuclear power plants, mining industries etc.

Pesticides are used to kill pests that damage crops. These pesticides ultimately reach the soil and persist there for a long time. DDT, HCH, endrin, lindane, heptachlor, endosulfan etc. Residues of these pesticides in the soils have long term effects.

The sources of ***radioactive substances*** in soil are explosion of radioactive devices, radioactive wastes discharged from industries and laboratories, aerial fall out etc.

II. EFFECTS OF SOIL POLLUTION:

- Soil pollution ultimately affect human health.
- Various types of chemicals like acids, alkalis, pesticides, insecticides, weedicides, fungicides, heavy metals etc. in the industrial discharges affect soil fertility by causing changes in physical, chemical and biological properties.
- Some of the persistent toxic chemicals inhibit the non-target organisms, soil flora and fauna and reduce soil productivity. These chemicals accumulate in food chain and ultimately affect human health.
- Radioactive fallout on vegetation is the source of radio-isotopes which enter the food chain in the grazing animals. Some of these radio isotopes replace essential elements in the body and cause abnormalities e.g. strontium-90 instead of calcium gets deposited in the bones and tissues. The bones become brittle and prone to fracture.
- Nitrogen and phosphorus from the fertilizers in soil reach nearby water bodies with agricultural run-off and cause eutrophication. Chemicals or their degradation products from soil may percolate and contaminate ground-water resources.

III. CONTROL OF SOIL POLLUTION

(i) Effluents should be properly treated before discharging them on the soil.
(ii) Solid wastes should be properly collected and disposed off by appropriate method.
(iii) From the wastes, recovery of useful products should be done.
(iv) Biodegradable organic waste should be used for generation of biogas.

(v) Cattle dung should be used for methane generation. Nightsoil (human faeces) can also be used in the biogas plant to produce inflammable methane gas.

(vi) Microbial degradation of biodegradable substances is also one of the scientific approaches for reducing soil pollution.

AIR POLLUTION

It is an atmospheric condition in which certain substances (including the normal constituents in excess) are present in concentrations which can cause undesirable effects on man and his environment. These substances include **gases, particulate matter, radioactive substances** etc.

- Gaseous pollutants include oxides of sulphur (mostly SO2, SO3) oxides of nitrogen (mostly NO and NO2 or NOx), carbon monoxide (CO), volatile organic compounds (mostly hydrocarbons) etc.

- Particulate pollutants include smoke, dust, soot, fumes, aerosols, liquid droplets, pollen grains etc.

- Radioactive pollutants include radon-222, iodine-131, strontium-90, plutonium-239 etc.

I. SOURCES OF AIR POLLUTION

The sources of air pollution are natural and man-made (anthropogenic).

Natural Sources: The natural sources of air pollution are volcanic eruptions, forest fires, sea salt sprays, biological decay, photochemical oxidation of terpenes, marshes, extra-terrestrial bodies, pollen grains of flowers, spores etc. Radioactive minerals present in the earth crust are the sources of radioactivity in the atmosphere.

Man-made: Man made sources include thermal power plants, industrial units, vehicular emissions, fossil fuel burning, agricultural activities etc. Thermal power plants have become the major sources for generating electricity in India as the nuclear power plants couldn't be installed as planned. The main pollutants emitted are fly ash and SO2. Metallurgical plants also consume coal and produce similar pollutants. Fertilizer plants, smelters, textile mills, tanneries, refineries, chemical industries, paper and pulp mills are other sources of air pollution. Automobile exhaust is another major source of air pollution. Automobiles release gases such as carbon monoxide (about 77%), oxides of nitrogen (about 8%) and hydrocarbons (about 14%). Heavy duty diesel vehicles spew more NOx and suspended particulate matter (SPM) than petrol vehicles which produce more carbon monoxide and hydrocarbons.

Indoor Air Pollution:

The most important indoor air pollutant is radon gas. Radon gas and its radioactive daughters are responsible for a large number of lung cancer deaths each year. Radon can be emitted from building materials like bricks, concrete, tiles etc. which are derived from soil containing radium. Radon is also present in groundwater and natural gas and is emitted indoors while using them.

(Sources of air pollution)

II. EFFECTS OF AIR POLLUTION:

1. Effects on Human Health:

- ***Human respiratory system has a number of mechanisms for protection from air pollution***. Bigger particles (> 10 μm) can be trapped by the hairs and sticky mucus in the lining of the nose. Smaller particles can reach tracheobronchial system and there get trapped in mucus. They are sent back to throat by beating of hair like cilia from where they can be removed by spitting or swallowing.

- ***Prolong exposure*** to air pollutants (including cigarette smoke) adversely ***affect these natural defenses*** and can result in lung cancer, asthma, chronic bronchitis and emphysema (damage to air sacs leading to loss of lung elasticity and acute shortness of breath).
- ***Suspended particulates*** can cause damage to lung tissues and diseases like asthma, bronchitis and cancer especially when they bring with them cancer causing or toxic pollutants attached on their surface.
- ***Sulphur dioxide (SO2)*** causes constriction of respiratory passage and can cause bronchitis like conditions. In the presence of suspended particulates, SO2 can form acid sulphate particles, which can go deep into the lungs and affect them severely.
- ***Carbon monoxide (CO)*** reaches lungs and combines with haemoglobin of blood to form carboxyhaemoglobin. CO has affinity for haemoglobin 210 times more than oxygen. Haemoglobin is, therefore, unable to transport oxygen to various parts of the body. This causes suffocation. Long exposure to CO may cause dizziness, unconsciousness and even death.

2. Effects on Plants:
- Air pollutants affect plants by entering through stomata (leaf pores through which gases diffuse), destroy chlorophyll and affect photosynthesis.
- Pollutants also erode waxy coating of the leaves called cuticle. Cuticle prevents excessive water loss and damage from diseases, pests, drought and frost.
- Damage to leaf structure causes necrosis (dead areas of leaf), chlorosis (loss or reduction of chlorophyll causing yellowing of leaf)

3. Effects on aquatic life:
- Air pollutants mixing up with rain can cause high acidity (lower pH) in fresh water lakes.
- This affects aquatic life especially fish. Some of the freshwater lakes have experienced total fish death

4. Effects on materials:
- Because of their corrosiveness, particulates can cause damage to exposed surfaces.
- Presence of SO2 and moisture can accelerate corrosion of metallic surfaces.
- SO2 can affect fabric, leather, paint, paper, marble and limestone.
- Ozone in the atmosphere can cause cracking of rubber.

III. CONTROL OF AIR POLLUTION

Air pollution can be minimized by the following methods:
- Siting of industries after proper Environmental Impact Assessment studies.
- Using low sulphur coal in industries and Removing sulphur from coal (by washing)
- Removing NOx during the combustion process.
- Vehicular pollution can be checked by regular tune-up of engines ; replacement of more polluting old vehicles; installing catalytic converters ; by engine modification to have fuel efficient (lean) mixtures to reduce CO and hydrocarbon emissions;
- Using mass transport system, bicycles etc.
- Shifting to less polluting fuels (hydrogen gas).
- Using non-conventional sources of energy.
- Using biological filters and bio-scrubbers.
- Planting more trees

NOISE POLLUTION

Sound is mechanical energy from a vibrating source. A type of sound may be pleasant to someone and at the same time unpleasant to others. The unpleasant and unwanted sound is called noise. The noise measurements are expressed as Sound Pressure Level (SPL) which is logarithmic ratio of the sound pressure to a reference pressure. It is expressed as a dimensionless unit, decibel (dB).

I. SOURCES OF NOISE POLLUTION:

The main sources of noise are

- Various modes of transportation (like air, road, rail-transportation),
- Industrial operations,
- Construction activities and celebrations (social/religious functions, elections etc)
- Electric home appliances.

II. EFFECTS OF NOISE:

Noise causes the following effects.

(i) Interferes with man's communication: In a noisy area communication is severely affected.

(ii) Hearing damage: Noise can cause temporary or permanent hearing loss. It depends on intensity and duration of sound level. Auditory sensitivity is reduced with noise level of over 90 dB in the midhigh frequency for more than a few minutes.

(iii) Physiological and Psychological changes: Continuous exposure to noise affects the functioning of various systems of the body. It may result in hypertension, insomnia (sleeplessness), gastro-intestinal and digestive disorders, peptic ulcers, blood pressure changes, behavioural changes, emotional changes etc

III. CONTROL OF NOISE POLLUTION

1. Reduction in sources of noise: Sources of noise pollution like heavy vehicles and old vehicles may not be allowed to ply in the populated areas.
2. Noise making machines should be kept in containers with sound absorbing media. The noise path will be in interrupted and will not reach the workers.
3. Proper oiling will reduce the noise from the machinery.
4. Use of sound absorbing silencers: Silencers can reduce noise by absorbing sound. For this purpose various types of fibrous material could be used.
5. Planting more trees having broad leaves.
6. Through Law: Legislation can ensure that sound production is minimized at various social functions. Unnecessary horn blowing should be restricted especially in vehicle-congested areas

SOLID WASTE (all non-liquid wastes)

The term "solid waste management" refers to the collection, treatment, and disposal procedure for solid wastes. Wastes are gathered from various sources and are disposed of through the waste management process, which involves the key components like collection, transportation, treatment, analysis, and disposal.

I. SOURCES OF SOLID WASTE

1. Urban or Municipal solid waste
    - Domestic waste
    - commercial waste
    - Construction waste
    - market waste
    - institutional
    - agricultural
    - open area
2. Industrial waste
    - Thermal power plants
    - Chemical industry
    - Nuclear power plants
    - Other industries
3. Bio-medical waste: Include syringes, bandages, used gloves, drugs, paper, plastics, food wastes and chemicals. All these require proper disposal or else they will cause a huge problem for the environment
4. Hazardous waste
    - e-waste
    - toxic waste
    - reactive waste
    - corrosive waste
    - radioactive waste

Examples
• Batteries containing toxic metals (zinc, lead or mercury)
• Wastes from hospitals & pathology Labs
• Toxic Chemicals

Categories of Waste:

1. **Organic waste:** Kitchen waste, waste from food preparation, vegetables, flowers, leaves, fruits, and market places.
2. **Combustibles:** Paper, wood, dried leaves, packaging for relief items etc. that are highly organic and having low moisture content.
3. **Non-combustibles:** Metal, Tins, Cans, bottles, stones, etc.
4. **Toxic waste:** Old medicines, paints, chemicals, bulbs, spray cans, fertilizer and pesticide containers, batteries, shoe polish.
5. **Recyclables:** Paper, glass, metals, plastics.
6. **Ashes or Dust:** Residue from fires that are used for cooking.
7. **Construction waste:** Rubble, roofing, broken concrete etc.
8. **Hazardous waste:** Oil, battery acid, medical waste, industrial waste, hospital waste.
9. **Dead animals:** Carcasses of dead livestock or other animals.

10. **Bulky waste:** Tree branches, tires etc.
11. **Soiled waste:** Hospital waste such as cloth soiled with blood and other body fluids.

If not correctly disposed of, waste may provide breeding sites for insects, pests, snakes and rats that increase the likelihood of disease transmission. It may also pollute water sources and the environment.

II. HARMFUL EFFECTS OF SOLID WASTE

- Bad odour of waste
- Production of toxic gases
- Degradation of natural beauty
- Air pollution
- Water pollution
- Soil pollution
- Spread of diseases
- Effect on biodiversity

Key components of solid waste management:
Solid waste management can be divided into five key components:

(i) Generation
(ii) Storage
(iii) Collection
(iv) Transportation
(v) Segregation
(vi) Disposal

Generation
Generation of solid waste is the stage at which materials become valueless to the owner, they wish to get rid of them. Items which may be valueless to one individual may not necessarily be valueless to another. For example, waste items such as tins and cans may be highly sought after by young children.

Storage
Storage is a system for keeping materials after they have been discarded and prior to collection and final disposal. Improved storage facilities include:

- Small containers: household containers, plastic bins, etc.
- Large containers: communal bins, oil drums, etc
- Shallow pits
- Communal depots: walled or fenced-in areas

Collection
Collection simply refers to how waste is collected for transportation to the final disposal site. Any collection system should be carefully planned to ensure that storage facilities do not become overloaded.

Transportation
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. For example, human powered, animal powered and motorized.

Disposal
The final stage of solid waste management is safe disposal where associated risks are minimised.

- **Landfill:** It involves burying the waste in vacant locations around the city. Modern landfills are designed in such a way that the bottom of the landfill is covered with an impervious liner which is made of several layers of thick plastic and sand. Top of the landfill is covered with layers of sand, clay, topsoil and gravel to prevent seepage of water.

  Benefits: A sanitary disposal method if managed effectively.
  Limitations: A reasonably large area is required.

- **Incineration:** It is the controlled oxidation (burning/thermal treatment) of mostly organic compounds at high temperatures to produce thermal energy, CO_2. Incineration with energy recovery is the next best option to recycling for waste management.

  Benefits: Burning significantly reduces the volume of combustible waste.
  Limitations: Smoke and fire hazards may exist.

- **Pyrolysis** - It is a process of breaking down combustible material at high temperature in the absence of oxygen.

  Benefits: Low cost technology, reduces greenhouse gas emissions and waste going to landfill
  Limitations: Technology is still evolving

- **Composting:** It is a natural process of recycling organic matter like leaves and food scraps into beneficial fertilizers that can benefit both soil and plants.

  Benefits: It is beneficial for crops and is an environment-friendly method.
  Limitations: Requires high-skilled labour for large-scale operation.

- **Recycling:** It is a process of converting waste material into new material. Examples: wood recycling, paper recycling, and glass recycling.

  Benefits: It is environment-friendly.
  Limitations: It is expensive to set up and not reliable in case of an emergency.

- **Vermicomposting:** Vermicomposting is a bio-conversion technique that is commonly used to handle solid waste. Earthworms feed on organic waste to reproduce and multiply in number, vermicompost, and vermiwash as products in this bio-conversion process.

  Benefits: It reduces the need for chemical fertilizers and enhances plant growth.
  Limitations: It is time-consuming, cost-ineffective, and requires extra care.

"3-R" Principle: We can significantly reduce the amount of solid waste by following some basic principles of reducing the amount of waste that is created, reusing materials that would otherwise be discarded, by recycling materials and by using recycled materials. The commonly-used "3-R" phrase to describe this principle is: ***"Reduce, Reuse, and Recycle".***

Reduce: Reducing is simply creating less waste. It's the best method for keeping the environment clean, so it's the first of the 3 Rs. By reducing, you stop the problem at the source. Making less waste to begin with means there's less waste to clean up.

Reuse: Reusing is taking old or unwanted items you might otherwise throw away and finding a new use for them.

Recycle: Recycling is the last — and most commonly used — of the 3 Rs. Recycling is changing discarded materials into new products in order to avoid using more virgin resources.

The process of reducing, reusing and recycling saves money, energy, raw materials, land space and also reduces pollution. Recycling of paper will reduce cutting of trees for making fresh paper. Reuse of metals will reduce mining and smelting of ores for recovery of metals from ores and prevent pollution.

https://www.intechopen.com/chapters/74184
https://www.conserve-energy-future.com/waste-management-and-waste-disposal-methods.php
https://byjus.com/biology/solid-waste-management/
https://www.vedantu.com/biology/solid-waste-management
https://ec.europa.eu/echo/files/evaluation/watsan2005/annex_files/WEDC/es/ES07CD.pdf

HAZARDOUS WASTE

Waste is any material for which the owner has no further use for the material and intends to discard this material. When the waste materials pose potential risks to human health and the environment, they are considered to be hazardous waste. Hazardous wastes can be a liquid, solid, contained gases, or discarded unused commercial product, or discarded used material.

Classification of Hazardous Waste:

1. Listed waste
2. Characteristic waste
3. Universal waste
4. Mixed waste
5. E-Waste
6.

1. Listed wastes are wastes from common manufacturing and industrial processes, specific industries and can be generated from discarded commercial products. According to Environmental Protection Agency (EPA) more than 450 listed wastes which are known to be hazardous are grouped as F-List, K-List, P-List and U-List.

F-list

The F-list contains hazardous wastes originated from a nonspecific source that includes various industrial processes leading to generation of these wastes.

- Solvent wastes
- Metal finishing wastes
- Dioxin-contaminated wastes
- Chlorinated aliphatic hydrocarbons production
- Wood preserving wastes
- Multisource leachate.

K-list

The K-list contains hazardous wastes generated as a result of specific industrial processes and are considered as source-specific wastes.

- Pesticides manufacturing
- Petroleum refining
- Explosives manufacturing
- Iron and steel production
- Primary aluminum production
- Secondary lead processing
- Coking (processing of coal to produce coke)

P and U lists

The unused chemicals of pure and commercial formulations that are being disposed come under P and U lists. For a P- or U-listed waste it requires the following three criteria:

- The waste must contain one of the chemicals listed on the P or U list
- The chemical in the waste must be unused
- The chemical in the waste must be in the form of a commercial chemical product.

2. Characteristic wastes are wastes that exhibit any one or more of the following characteristic properties: ignitability, corrosively, reactivity or toxicity.

Ignitability

A waste is considered to be an ignitable hazardous waste if its flash point is less than 60°C, readily catches fire and burns vigorously as a hazard; or is an ignitable compressed gas or an oxidizer. Ex: Naphtha, lacquer thinner, epoxy resins, adhesives, and oil based paints etc.

Corrosivity

Any type of liquid waste whose pH is less than or equal to 2 or greater than or equal to 12.5 is considered to be corrosive hazardous waste. Sodium hydroxide (High pH) and hydrochloric acid (Low pH) is often used in many industries to clean or degrease metal parts. Prior to painting disposed solvents without any treatment contributes to corrosive hazardous waste.

Reactivity

A material is considered as reactive hazardous waste, if it is unstable, reacts violently with water, and generates toxic gases when exposed to water or corrosive materials, or explodes when exposed to heat or a flame. Examples of reactive wastes would be waste gunpowder, sodium metal or wastes containing cyanides or sulphides.

Toxicity

Toxicity of a hazardous waste can be determined by taking a representative sample of the material and subjected to a test conducted in a certified laboratory and toxic characteristics can be determined.

Categories of hazardous wastes

Radioactive substance

Any substances capable of emitting ionizing radiation are said to be radioactive and are hazardous because prolonged exposure often results in damage to living organisms. Radioactive substances attract special concern because they persist for a long period and

disposal depends upon half-life period of the radioactive substance. For example, uranium compounds have half-lives that range from 72 years for U232 to 23,420,000 years for U236.

Chemicals

The hazardous chemical wastes can be categorized into five group's namely synthetic organics, inorganic metals, salts, acids and bases, and flammables and explosives. Some of the chemicals are hazardous because they threaten human lives.

Bio-medical wastes

The main sources of hazardous biological wastes are from hospitals and biological research facilities. The biological waste has the capability of infecting other living organisms and has the ability to produce toxins. Biomedical waste mainly includes malignant tissues discarded during surgical procedures and contaminated materials, such as hypodermic needles, bandages and outdated drugs.

Flammable wastes

The hazardous waste category also includes flammable wastes. This grouping is necessary because of risk involved in storage, collection and disposal of flammable wastes. The flammable wastes may be of solid, liquid or gaseous form. Examples of flammable waste include organic solvents, oils, plasticizers and organic sludge's.

Explosives

Explosive hazardous wastes are mainly ordnance (artillery) materials. Explosives also involve high potential for hazard in case of storage, collection and disposal. These types of wastes may exist in solid, liquid or gaseous form.

3. Universal wastes are certain hazardous wastes that are generated by a large cross section of the regulated community and include such wastes as batteries, pesticides, mercury containing equipment, lamps.

4. Mixed waste contains both radioactive and hazardous waste components. As a result, both treatment and regulation are complex.

5. E-waste is any electrical or electronic equipment that's been discarded. E-waste is particularly dangerous due to toxic chemicals that naturally leach from the metals inside when buried.

Hazardous waste management is the general term associated with procedures and policies of hazardous waste management that it does not cause any potential threat to man and the environment.

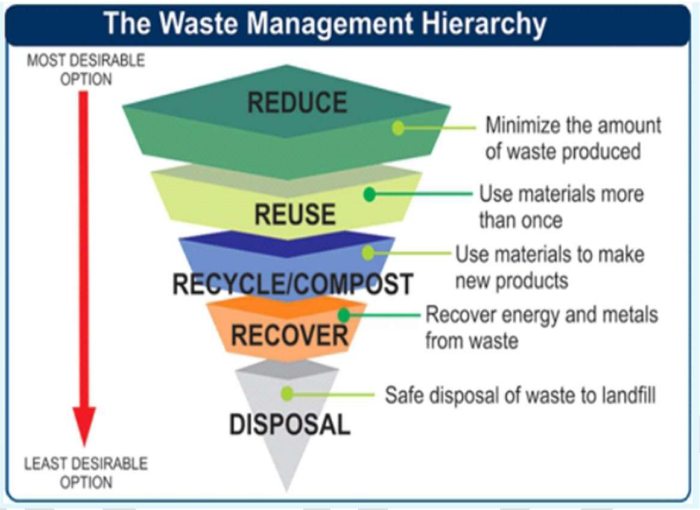
HAZARDOUS WASTE CONTROL MEASURES:

i. Source reduction
ii. Waste minimization
iii. Waste recycling
iv. Waste treatment: Hazardous waste can be treated by following methods.

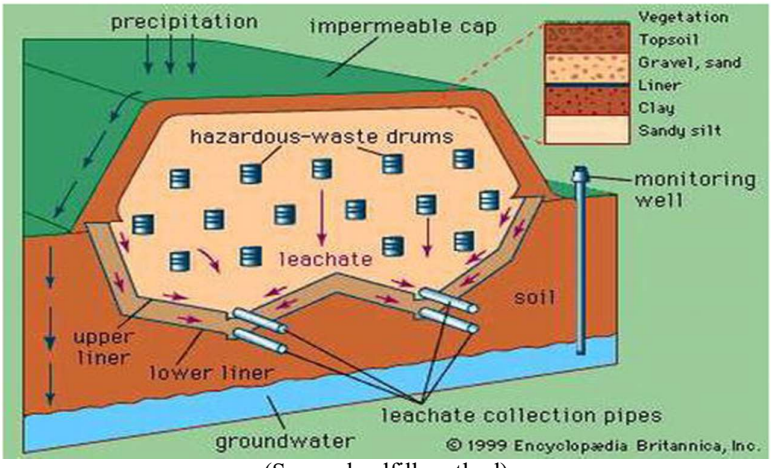
- *Chemical methods* include ion exchange, precipitation, oxidation and reduction, and neutralization.
- *Thermal methods* include incineration, boiling, autoclaving, UV treatment, Microwave use. Special types of thermal equipment are used for burning waste in either solid, liquid, or sludge form. Potential for air pollution is the disadvantage in incineration.

- *Biological method* includes composting, aerobic and anaerobic decomposition, activated sludge and enzyme treatment.
- *Physical treatment* methods include drying, screening, grinding, filtration. Physical treatment concentrates, solidifies, or reduces the volume of the waste.

v. Waste Disposal: Disposal of hazardous waste is the final stage of a hazardous waste management system. The different waste disposal methods includes secure landfill, deep well and bedrock disposal



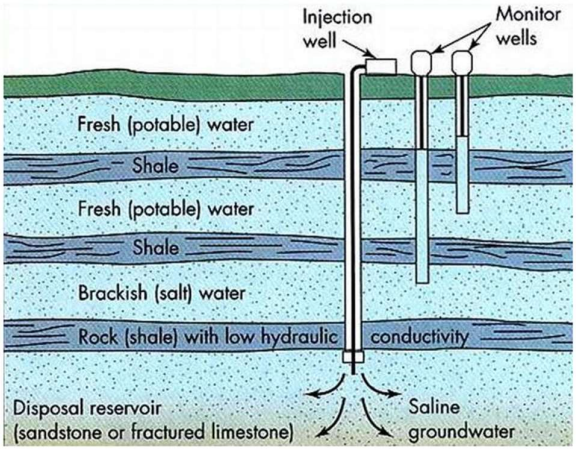
- **A landfill** is a disposal facility where hazardous wastes are placed into and stored in the soil. An example of a recommended design is shown in figure. The wastes are dumped in sealed drums before disposal. The hazardous-waste landfill setup consists of two impermeable liners and also includes leachate collection systems. Double leachate collection system is made up of network of pipes placed above each liner. The upper layer reduces the accumulation of leachate trapped in the fill, and the lower layer acts as a backup. The leachate collected is transferred to treatment plant for further process.



(Secure landfill method)

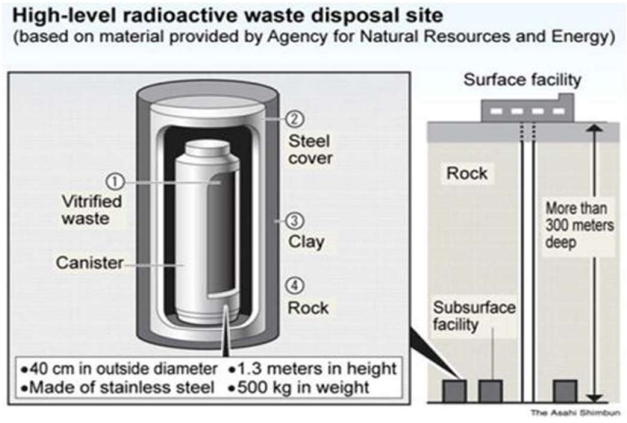
- **Deep well injection** is a liquid waste disposal technology. This alternative uses injection wells to place treated or untreated liquid waste into geologic formations that have no

potential to allow migration of contaminants into potential potable water aquifers. In order to force the liquid into the pores and fissures of the rock, high pressures are applied.



(Deep well disposal method)

- **Bedrock disposal** is mainly meant for solid hazardous waste and a variety of bed rock types are being investigated as host rocks. The design of a bedrock disposal site or repository for hazardous wastes is shown in figure. It is based on the multiple barrier (or multi barrier) concept: surrounding solid hazardous waste sealed with several different types of materials to prevent waste leakage or invasion by ground water. A major concern is the nature of the host rock as well as some potential drawbacks. The method is widely used for high-level radioactive wastes.



(Bedrock disposal method)

https://www.npcindia.gov.in/NPC/Files/delhiOFC/EM/Hazardous-waste-management-rules-2016.pdf

E-WASTE

e- waste describes discarded electrical (or) electronic devices.

e-wastes are considered as dangerous because they contain hazardous chemicals. The hazardous content of e-waste pose a threat to human health and environment.

2.8.1 Hazardous chemicals in e-wastes (or) Causes of e-wastes

Some of the hazardous chemicals present in some e-wastes are

1. Circuit boards in computer have heavy metals like lead and cadmium.
2. Batteries have cadmium.
3. Cathode ray tubes have lead oxide and barium.
4. Most of the electronic products have polyvinyl chloride.
5. Plastics have dioxins and furans.

So, if these waste electronic products are not properly disposed, they can leach hazardous elements such as lead, cadmium and other chemicals into the soil and ground water and cause severe threat to environment.

2.8.2 e-waste management

Definition

e-waste management is defined as a holistic method of cutting down e-waste from the earth to prevent its harmful toxic to deteriorate earth.

Management of e-waste should begin at the point of generation. This can be done by waste minimisation techniques and by sustainable product design.

Some e-waste management techniques

Waste management in industries involves adopting,

(a) inventory management,

(b) production process modification,

(c) sustainable product design,

(d) use of renewable raw materials.

1. Inventory management

Proper control over the materials, used in the manufacturing process, is an important way to reduce waste generation. By reducing the quantity of hazardous materials, used in the process, e-waste could be reduced.

2. Production process modification

By changing the production process e-waste generation can be minimised.

3. Sustainable product design

Efforts should be made to design a product with less amount of hazardous material.

Example

New computer designs that are lighter and more integrated.

4. Use of renewable materials

Bio based plastics are plastics made with plant based chemistry (or) plant producted polymers. Most e-waste have non-degradable polymers in them. By using these bio polymers we can reduce 'e'-wastes. Like wise bio based toners, glues and inks are new development e-wastes.

2.9 OCCUPATIONAL HEALTH AND SAFETY MANAGEMENT SYSTEM (OHASMS)

An occupational health and safety management system (OHASMS) is a fundamental part of an organization's risk management strategy. It enables an organization to protect its work force and others under its control.

Importance

It reduces risk (or) accidents (or) injuries by identifying and mitigating hazards.

2.9.1 Case studies on OHASMS

1. A footwear manufacturing industry in Ambur, Tamil Nadu

Objective

The main objective of this case study is to assess the status of occupational health and safety of a footwear manufacturing industry with respect to the social compliance.

Observation

We have visited Azim leather and footwear industries. Ambur, Tamil nadu. Overall occupational health and safety management practice in Azim leather and footwear industries was found to be good.

Production Process

Production process of Azim industries starts after collecting the raw materials, cutting them, assembling, joining the insole and outsole to the shoe, finishing and packing. Lots of people engaged during this production process. About 70% of total workers are female. In every section, Azim industries have employed experts to look after the work of the worker and improve the efficiency.

Some of the encouraging approaches observed in Azim industry

(i) Positive attitude of owner towards welfare of the workers.

(ii) Dedicated work force.

(iii) Experienced and professional management team.

(iv) Good relationship between management and workers.

(v) Disbursement of salary and wages to workers.

(vi) First aid box is found in all floors according to requirements of Indian labour rules.

(vii) Factory has own health centre to provide primary treatment.

(viii) Certified physician and nurse were available during the visit.

(ix) Factory has its child care centre.

(x) Factory has well maintained hygienic canteen.

(xi) Factory is conducting fire drill regularly.

(xii) Regular testing of drinking water, etc., is carried out.

Deficiency observed in Azim Industry and solution

According to environmental conservation rules, labour rules of Indian Government and International guide lines, below findings are observed during factory visit and discussed the solutions with management.

1. Management should maintain cleanliness of the area.
2. Management should place temperature and humidity measuring device in workplace because excessive heat and humidity are injurious for workers health.
3. Management should monitor and maintain sufficient and suitable lightings.
4. Factory must display material safety data sheet at all chemical storage areas.
5. Factory should confirm risk assessment for entire work place health and safety.

Report (or) Conclusion

Overall occupational health and safety management practice in Azim industries was found good. Though some deficiency were found during this visit, but commitment of top management towards occupational health and safety was impressive.

2. Fire works industry in Sivakasi, Tamilnadu

Safety and well-being is very essential for firework employees because in fireworks they are handling dangerous materials every day. So the safety measures are most important in the firework industry. They are handling chemicals which will affect their health too. According to the factories Act, safety and well-being is very necessary.

For well-being first aid kit, toilet facilities, cleanliness and medical camp are very essential.

Objectives of this study

The main objective of this study is to analyze the industrial safety and well-being of firework employees in "Kumaran fireworks" in Sivakasi.

We have visited "Kumaran fireworks" and analyzed overall occupational health and safety management practices of 257 employees and selected 30 respondents and conducted survey question regarding safety measures of the employees.

Some of the encouraging approaches observed in "Kumaran fireworks"

(i) 100% of respondent feels that adequate safety measures are taken during fire accidents.

(ii) 93.3% of respondent said limited safety materials are provided during the work.

(iii) 100% of respondent said the air circulation is perfect in the industry.

(iv) 90% of respondent said first aid box is available all the time.

(v) 80.5% of respondent felt the work place is always clean and neat.

(vi) 85% of respondent said the building and machines are maintained in proper way.

Deficiency observed in Kumaran fireworks and solution

(i) Management should conduct medical camp once in 6 months, in the industry.

(ii) Management must provide separate toilet facilities for men and women.

(iii) Proper rest room must be provided to the workers for taking rest in the break time.

(iv) Enough safety materials like gloves, face mask must be provided while they are working near chemicals and machines in the factory.

(v) More safety guards around the machines must be provided.

Report (or) Conclusion

Overall occupational health and safety management practice in "Kumaran fireworks" was found good. Though some deficiency were found during this visit, commitment of top management towards occupational health and safety was impressive.

2.10 ENVIRONMENTAL PROTECTION

Definition

Environmental protection is the practice of protecting the natural environment by individuals, organizations and governments.

Objectives

Its objectives are

(i) to conserve natural resources,

(ii) to conserve the existing natural environment,

(iii) to repair damage and reverse trends.

Due to the pressures of over consumption, population growth and technology, the biophysical environment is being degraded. This has been recognized and governments have begun placing restraints on activities that cause environmental degradation.

Importance (or) Goal of environmental protection

(i) To reduce air, water and land pollution.

(ii) To facilitate the conservation of natural resources for our future generations.

(iii) To ensure the protection of biodiversity.

(iv) To implement sustainable development.

(v) To restore the ecological balance.

(vi) To save our planet from harmful effects of global warming.

2.10.1 Environment (Protection) Act, 1986

This is a general legislation law in order to rectify the gaps and laps in the above Acts. This Act empowers the Central government to fix the standards for quality of

air, water, soil and noise and to formulate procedures and safe guards for handling of hazard substances.

Objectives of environmental act

(i) to protect and improvement of the environment,

(ii) to prevent hazards to all living creatures and property,

(iii) to maintain harmonious relationship between humans and their environment.

Important features of Environment Act

1. The Act further empowers the Government to lay down procedures and safe guards for the prevention of accidents which cause pollution and remedial measures if an accident occurs.
2. The Government has the authority to close (or) prohibit (or) regulate any industry (or) its operation, if the violation of the provisions of the Act occur.
3. The penal sections of the Act contain more stringent penalties. Any person who fails to comply (or) who contravenes any provision of the Act shall be punishable with imprisonment for a term extending to five years (or) be punishable with fine up to Rupees one lakh (or) both.
4. If the violation continues, an additional fine of Rupees five thousands per day may be imposed for the entire period of violation of rules.
5. The Act fixes the liability of the offence punishable under Act on the person who is directly in charge.

   Whether he/she is the director (or) Manager (or) Secretary (or) any other officer, unless he/she proves that it was committed without his/her knowledge (or) consent.

6. The Act empowers the officer of Central government to inspect the site (or) the plant (or) the machinery for preventing pollution and to collect samples of air, water, soil (or) other material from any factory (or) its premises for testing.

The Environment (Protection) Act is the most comprehensive legislation with powers for the central government to directly act, avoiding many regulatory authorities (or) agencies.

2.10.2 Water (Prevention and Control of Pollution) Act, 1974

This act provides for maintaining and restoring the sources of water. It also provides for preventing and controlling water pollution.

Objectives of the water act

(i) prevention and control of water pollution,

(ii) maintaining (or) restoring the wholesomeness of water,

(iii) establishing central and state boards for the prevention and control of water pollution.

Important features of Water Act

1. This Act aims at, to protect the water from all kinds of pollution and to preserve the quality of water in all aquifers.
2. The Act further provides for the establishment of Central Board and State Boards for prevention of water pollution.
3. The States are empowered to restrain any person from discharging a pollutant (or) sewage (or) effluent into any water body without the consent of the Board.

4. Any contravention of the guidelines (or) standards would attract penal action including prison sentence ranging from three months to six years.
5. The Act is not clear about the definition of pollutant, discharge of pollutant, toxic pollutant which allows scope for misinterpretation at the time of decision whether the law is violated (or) not.

The Amendment Act of 1988 requires permission to set up an industry which may discharge effluent.

State Pollution Control Board

The consent of the State Pollution Control Board is needed to

(i) Take steps to establish any industry (or) any treatment and disposal system (or) any extension (or) addition there to, which is likely to discharge (or) trade effluent into a stream (or) well (or) river (or) on land.

(ii) Use any new (or) altered outlet for the discharge of a sewage.

(iii) Begin to make any new discharge of sewage.

In the event of a violation of the conditions imposed, the State Board may serve on the offender a notice imposing any such conditions as it might establishment, such outlet (or) discharge that is a violation of the conditions.

The Act further empowers the State Board to order closure (or) stoppage of supply (or) electricity, water (or) any other services to the polluting unit. Non-compliance of the order may attract imprisonment for a term of one and half years to six years and fine which may extend to Rupees five thousand for every day, if the default continues.

2.10.3 Air (Prevention and Control of Pollution) Act, 1981

This Act was enacted in the Conference held at Stockholm in 1972. It deals with the problems relating to air pollution. It envisages the establishment of Central and State Control Boards endowed with absolute powers to monitor air quality and pollution control.

Objectives of air act are

(i) to prevent, control and abatement of air pollution,

(ii) to maintain the quality of air,

(iii) to establish a board for the prevention and control of air pollution.

Important features of Air Act

(a) The Central Board may lay down the standards for the quality of air.

(b) The Central Board co-ordinates and settle disputes between state boards, in addition to providing technical assistance and guidance to State Boards.

(c) The State Boards are empowered to lay down the standards for emissions of air pollutants from industrial units (or) automobiles (or) other sources.

(d) The State Boards are to collect and disseminate information related to air pollution and also to function as inspectorates of air pollution.

(e) The State Boards are to examine the manufacturing processes and the control of equipment to verify whether they meet the standards prescribed.

(f) The State Board can advise the State Government to declare certain heavily polluted areas as pollution control areas and can advice to avoid the burning of waste products which cause air pollution in such areas.

(g) The directions of the Central Board are mandatory on State Boards.

(h) The operation of an industrial unit is prohibited in a heavily polluted areas without the consent of the Central Board'.

(i) Violation of law is punishable with imprisonment for a term which may extend to three months (or) fine up to Rupees ten thousand (or) both.

This Act applies to all pollution industries. The Air Act, like Water Act, confers wide powers on State Boards to order closure of any industrial unit (or) stoppage (or) regulation of supply of water, electricity (or) other services, if it is highly polluting.

2.10.4 Forest (Conservation (or) Preservative) Act, 1980

This act provides conservation of forests and related aspects. This act also covers all type of forests including reserved forests, protected forests and any forested land.

This Act is enacted in 1980. It aims at to arrest deforestation.

Objectives of forest act

(i) to protect and conserve the forest,

(ii) to ensure judicious use of forest products.

Important features of Forest Act

(i) The reserved forests shall not be diverted (or) dereserved without the prior permission of the central government.

(ii) The land that has been notified (or) registered (or) forest land may not be used for non-forest purposes.

(iii) Any illegal non-forest activity within a forest area can be immediately stopped under act.

Important features of Amendment Act of 1988

(i) Forest departments are forbidden to assign any forest land 'by way of lease (or) otherwise to any private person' (or) non-government body for re-afforestation.

(ii) Clearance of any forest land of naturally grown trees for the purpose of re-afforestation is forbidden.

(iii) The diversion of forest land for non-forest uses is cognisable offence and any one who violates the law is punishable.

2.10.5 Wildlife (Protection) Act, 1972, Amended in 1983, 1986 and 1991

This act is aimed to protect and preserve wildlife. Wild life refers to all animals and plants that are not domesticated. India has rich wildlife heritage. It has 350 species of mammals, 1200 species of birds and about 20,000 known species of insects. Some of them are listed as 'endangered species' in the Wildlife (Protection) Act.

Wildlife is an integral part of our ecology and plays an essential role in its functioning. The wildlife is declining due to human actions, the wildlife products - skins, furs, feathers, ivory etc., have decimated the populations of many species.

Wildlife populations are regularly monitored and management strategies formulated to protect them.

Objectives of the wildlife act

(i) to maintain essential ecological processes and life-supporting systems,

(ii) to preserve biodiversity,

(iii) to ensure a continuous use of species.

Important features

1. The act covers the rights and non-rights of forest dwellers.
2. It provides restricted grazing in sanctuaries but prohibits in national parks.
3. It also prohibits the collection of non-timber forest.
4. The rights of forest dwellers recognized by the Forest Policy of 1988 are taken away by the Amended Wild life Act of 1991.

2.11 PART B QUESTIONS

1. Explain the effect of CO, SO_2, Hydrocarbons and chromium on human beings. *(A.U. May 2006)*
2. Discuss the major sources air pollutants and their impact and methods of controlling air pollution. *(A.U. Dec 2013, June 2016, Dec 2015)*
3. Explain the causes, effects and control measures of air pollution. *(Che AU June 2010 Dec'08 May 2015, June 2010)*
4. Explain the effects of air pollution on human health, plants and animals. *(TCY AU Dec'08)*
5. Discuss the causes and effects of
   (i) Air pollution
   (ii) Water pollution *(AU May 2008, TNV AU Dec'08)*
6. Suggest measures to control air pollution. *(Che A.U. Dec 2009)(Coim AUT May 2011, TCY AUT June 2011)*

UNIT III RENEWABLE SOURCES OF ENERGY

Energy management and conservation, New Energy Sources: Need of new sources. Different types new energy sources. Applications of- Hydrogen energy, Ocean energy resources, Tidal energy conversion. Concept, origin and power plants of geothermal energy.

ENERGY MANAGEMENT AND CONSERVATION

1) Explain the principle and various steps involved in energy management

Or

Write in detail about **ENERGY MANAGEMENT AND CONSERVATION**

ENERGY MANAGEMENT

Energy management includes planning and operation of energy production and energy consumption units as well as energy distribution and storage. For the past decades energy generation has been shifted to alternative energy sources like renewable energy forms such a solar wind and biomass energy. Apart from the growth in the energy sector there has been an equivalent increase in business and Organisations. Energy Management introduced in an organisation can effectively manage how much energy they produce and how to control and monitor. Energy and money can be saved by employing Energy Management principles.

Aims of Energy Management:

- Resource conservation
- Climate protection
- Cost savings minimise waste
- Minimise Environmental effects

The Ultimate aim or objectives of this process is not only to save the cost but also to achieve complete environmental sustainability

Principles of Energy Management:

- Reducing needless energy use
- Increasing energy efficiency
- Purchasing energy at a lesser cost
- Changing operations to allow for lower cost energy purchases

Following five steps are important in the process of Energy Management

Step 1 Collecting and analysing continuous data
Step 2 Identify optimisation in equipment schedules
Step 3 Calculate return on investment
Step 4 Execute energy optimization solutions
Step 5 Repeat step 2 to continue optimising Energy Efficiency

Importance of Energy management:
Primary goal of energy management is design and maintain optimal energy consumption Energy Management is a best strategy for lowering direct and immediate energy use Managing and reducing energy usage not only results in financial savings but also benefits the environment and a company's reputation. Energy should be considered a business cost.

ENERGY CONSERVATION

Energy conservation means reducing the consumption of energy by producing are using less energy. Energy conservation is the practice of using less energy in order to lower the cost and reduce environmental impact.

Needs to save energy:

- We have finite and our demand for energy is growing.
- Most fossil feels likely to run out and forcing which to alternative sources of energy.

Aims of energy conservation

To reduce overall energy demand
To lower energy cost
To reduce energy consumption
To lower the overall Greenhouse gas emission

10 ways to conserve energy:

1. Adjust your day today behaviours: switch off lights and appliances when you do not need them
2. Replace your light bulbs: traditional incandescent light bulbs consume more amount of electricity and must be replaced by energy efficient like LED bulbs.
3. Install Programmable or smart thermostat
4. Turn off or reduce heating and cooling during the time when you are asleep or away
5. Purchase energy efficient appliances
6. Install energy efficient Windows: prevent heat loss through windows
7. Update your HVAC systems
8. Insulate your home: Insulation retains heat during winter
9. Using Natural light like sun we can reduce the energy consumption.
10. Replacing dirty air filters in HVAC and AC's

NEW ENERGY SOURCES

Need for new energy sources

- Fossil fuels and nuclear energy are the important resources used to meet most of our energy needs today these are expected to be widely used in the near future.
- Fossil and a nuclear energy resources are non-renewable and will someday be exhausted, while their continued use possess environmental risks related to air pollution, land use and waste disposal. These issues have stimulated the research for new energy sources for producing and using energy.

2. List out the different TYPES OF NEW ENERGY SOURCES (OR) RENEWABLE ENERGY RESOURCES and explain it briefly

1. Hydrogen energy
2. Ocean Thermal Energy conversion
3. Tidal and wave energy
4. Geothermal energy
5. Solar energy
6. Wind energy
7. Biomass energy

1. **Hydrogen energy:**
   - The hydrogen reacts with oxygen across an electrochemical cell similar to that of a battery to produce electricity, water and a small amount of heat.
   - Hydrogen is an energy carrier that can be used to store move and deliver energy produced from other sources.
   - Hydrogen is a clean fuel, when used in a fuel cell, produces only water.
   - Hydrogen can be produced from here various sources such as water, natural gas, Biomass, microbes such as green algae.

2. **Ocean Thermal Energy**
   The energy available due to the difference in temperature of ocean water is called Ocean Thermal Energy. The temperature difference between the surface level and deep level in the ocean can be utilised to generate electricity. *The temperature difference should be of 20 degrees Celsius or more.*

3. **Tidal and wave energy:**
   Title energy is a renewable energy powered by the natural rise and the fall of ocean tides. Tides are the result of the Sun and moons gravitational pull. Extremely energetic. Building tidal Barrage is one way to harness tidal energy. Seawater is allowed to enter the barrages reservoir during high tide, driving the turbine which then turns the generators to generate power. When the sea level is low at low tide, the seawater collected in the barrage reservoir is let to flow into the sea restarting the turbine.

4. **Geothermal energy:**
   The Heat produced deep in the earth core is called geothermal energy. Energy harnessed from the high temperature present inside the earth can be used to produce electricity.

5. **Solar energy:**
   Solar energy is a form of renewable energy that is derived from the sun's rays. It can be harnessed and converted into usable energy through various technologies such as photovoltaic (PV) cells, concentrated solar power (CSP), and solar heating systems. Solar water heaters, cookers use only solar energy.

Advantages of Solar Energy:

- Renewable and Clean Energy
- Cost-effective
- Low Maintenance
- Energy Independence
- Job Creation

Disadvantages of Solar Energy:

- Solar energy is intermittent, meaning it is only available during daylight hours and can be affected by weather conditions.
- Solar panels require a significant amount of land to generate large amounts of energy.

- While the cost of solar panels has decreased significantly, the upfront costs of installation can still be expensive for some individuals and businesses.
- Energy Storage: Energy storage systems, such as batteries, are required to store energy generated by solar panels for later use. These storage systems can be expensive and require maintenance.
- Environmental Impact: The manufacturing of solar panels and storage systems can have environmental impacts, such as the use of toxic materials and the generation of waste.

6. **Wind energy:**

Moving air is called wind. Energy recovered from the force of wind is called wind energy. Energy possessed by wind is because of its high speed. Wind energy is harnessed by making use of windmills.

7. **Biomass energy:**

Biomass is the organic matter produced by plants or animals used as sources of energy most of the biomass is burned directly for heating, cooling and industrial purposes. Examples are wood, crop, residues of agricultural waste.

3. Discuss in detail about **HYDROGEN ENERGY** and its application

Hydrogen energy is a type of renewable energy that uses hydrogen gas as a fuel to generate electricity or power vehicles. Hydrogen is the most abundant element in the universe, and it can be obtained from a variety of sources such as natural gas, biomass, and water.

The process of generating hydrogen involves separating it from other elements in a process called electrolysis. This process uses electricity to split water molecules into hydrogen and oxygen. Once the hydrogen is separated, it can be stored and transported to be used as a fuel.

One of the main advantages of hydrogen energy is that it produces zero emissions, as the only by product of hydrogen combustion is water vapour.

Applications of Hydrogen Energy:

- ✓ Hydrogen is a reagent used in many industries including chemicals, textile fibre manufacturing, glass electronic and metallurgy.
- ✓ It is also used as a fuel for rocket launchers.
- ✓ In electronics hydrogen is used as a carrier gas, for manufacture of electronic components.
- ✓ In industry hydrogen combines with nitrogen to produce ammonia, base for fertilizers.
- ✓ It is a good reagent for textile fibres like nylon.
- ✓ Hydrogen is used in metallurgy for heat treatment process mechanical parts or to alter their properties.
- ✓ Atomic hydrogen welding (AHW) is a type of arc welding which utilizes hydrogen environment.
- ✓ A mixture of hydrogen and nitrogen is used to prevent oxidation in flat glass production.

- ✓ Hydrogen is used to create semiconductors, LEDs and display units.
- ✓ Hydrogen gas is used as a therapeutic gas for a number of different diseases.
- ✓ Hydrogen fuel cell uses hydrogen as a fuel in an electrochemical process to produce electrical energy with water and heat.
- ✓ Two main applications of hydrogen fuel cells are
    - **Stationery power sources** are used to power office buildings, data centres, grocery stores and telecommunication towers, it is used as a part of UPS system.
    - **Hydrogen fuel cell vehicles** (FCVs) are a type of electric vehicle that use hydrogen gas as their primary fuel source. The hydrogen is stored in high-pressure tanks and is combined with oxygen from the air in a fuel cell to generate electricity. The electricity is then used to power an electric motor, which drives the vehicle's wheels. Hydrogen fuel cell trains have now appeared. Hydrogen fuel cells are found a number of marine applications.

Advantages of hydrogen energy:

- Hydrogen is readily available
- It does not produce harmful emissions
- It is environmentally friendly
- Efficient and more powerful than fossil fuels
- It is renewable
- It reduces carbon footprints
- It can be used for long time

Disadvantages of hydrogen energy:

- The production of hydrogen is highly energy-intensive, requiring large amounts of energy and **expensive technologies**
- **Storage and Transportation**: Unlike traditional fuels, hydrogen is lightweight and highly volatile. It requires specialized storage and transportation Highly inflammable
- Safety concerns: Hydrogen is **highly flammable**, which raises serious safety concerns. Any leakage or exposure to oxygen can potentially result in an explosion.
- Limited availability: Hydrogen is **not readily available** at gas stations and service stations, making it difficult to refuel vehicles.

4. Discuss the concept of OCEAN ENERGY and its applications

Ocean energy refers to the renewable energy generated from the ocean's tides, waves, currents, temperature differences, and salinity gradients.

Tides are the rise and fall of sea levels caused by the gravitational pull of the moon and the sun. The gravitational force of the moon is stronger than that of the sun, and it causes two high tides and two low tides each day. Tides are predictable and follow a regular pattern based on the positions of the moon and the sun.
Waves, on the other hand, are caused by the wind blowing over the surface of the water. Waves can be generated by local winds or winds far away from the location where the waves are observed. Waves can be small ripples or huge swells, and they can travel long distances across oceans. Waves can be unpredictable, and their size and frequency can vary greatly.

Concept: Tidal energy or tidal power is a form of ocean energy that is harnessed by converting tidal energy into useful forms of power. Tidal energy is obtained from the rise and fall of tides. Tidal barrages and dams are constructed across a narrow opening to the sea, where water rushes into the dam when the sea level rises which moves the blade of the turbines which helps in the generation of electricity.

Important applications of ocean energy:

- ***Electricity generation:*** Ocean energy resources can be used to generate electricity using different technologies such as tidal turbines, wave energy converters, and ocean thermal energy conversion systems.
- ***Desalination:*** Ocean energy can be used to power desalination plants, which convert seawater into fresh water for drinking and irrigation.
- ***Aquaculture:*** Ocean energy resources can be used to create favourable conditions for fish and other aquatic species in fish farms, promoting their growth and improving the yield.
- ***Transportation:*** Ocean energy can be used to power ships and other marine vessels, reducing the dependence on fossil fuels and promoting sustainable transportation.
- ***Oil and gas exploration:*** Ocean energy can be used to power offshore oil and gas exploration and production platforms, reducing the environmental impact of such operations.
- ***Recreation:*** Ocean energy resources can be used for recreational activities such as surfing, sailing, and kiteboarding, promoting tourism and improving the economy of coastal regions.

Advantages of ocean energy

1. Ocean energy is cheaper and efficient
2. It is environment friendly
3. Operational and maintenance cost or low
4. Tidal energy sources can last for decades
5. It protects coastal flooding due to the stability of rock armor

Disadvantages of ocean energy:

1. **High capital costs:** The initial capital costs of building ocean energy systems can be very high, which can make it difficult to attract investors and finance these projects.
2. **Location-dependent:** Ocean energy systems are highly dependent on the location of the ocean currents, tides, and waves, which may limit their deployment in certain areas.
3. **Environmental impacts:** Some ocean energy technologies can have negative impacts on the marine environment, such as disrupting the migration patterns of marine animals or altering the seabed.
4. **Maintenance costs:** The harsh ocean environment can increase the maintenance costs of ocean energy systems, which may require regular repairs and replacements of components.
5. **Interference with shipping and fishing:** Some ocean energy systems, such as tidal turbines, can interfere with shipping and fishing activities, which can be a source of conflict with local communities.

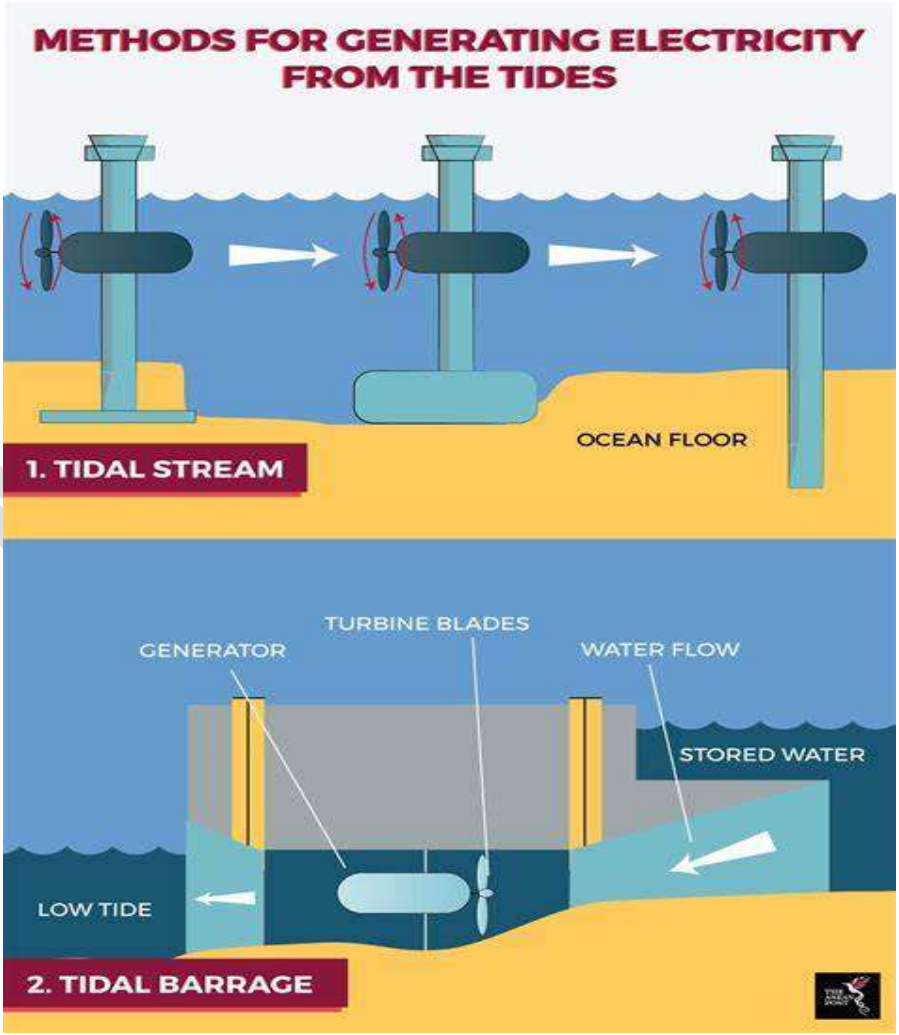
5. Discuss about the TIDAL ENERGY and its advantages & disadvantages.

Tidal energy is a form of renewable energy that harnesses the power of the tides to generate electricity. Tides are caused by the gravitational pull of the moon and the sun, and as the water moves in and out with the tides. *Tidal energy conversion is the process of generating electricity from the movement of ocean tides.* This is typically done by placing turbines in tidal currents or using underwater turbines that are driven by the kinetic energy of moving water. As the tides move in and out, the turbines spin and generate electricity, which can then be used to power homes, businesses, and other electrical devices.

There are two main types of tidal energy systems: tidal stream and tidal barrage.

Tidal stream systems use underwater turbines that are placed in areas with strong tidal currents, such as narrow channels or between islands. The turbines are turned by the movement of the water, generating electricity that can be transmitted to shore.

Tidal barrage systems, on the other hand, use large dams or barrages to trap the incoming tide and then release it through turbines as the tide goes out. This method is similar to hydroelectric power generation, but uses the power of the tides rather than the flow of a river.



Tidal energy has the potential to be a significant source of renewable energy, especially in coastal areas with strong tidal currents. However, there are also challenges associated with the technology, including high upfront costs and potential impacts on marine life and ecosystems. As with other forms of renewable energy, ongoing research and development are needed to improve the efficiency and reduce the costs of tidal energy systems.

APPLICATIONS OF TIDAL ENERGY

- Electricity can be generated from the tidal energy
- Tidal energy is used to grinning mills for the mechanical crushing of grains.
- Tidal energy is used to rotate at turbine
- Tidal energy is used to store energy in hydroelectric Dam acting as large energy storage
- Tidal barrage and reservoirs can be modified to store energy
- Tidal barrages are capable of preventing damages to the coast during high storms
- Tidal barrage is also help to create easy transport.

Advantages of tidal energy

- It is environment friendly
- It is cheaper, efficient and predictable
- Low operating and maintenance cost
- Protects coastal flooding
- Power output is highly predictable

Disadvantages of tidal energy

- Construction of title Power Plant is expensive.
- Equipment maintenance difficult
- Storage capacity is required.
- Negative influence on marine life forms.
- Location Limited

6) Write brief notes on GEOTHERMAL ENERGY (GTE) and types of geothermal power plants

Geothermal energy is the energy that is derived from the heat within the earth's crust. The earth's crust contains a large amount of heat, which is generated by the radioactive decay of minerals and the residual heat left over from the earth's formation. This heat can be used to generate electricity through the use of geothermal power plants.

- GTE is used for space heating and cooling
- GTE is used to generate electricity
- It is also used for industrial process heat
- geothermal heat pumps are used to heat buildings in the winter and cool them in summer

CONCEPT

Geothermal technology extracts the heat found within the subsurface of the earth, which can be used directly for heating and cooling or converting it to electricity. The steam comes from the reservoirs of hot water found a few miles below the earth surface rotate a turbine that activates a generator, which produces electricity.

POWER PLANTS OF GEOTHERMAL ENERGY:

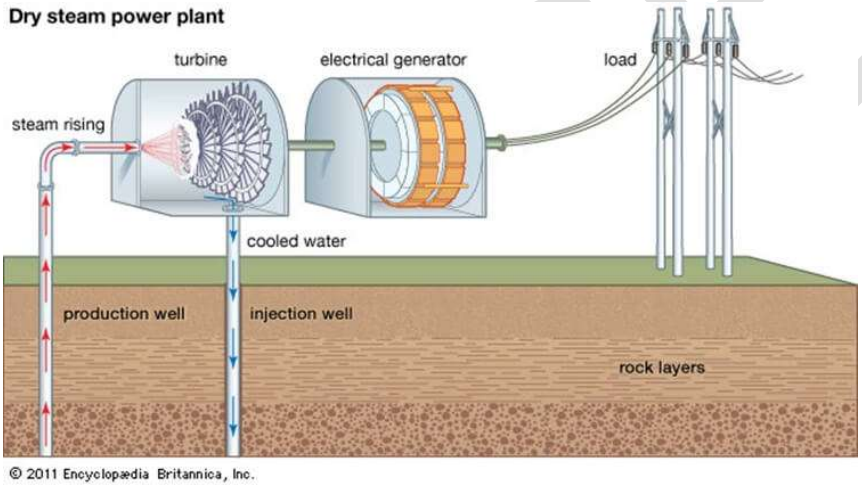
Geothermal power plant uses hydro thermal resources that have both water and heat. Geothermal power plants require high temperature hydro thermal resources that come from either dry steam wells or from hot water wells. Generally, we use this resources by drilling wells into the earth and then piping steam or hot water to the surface. The hot water or steam rotates a turbine that generates electricity, the depth of the geothermal Wells is as much as two miles.

TYPES OF GEOTHERMAL POWER PLANTS:

There are 3 basic types of geothermal power plants

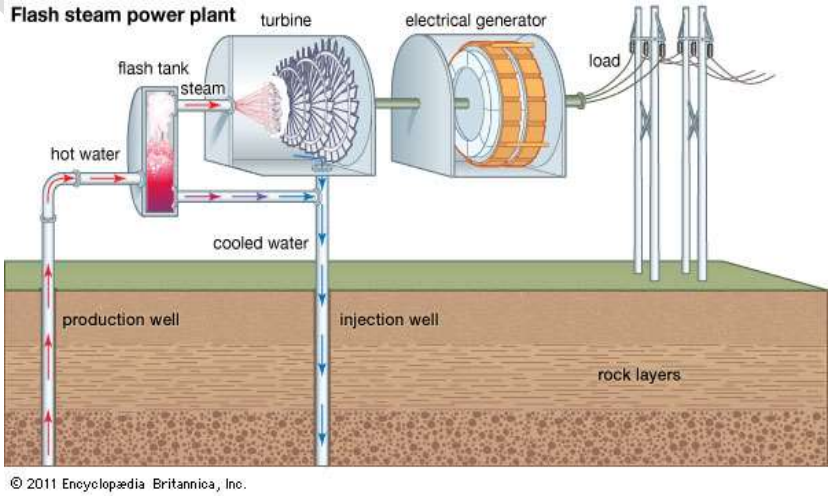
1) Dry steam power plant

It uses steam directly from here geothermal reservoir to drive generator's turbine



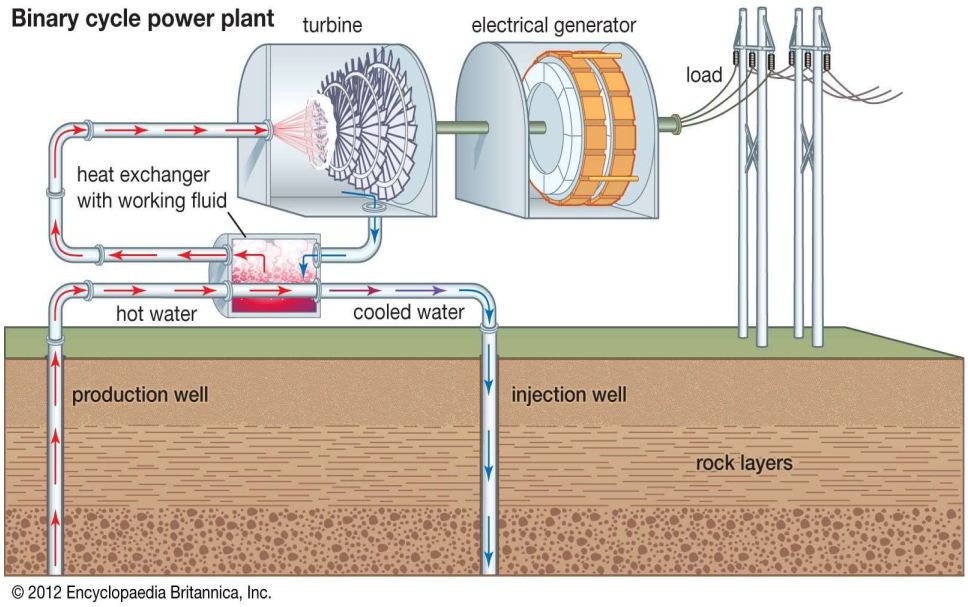
2) Flash steam power plant

It takes high pressure hot water from deep inside the earth and Converts it into steam to drive generator's turbine. When the steam cools, it condenses to water and is injected back into the ground to be used again. Most thermal power plants are flash steam plants.



3) Binary cycle power plants

It transfers the heat from geothermal hot water to another liquid. The heat causes the second liquid to convert it into steam which is used to drive a generator's turbine.



(Binary Cycle power plant)

Advantages of geothermal energy:	**Disadvantages**
GT energy is environmentally friendly GT is a source of renewable energy The potential of GTE is huge GTE is natural	• Location is restricted • There are many other gases released into the atmosphere • May cause earthquakes • It is expensive resource, management is required to maintain sustainability

7. Write brief notes on wind energy

Air in motion is referred to as wind. wind has a lot of energy since it moves quickly. Wind energy is the power that has been harnessed from the winds force it is captured using wind turbines.

The basic principle involves converting the kinetic energy of the wind into mechanical energy through the use of wind turbines, and then converting that mechanical energy into electrical energy using generators. Here's a breakdown of the concept:

1. **Wind:** Wind is created by the movement of air masses in the atmosphere.
2. **Wind Turbines:** Wind turbines are designed to capture the energy of the wind and convert it into rotational motion. They consist of three main components:

- **Blades:** The turbine blades are typically made of lightweight materials such as fiberglass or carbon fiber and are shaped to maximize the capture of wind energy.
- **Rotor:** The rotor connects the blades to the main shaft and transfers the rotational energy to the generator.
- **Generator:** The generator is located inside the nacelle, which is the housing at the top of the wind turbine tower. As the rotor spins, it drives the generator, which converts the mechanical energy into electrical energy. The electricity generated is usually in the form of alternating current (AC).

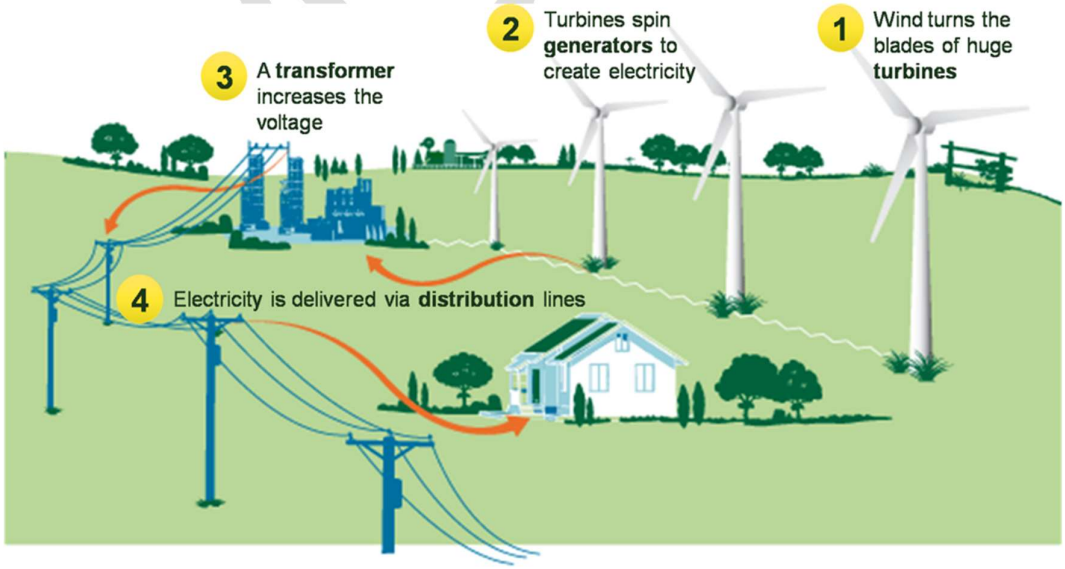
3. **Power Distribution:** The electrical energy produced by the wind turbine is transmitted through power lines to a transformer, where it is converted to a higher voltage. The electricity can then be distributed to homes, businesses, or the power grid for use.
4. **Environmental Benefits:** Wind energy is considered a clean and renewable energy source. It does not produce greenhouse gas emissions or air pollutants during operation, helping to reduce carbon dioxide emissions and mitigate climate change. Wind energy also helps to conserve water resources, as it does not require significant amounts of water for cooling or operation like some other power generation methods.

Wind energy harvesting

Wind mill:
Wind mill structure consists of huge rotating blades mounted on a tower. The winds impact causes the windmills blade to rotate indefinitely. Numerous machineries such as water pumps, grain mills and electric generators or powered by the blades rotation. The windmill Converts wind energy into rotational energy by means of the blades.

Wind farms:

When several windmills are built and join together in a specific way a wind farm is created. Wind farms provide a significant quantity of power. The lowest speed necessary for a wind generator to function properly is 15 km/ hour.



Advantages of wind energy:

- Wind is stable and endless renewable energy source
- Wind energy is inexpensive
- Using wind energy instead of fossil fuels minimises carbon emission
- Low operating expenses

Disadvantages:

- production of electricity depends upon the speed and direction of the Wind.
- Birds and marine life habitats may be harmed by wind turbines.
- Building wind farms could be expensive

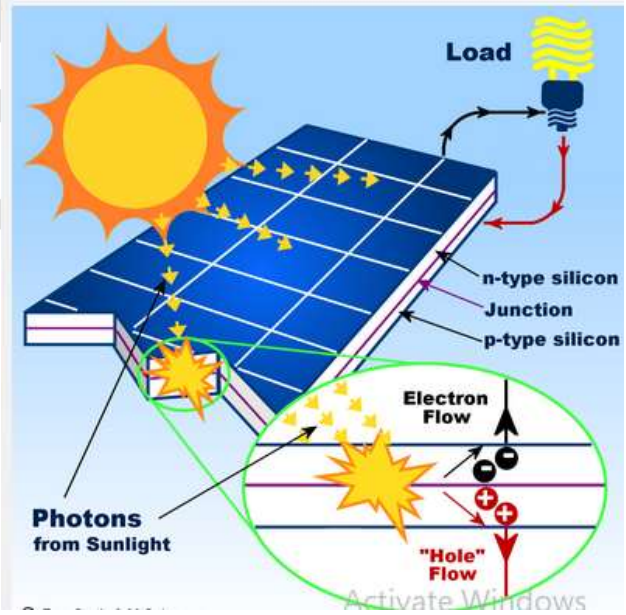
8. Write in detail about Solar energy.

Definition: Solar energy refers to the energy derived from the Sun's radiation, that can be harnessed and converted into electricity or used for various other applications.

Method of harnessing solar energy:

1. ***Photovoltaic (PV) panels, which convert sunlight directly into electricity***. These panels consist of numerous solar cells made of semiconductor materials, such as silicon. When sunlight strikes these cells, it excites electrons, creating an electric current.

    - ✓ Solar panels are comprised of several individual solar cells which are themselves composed of layers of silicon, phosphorous (which provides the negative charge), and boron (which provides the positive charge).
    - ✓ Solar panels absorb the photons and in doing so initiate an electric current.
    - ✓ The solar energy striking the surface of the solar panel allows electrons to be knocked out of their atomic orbits and released into the electric field generated by the solar cells which then pull these free electrons into a directional current. This entire process is known as the Photovoltaic Effect.



2. **Solar heat harvesting** refers to the process of capturing and utilizing solar energy in the form of heat. Solar heat harvesting focuses on **capturing the Sun's thermal energy for various applications.**

There are several methods and technologies used for solar heat harvesting:

A. **Solar Water Heating:** Solar water heaters capture the Sun's heat to warm water for domestic, commercial, or industrial use. These systems typically consist of solar collectors, which absorb sunlight and transfer the heat to water or a heat transfer fluid circulating through the collectors. The heated water or fluid is then stored in a tank for later use.
B. **Solar Thermal Power Generation:** Concentrated solar power (CSP) plants use mirrors or lenses to focus sunlight onto a receiver, which contains a working fluid. The concentrated sunlight heats the fluid, generating steam that drives a turbine to produce electricity. CSP plants are often used for large-scale power generation.
C. **Solar Air Heating:** Solar air heating systems capture solar energy to heat air for space heating or drying applications. These systems typically consist of solar collectors that absorb sunlight and transfer the heat to air, which is then circulated and used for heating indoor spaces or industrial processes.
D. **Solar Cooking:** Solar cookers or solar ovens use sunlight to heat and cook food. These devices typically use reflective panels or surfaces to concentrate sunlight onto a cooking vessel, converting solar energy into heat for cooking purposes.

Advantages:

1. **Renewable and Clean Energy:** Solar energy is a renewable energy source and producing no emissions or pollution during use.
2. **Cost-effective:** The cost of solar panels and installation has decreased significantly over the years.
3. **Low Maintenance:** Solar panels require little maintenance and have a long lifespan.
4. **Energy Independence:** Solar energy provides energy independence.
5. **Job Creation:** The solar industry is a growing industry that creates jobs in manufacturing, installation, and maintenance.

Disadvantages:

1. **Intermittent:** Solar energy is only **available during daylight hours** and can be affected by weather conditions. This means that **energy storage systems are required** to provide energy when the sun is not shining.
2. **Land Use:** Solar panels require a significant amount of land to generate large amounts of energy.
3. **Upfront Costs:** While the cost of solar panels has decreased significantly, the upfront costs of installation can still be expensive for some individuals and businesses.
4. **Energy Storage:** Energy storage systems, such as batteries, are required to store energy generated by solar panels for later use. These storage systems can be expensive and require maintenance.
5. **Environmental Impact:** The manufacturing of solar panels and storage systems can have environmental impacts, such as the use of toxic materials and the generation of waste.

UNIT IV SUSTAINABILITY AND MANAGEMENT

Development, GDP, Sustainability- concept, needs and challenges-economic, social and environmental aspects of sustainability-from unsustainability to sustainability-millennium development goals, and protocol - Sustainable Development Goals-targets, indicators and intervention areas Climate change- Global, Regional and local environmental issues and possible solutions-case studies. Concept of Carbon Credit, Carbon Footprint. Environmental management in industry-A case study.

DEVELOPMENT

It's a process that creates growth, progress, positive change in economic, environment and social component without changing the resources of the environment.

Development is a process of growth, change, or improvement, usually involving progress towards a particular goal. The term is commonly used to refer to the process of personal or social growth, economic progress, technological advancement, or political reform.

Characteristics of Environment:

1. It is a continuous process
2. It is the result of interaction of individual and environment
3. It is both qualitative and quantitative
4. Follows a particular pattern

Country development refers to the process by which a country improves its economic, social, and political systems to improve the well-being of its citizens. This can involve a wide range of activities, including improving infrastructure, investing in education and healthcare, promoting entrepreneurship and innovation, and implementing policies that encourage sustainable economic growth.

There are several types of development that can refer to various aspects of growth and progress:

1. Economic Development: The process of improving a country's economic well-being by increasing its production, income, and employment opportunities.

2. Social Development: The process of improving the social well-being of individuals and communities through education, health care, housing, and other basic services.

3. Human Development: The process of improving the quality of life and well-being of people, including aspects such as education, health, and access to resources.

4. Sustainable Development: Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

5. Infrastructure Development: The process of building and improving physical structures such as roads, bridges, airports, and communication systems.

6. Personal Development: The process of improving one's knowledge, skills, and abilities to achieve personal goals and enhance overall well-being.

7. Community Development: The process of empowering communities to improve their own social, economic, and environmental conditions.

8. Organizational Development: The process of improving the effectiveness of an organization by enhancing its processes, systems, and structures.

9. Environmental Development: The process of promoting the sustainable use of natural resources, reducing pollution, and conserving biodiversity.

FACTORS AFFECTING DEVELOPMENT:

Development and growth are influenced by four factors: human resources, physical capital, natural resources and technology. Highly developed countries have governments that focus on these areas. Less-developed countries, even those with high amounts of natural resources, will lag behind when they fail to promote research in technology and improve the skills and education of their workers.

- Natural Resources: Trees, soil, water, minerals, coal, oil, etc help countries develop by creating jobs and increasing their wealth.
- Power & energy resources: Oil, gas, coal & water can be mined and sold quickly. Important for producing power and energy within the country.
- Capital accumulation: More capital creates more job, low capital countries may have a low living wage and high unemployment.
- Technological resources: Refers the ability to use advanced technologies within a country. Countries with low technological resources have poor economic development.
- Available labor force: Availability of skilled labors within the country increases the development.
- Transportation and Communication
- Education and Training

Development can have both positive and negative effects on individuals, societies, and the environment. Here are some of the effects of development:

Positive Effects:

•Increased standard of living: Development can lead to increased income levels, improved healthcare, better education, and access to basic necessities such as food, water, and shelter. This can enhance the overall quality of life of people.

•Improved infrastructure: Development can also lead to the construction of better roads, bridges, airports, and other transportation systems. This can facilitate trade and commerce, and help connect people from different parts of the world.

•Technological advancements: Development can lead to innovations in technology, which can improve productivity and efficiency, and provide new opportunities for growth and development.

•Social progress: Development can promote gender equality, human rights, and social justice. It can lead to the empowerment of marginalized communities, and improve their participation in decision-making processes.

Negative Effects:

•Environmental degradation: Development can also have negative effects on the environment, such as deforestation, pollution, and depletion of natural resources. This can lead to climate change, loss of biodiversity, and other environmental problems.

•Displacement of communities: Development can also result in the displacement of communities from their homes, as land is cleared for development projects. This can lead to social unrest and conflict.

•Inequality: Development can exacerbate existing inequalities between different groups of people, such as the rich and poor, urban and rural populations, and men and women.

•Cultural erosion: Development can also lead to the erosion of traditional cultural practices and values, as people adopt new lifestyles and ways of thinking.

Overall, development can have both positive and negative effects, and it is important to strike a balance between economic growth, social progress, and environmental sustainability.

GROSS DOMESTIC PRODUCT (GDP)

GDP stands for Gross Domestic Product, which is a measure of the total value of all goods and services produced within a country's borders over a specific period of time, typically a year. It is often used as a key indicator of a country's economic performance and is calculated by adding up the value of all final goods and services produced in a country during a specific period of time. This includes everything from the sale of goods and services to government spending and investments.

GDP stands for Gross Domestic Product, which is a measure of the total value of goods and services produced within a country's borders over a specific period of time. There are several types of GDP that are commonly used to measure different aspects of an economy:

1. Nominal GDP: This is the raw GDP figure that is calculated using current prices and does not account for inflation. It reflects the current market value of all goods and services produced within a country.

2. Real GDP: Real GDP is adjusted for inflation, so it provides a more accurate measure of an economy's growth over time. It represents the value of goods and services produced within a country, adjusted for changes in prices over time.

3. Per capita GDP: This is calculated by dividing the GDP of a country by its population. It provides a measure of the average economic output per person within a country.

4. Purchasing power parity (PPP) GDP: This adjusts GDP figures to account for differences in the cost of living between countries. It provides a more accurate comparison of economic output between countries by taking into account the relative cost of goods and services.

5. Gross National Product (GNP): GNP measures the total economic output of a country's citizens, regardless of their location. It includes the value of goods and services produced by citizens of a country living abroad, and excludes the value of goods and services produced by non-citizens living within the country.

Gross Domestic Product (GDP) is the monetary value of all final goods and services produced within a country's borders in a specific time period, usually a year.

GDP can be calculated using one of the following three methods:

1. Expenditure approach: This method calculates GDP by adding up all the spending on final goods and services within a country's borders. The formula is:

$$GDP = C + I + G + (X - M)$$

C = Personal consumption expenditures; **I** = Gross private domestic investment;
G = Government consumption and gross investment; **X** = Exports of goods and services;
M = Imports of goods and services.

2. Income approach: This method calculates GDP by adding up all the incomes earned by individuals and businesses within a country's borders. The formula is:

$$GDP = Wages + Interest + Rent + Profits + Indirect\ taxes - Subsidies$$

where: **Wages** = Compensation of employees; **Interest** = Net interest; **Rent** = Rental income; **Profits** = Corporate profits and proprietors' income; **Indirect taxes** = Taxes on production and imports; **Subsidies** = Government subsidies

3. Production approach: This method calculates GDP by adding up the value of all goods and services produced within a country's borders. The formula is:

$$GDP = Value\ of\ output - Intermediate\ consumption$$

where: **Value of output** = Total sales revenue of all goods and services produced; **Intermediate consumption** = Cost of materials, supplies, and services used in the production process.

All three methods should give the same result for the calculation of GDP. The choice of method depends on the availability of data and the preference of the analyst.

Here are some reasons why GDP is important:

1. Economic growth: GDP is used as an indicator of a country's economic growth. A higher GDP indicates that the country is producing more goods and services, which can lead to more job creation, higher wages, and improved standards of living for its citizens.

2. International comparison: GDP is a widely recognized measure of a country's economic output, and it is often used to compare the economic performance of different countries. It can be used to determine the relative strength of different economies and to identify areas where a country might need to improve.

3. Government policy: GDP is an important factor in determining government policy. For example, a government might use GDP as a basis for setting tax rates, determining budget priorities, or deciding on economic stimulus measures.

4. Investment decisions: Investors often use GDP as an indicator of a country's economic health and potential for future growth. A high GDP can indicate a stable economy with good investment opportunities, while a low GDP may signal economic instability or a lack of investment potential.

Gross Domestic Product (GDP) is a widely used economic indicator that measures the total value of goods and services produced in a country during a specific time period, usually a year. While GDP has several advantages as a measure of economic activity, it also has some limitations. Here are some pros and cons of GDP.

Pros of GDP:

1. Provides a comprehensive measure of economic activity: GDP measures the value of all goods and services produced in a country, including those in the informal sector, which provides a more comprehensive picture of the economy's size and activity.

2. Allows for comparison of economic activity across countries: GDP allows for easy comparison of economic activity across countries, which helps policymakers and investors make informed decisions.

3. Can be used to track economic growth over time: GDP can be used to track changes in economic activity over time, allowing policymakers to identify periods of economic growth or recession.

Cons of GDP:

1. Doesn't account for income distribution: GDP doesn't take into account the distribution of income among the population. A country can have a high GDP but still have significant income inequality.

2. Doesn't measure non-market activities: GDP doesn't include non-market activities, such as unpaid work done in the home or the informal economy. This can lead to an underestimation of the economy's size and activity.

3. Doesn't account for environmental degradation: GDP doesn't consider the environmental costs of economic activity, such as pollution or resource depletion. This can lead to an overestimation of the economy's value.

4. Doesn't reflect quality of life: GDP doesn't reflect the quality of life of a country's citizens, such as access to healthcare, education, or social services. A country can have a high GDP but still have low levels of well-being.

Overall, while GDP is a useful measure of economic activity, it's important to recognize its limitations and use it in conjunction with other measures of economic and social well-being.

SUSTAINABILITY

Sustainability refers to the ability to maintain or support a process continuously over long time. In business and policy contexts, sustainability seeks to prevent the depletion of natural or physical resources, so that they will remain available for the long term.

Sustainability is concerned with protecting the planet, halting climate change and promoting social development, without endangering life on Earth or leaving anyone behind.

Need of Sustainability:

1. Sustainability is key to preserving our planet
2. Sustainability helps reduce pollution and conserve resources
3. Sustainability creates jobs and stimulates the economy
4. Sustainability improves public health
5. Sustainability protects biodiversity

Approaches of Sustainability:

1. Developing appropriate technology: It is the one, which is locally adaptable, eco-friendly, resource-efficient, labor intensive, decentralized and culturally suitable. It uses local labors, less resources and produces minimal waste.
2. 3 R Approach: It insists optimum use of natural resources, using it again and again instead of throwing it and recycling the material into further products. Reduces the pressure on our natural resources and reduces waste generation and pollution.
3. Providing environmental education and awareness: By providing environmental education and awareness, the thinking and attitude of people towards our earth and the environment can be changed.
4. Consumption of renewable resources: In order to attain sustainability, it is very important to consume the natural resource in such a way that the consumption should not exceed regeneration capacity.
5. Conservation of non-renewable resources: Non-renewable resources should be conserved by recycling and reusing.
6. Population Control: By controlling population growth, we can make very good sustainable development.

Economic and social challenges of Sustainability:

1. **Economic sustainability:** It refers to the organization's ability to manage its resources and responsibly generate profits in the long term.

   Economic Challenges:

   (i) High rates of unemployment
   (ii) High rates of poverty and low growth

(iii) Increasing inequality
(iv) Disruption of major economic activities due to the pandemic situation
(v) Growth dependent on one source
(vi) Skills mismatch

2. **Social Sustainability:** It refers to the stability of specific social groups.

   Social Challenges: Social impact, issues are not easily measurable but they are easier to identify.

   (i) Human rights
   (ii) Fair labor practices
   (iii) Living conditions
   (iv) Health and safety
   (v) Wellness, diversity and equity
   (vi) Work-life balance
   (vii) Empowerment

Aspects of sustainability:

Sustainability requires consideration of four aspects (sometimes also known as perspectives, pillars). While all four aspects of sustainability are important, environmental sustainable is fundamental to the protection of our environment.

Environmental – this aspect acknowledges the need to enhance and maintain the biophysical systems that sustain all life on Earth. It includes the structure and function of natural ecosystems and the interactions between them and people, and calls for guardianship of our environment.

Social – this aspect acknowledges the need for equity within and between generations, and within and between ethnic and social groups. It is inclusive of people's mental and physical well-being and the cohesion of their communities based on a fair distribution of resources.

Cultural – this aspect acknowledges the need to nourish and share attitudes and values that represent diverse worldviews, and the political need for all people to express their views freely and to participate in decision-making. Addressing these needs can build resilience for the future.

Economic – this aspect acknowledges the interactions of humans with the natural environment in using resources to create goods and services which add value to their lives. It acknowledges the resource use and waste disposal must occur within the capacity of our planet. It encourages a fair trading system that equitably distributes benefits and costs. It further encourages innovation and creativity in developments that lead to a sustainable future.

An integrative model: A model showing how these aspects are related (in this model, the social and cultural aspects sit within society). This model shows how our economy is a subset of our society, as in reality it is situated entirely within our society. It also shows that everything in our economy and everything in our society is situated within, and entirely dependent on, our

environment. This relationship means that any impact or change to our environment will impact on society and the economy, and therefore that any sustainability-related issue must be considered holistically, and recognize this interdependence.

UNSUSTAINABILITY

Unsustainability refers to a condition or situation that cannot be maintained over the long term without causing negative consequences, particularly in relation to environmental, social, or economic systems. It implies that the current practices, policies, or behaviors are not capable of being continued indefinitely without depleting resources, damaging ecosystems, or causing harm to communities and societies.

There are various aspects of unsustainability that can manifest in different contexts:

Environmental unsustainability: This refers to practices or behaviors that degrade or deplete natural resources, disrupt ecosystems, or contribute to environmental degradation such as deforestation, overfishing, pollution, and greenhouse gas emissions. Environmental unsustainability can lead to long-term negative impacts on the health of the planet, including loss of biodiversity, climate change, and habitat destruction.

Social unsustainability: This refers to practices or behaviors that harm communities, societies, or human well-being. Examples include social inequality, discrimination, human rights abuses, labor exploitation, and disregard for cultural heritage. Social unsustainability can result in social unrest, conflict, and inequality, leading to long-term negative impacts on the well-being and stability of societies.

Economic unsustainability: This refers to economic practices or behaviors that are not viable over the long term, leading to economic instability, inequality, and inefficiencies. Examples include unsustainable debt levels, overreliance on non-renewable resources, unsustainable consumption patterns, and lack of economic diversification. Economic unsustainability can lead to economic crises, inequality, and poverty, affecting the long-term well-being of societies.

Addressing unsustainability requires adopting sustainable practices, policies, and behaviors that balance economic, social, and environmental considerations. This may involve transitioning to renewable energy sources, conserving natural resources, protecting ecosystems, promoting social

equity and inclusion, promoting responsible consumption and production, and adopting circular economy principles. It also involves considering the long-term impacts of our actions and making decisions that prioritize the well-being of people and the planet for present and future generations.

CAUSES OF UNSUSTAINABILITY:

Unsustainability can arise from a combination of various factors and causes, which can vary depending on the context and the specific issue being addressed. Some common causes of unsustainability include:

Overexploitation of natural resources: The extraction, production, and consumption of natural resources beyond their regenerative capacity or carrying capacity can lead to depletion and degradation of resources, such as deforestation, overfishing, and over-extraction of fossil fuels. This can result in ecosystem disruption, loss of biodiversity, and environmental degradation, leading to unsustainability.

Environmental pollution: Pollution of air, water, and soil caused by human activities, such as industrial emissions, chemical waste, and plastic pollution, can have detrimental impacts on the environment, wildlife, and human health. Pollution can disrupt ecosystems, degrade natural resources, and contribute to climate change, leading to unsustainability.

Unsustainable consumption and production patterns: The patterns of production and consumption in modern societies, characterized by excessive resource use, waste generation, and a linear "take-make-dispose" approach, can contribute to unsustainability. This includes overconsumption of goods and services, planned obsolescence, and wasteful production practices that result in resource depletion, pollution, and waste accumulation.

Social and economic inequalities: Social and economic inequalities, such as poverty, lack of access to education, healthcare, and basic services, and discrimination, can contribute to unsustainability. These inequalities can lead to social unrest, conflict, and instability, which can have long-term negative impacts on societies and their ability to achieve sustainability.

Lack of policy and governance mechanisms: Inadequate or ineffective policies, regulations, and governance mechanisms can contribute to unsustainability. This includes weak enforcement of environmental regulations, insufficient planning and management of resources, and lack of coordination among different stakeholders. Inadequate policy and governance mechanisms can hinder the adoption of sustainable practices and contribute to unsustainability.

Short-term focus and prioritization of economic growth: An emphasis on short-term economic gains and prioritization of economic growth over long-term sustainability can contribute to unsustainability. This includes practices such as overexploitation of resources for immediate economic benefits, disregarding environmental and social considerations, and prioritizing profit over people and the planet.

Lack of awareness and engagement: Limited awareness, understanding, and engagement among individuals, communities, businesses, and governments about the importance of sustainability, and

the need for sustainable practices and behaviors, can contribute to unsustainability. This includes lack of education, information, and motivation to adopt sustainable practices, resulting in unsustainable behaviors and choices.

It's important to note that unsustainability often arises from complex, interconnected factors, and addressing it requires a multifaceted approach that considers the interactions among environmental, social, and economic dimensions. Solutions often involve systemic changes in policies, behaviors, and attitudes, as well as fostering awareness, education, and engagement at individual, community, and global levels.

Difference in Sustainability and Unsustainability:
Sustainability and unsustainability are two contrasting concepts that describe the ability of a system or practice to maintain itself over the long term. The main differences between sustainability and unsustainability are as follows:

	Sustainability	**Unsustainability**
Environmental Impact	Sustainability refers to practices that are **environmentally responsible,** where **resources are used efficiently and the natural environment is protected** or conserved for future generations	Unsustainability, on the other hand, refers to practices that harm or **deplete the environment, resulting in negative impacts such as pollution,** deforestation, or over-extraction of resources.
Social Responsibility	Sustainability encompasses social responsibility, which involves considering the social and cultural impacts of practices on communities, workers, and other stakeholders. Sustainable practices aim to **promote social equity, diversity, and inclusivity, and protect human rights.**	Unsustainability, on the other hand, may **neglect social responsibilities**, leading to negative social impacts such as **exploitation, inequality**.
Economic Viability	Sustainability involves economic viability, where practices are economically feasible and do not compromise the long-term economic well-being of individuals or communities. **Sustainable practices often aim to create economic value while minimizing negative impacts.**	Unsustainability, on the other hand, may result in **short-term economic gains** at the expense of long-term economic stability, **leading to economic decline, inequality**, and financial instability.
Long-Term Outlook	Sustainability is **focused on the long-term,** aiming to create practices that can be maintained indefinitely without compromising	Unsustainability, on the other hand, often involves **short-sighted practices that prioritize immediate gains without considering long-term consequences,** leading to depletion of

	the ability of future generations to meet their own needs.	resources, environmental degradation, and social and economic challenges in the future.
Holistic Approach	Sustainability **takes a holistic approach, considering the interconnections between environmental, social, and economic aspects** of a system or practice. It seeks to balance these three pillars to create a sustainable system.	Unsustainability, on the other hand, often **neglects this holistic approach and may prioritize one aspect at the expense of others**, leading to imbalances and negative impacts in the long run.

Summary:

Sustainability	**Unsustainability**
Sustainability refers to the practices that are • Environmentally responsible • Socially equitable • Economically viable • Long-term oriented • Holistic	Unsustainability refers to practices that are • Environmentally irresponsible and harming. • Neglect social responsibility • Compromise economic viability • Lack a long-term outlook and prioritize short-term gains over long-term well-being • Concentrate or focus on one aspect/ Unholistic

Millennium Development Goals:

The Millennium Development Goals (MDGs) were a set of eight global development targets established by the United Nations (UN) in the year 2000, with a deadline of 2015. The MDGs were aimed at addressing key issues related to poverty, health, education, gender equality, environmental sustainability, and global partnerships. The eight MDGs were:

1. Eradicate Extreme Poverty and Hunger: To reduce the proportion of people living in extreme poverty and suffering from hunger.
2. Achieve Universal Primary Education: To ensure that all children have access to primary education and complete a full course of primary schooling.
3. Promote Gender Equality and Empower Women: To achieve gender equality in education, employment, and decision-making, and to eliminate gender-based discrimination and violence.
4. Reduce Child Mortality: To reduce the mortality rate of children under five years of age.
5. Improve Maternal Health: To improve maternal health, reduce maternal mortality, and increase access to maternal healthcare services.
6. Combat HIV/AIDS, Malaria, and Other Diseases: To halt and reverse the spread of HIV/AIDS, malaria, and other major diseases.

7. Ensure Environmental Sustainability: To promote environmental sustainability, including targets for access to clean water, sanitation, and sustainable management of natural resources.
8. Develop a Global Partnership for Development: To strengthen global partnerships for development, including aid, trade, debt relief, and access to affordable essential medicines and technologies.

SUSTAINABLE PROTOCOLS:

Sustainability is based on a simple principle: Everything that we need for our survival and well-being depends, either directly or indirectly, on our natural environment. Sustainable standards and certifications are third-party verified systems that assess the environmental, social, and economic performance of products, services, or organizations against predetermined criteria related to sustainability. They are used as tools to promote sustainability, provide transparency to consumers, and drive positive change in various industries. Some popular sustainable standards and certifications include:

LEED (Leadership in Energy and Environmental Design): A green building certification system that evaluates the sustainability of buildings and encourages the use of energy-efficient technologies, renewable energy, and resource conservation.

The **WELL Building Standard** is an international system that measures, monitors and certifies a series of features to promote occupant wellbeing. It investigates seven key concepts: air, water, nourishment, light, fitness, comfort, and mind.

Fair Trade: A certification that ensures farmers and workers receive fair wages, work in safe conditions, and have access to sustainable farming practices, promoting social and economic sustainability in agriculture and trade.

BREEAM is the world's leading science-based suite of validation and certification systems for sustainable built environment. Since 1990, BREEAM's third-party certified standards have helped improve asset performance at every stage, from design through construction, to use and refurbishment.

The National Green Building Standard (NGBS) is the only green building rating system for homes and apartments approved by the American National Standards Institute (ANSI), as an American National Standard. The NGBS provides a blueprint for builders to follow for the design and construction of new and renovated single-family homes and multifamily apartment buildings.

Forest Stewardship Council (FSC): A certification that verifies that forest products, such as wood and paper, are sourced from responsibly managed forests that promote biodiversity, protect indigenous rights, and support local communities.

Organic: A certification that verifies that agricultural products are grown without synthetic fertilizers, pesticides, and genetically modified organisms (GMOs), promoting environmentally-friendly farming practices and healthy food systems.

B Corp: A certification for businesses that meet high social and environmental performance standards, demonstrating their commitment to sustainability, accountability, and transparency. ISO 14001: An international standard for environmental management systems that helps organizations implement environmentally sustainable practices and reduce their environmental footprint.

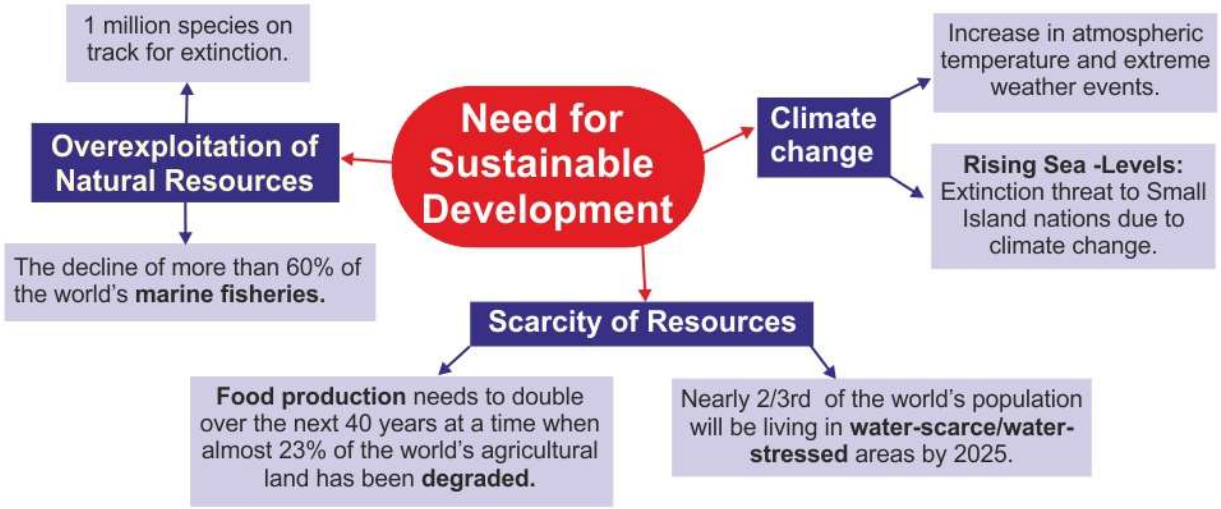
Cradle to Cradle (C2C): A certification that evaluates products based on their sustainability throughout their lifecycle, from raw material extraction to end-of-life disposal, encouraging circular economy principles and waste reduction.

These are just a few examples of the many sustainable standards and certifications that exist across various industries. They provide consumers and businesses with assurance that products and services meet specific sustainability criteria and contribute to a more sustainable future.

SUSTAINABLE DEVELOPMENT:

The concept of sustainable development came to the limelight with Brundtland Declaration of 1987. It defined sustainable development as a pattern of growth and development that meets the needs and requirements of the present, without compromising with the ability of our future generations, to meet their requirements and needs.

Sustainable development aims at optimum use of natural resources with high degree of sustainability, minimum wastage, least generation of toxic byproducts and maximum productivity



(https://www.drishtiias.com/to-the-points/paper3/sustainable-development-3)

Three core elements of sustainable development are economic **growth, social inclusion and environmental protection.**

- Environmental **Sustainability:**
  - It prevents nature from being used as an inexhaustible source of resources and ensures its **protection and rational use.**

- Aspects such as **environmental conservation,** investment in **renewable energy, saving water,** supporting **sustainable mobility,** and innovation in **sustainable construction and architecture,** contribute to achieving environmental sustainability on several fronts.

 Social **Sustainability:**

1. It can foster **gender equality, development of people, communities and cultures** to help achieve a reasonable and **fairly-distributed quality of life,** healthcare and education across the Globe.

 Economic **Sustainability:**

- Focuses on **equal economic growth** that generates **wealth for all,** without harming the environment.
- **Investment** and **equal distribution** of **economic resources.**
- Eradicating poverty in all its forms and dimensions.

SUSTAINABLE DEVELOPMENT GOALs (SDG):

The Sustainable Development Goals (SDGs) are a **set of 17 global goals established by the United Nations in 2015 as part of the 2030 Agenda for Sustainable Development.** The SDGs are designed to address various social, economic, and environmental challenges facing the world, with the overarching aim of promoting sustainable development that is inclusive, equitable, and environmentally responsible. The SDGs build on the Millennium Development Goals (MDGs), which were established in 2000 and aimed to address poverty and other global issues by 2015.

The 17 Sustainable Development Goals are as follows:

1. **No Poverty:** End poverty in all its forms and ensure social protection for all.
2. **Zero Hunger:** End hunger, achieve food security, improve nutrition, and promote sustainable agriculture.
3. **Good Health and Well-being:** Ensure healthy lives and promote well-being for all at all ages.
4. **Quality Education:** Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
5. **Gender Equality:** Achieve gender equality and empower all women and girls.
6. **Clean Water and Sanitation:** Ensure availability and sustainable management of water and sanitation for all.
7. **Affordable and Clean Energy:** Ensure access to affordable, reliable, sustainable, and modern energy for all.
8. **Decent Work and Economic Growth:** Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all.
9. **Industry, Innovation, and Infrastructure:** Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation.
10. **Reduced Inequalities:** Reduce inequality within and among countries.
11. **Sustainable Cities and Communities:** Make cities and human settlements inclusive, safe, resilient, and sustainable.
12. **Responsible Consumption and Production:** Ensure sustainable consumption and production patterns.
13. **Climate Action:** Take urgent action to combat climate change and its impacts.

14. **Life below Water:** Conserve and sustainably use the oceans, seas, and marine resources for sustainable development.
15. **Life on Land:** Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and biodiversity loss.
16. **Peace, Justice, and Strong Institutions:** Promote peaceful and inclusive societies, provide access to justice for all, and build effective, accountable, and inclusive institutions at all levels.
17. **Partnerships for the Goals:** Strengthen the means of implementation and revitalize the global partnership for sustainable development.

SUSTAINABLE DEVELOPMENT TARGETS:

The Sustainable Development Goals (SDGs) are accompanied by a set of targets that provide specific objectives to be achieved by 2030 in order to fulfill the goals. These targets provide measurable benchmarks and indicators to track progress towards achieving the SDGs. Each of the 17 SDGs has a set of targets associated with it, totaling to 169 targets in total. Some of the key targets for each SDG are given here.

Goal 1: End poverty in all its forms everywhere
Targets
1.1 By 2030, eradicate extreme poverty for all people everywhere
1.2 By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty.
1.3 Implement nationally appropriate social protection systems and measures for all, including floors, and by 2030 achieve substantial coverage of the poor and the vulnerable

Goal 2 End hunger, achieve food security and improved nutrition and promote sustainable agriculture
Targets
2.1By 2030, ensure access by all people, the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round
2.2 By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment
2.3 By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels.

Goal 3 Ensure healthy lives and promote well-being for all at all ages
Targets
3.1 By 2030, reduce the global maternal mortality ratio to less than 70 per 100,000 live births
3.2 By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases
3.3 By 2020, halve the number of global deaths and injuries from road traffic accidents

Goal 4 Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

Targets

4.1 By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes

4.2 By 2030, eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples and children in vulnerable situations

4.3 By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development

Goal 5 Achieve gender equality and empower all women and girls

Targets

5.1 End all forms of discrimination against all women and girls everywhere

5.2 Eliminate all forms of violence against all women and girls in the public and private spheres, including trafficking and sexual and other types of exploitation

5.3 Eliminate all harmful practices, such as child, early and forced marriage.

Goal 6 Ensure availability and sustainable management of water and sanitation for all

Targets

6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all

6.2 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate

6.3 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes

Goal 7 Ensure access to affordable, reliable, sustainable and modern energy for all

Targets

7.1 By 2030, ensure universal access to affordable, reliable and modern energy services

7.2 By 2030, increase substantially the share of renewable energy in the global energy mix

7.3 By 2030, double the global rate of improvement in energy efficiency

Goal 8 Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

Targets

8.1 Sustain per capita economic growth in accordance with national circumstances and, in particular, at least 7 per cent gross domestic product growth per annum in the least developed countries

8.2 Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labour-intensive sectors

8.3 Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro, small and medium-sized enterprises, including through access to financial services

Goal 9 Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

Targets

9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and trans border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all

9.2 Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries

9.3 Increase the access of small-scale industrial and other enterprises, in particular in developing countries, to financial services, including affordable credit, and their integration into value chains and markets

Goal 10 Reduce inequality within and among countries

Targets

10.1 By 2030, progressively achieve and sustain income growth of the bottom 40 per cent of the population at a rate higher than the national average

10.2 By 2030, empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status

10.3 Adopt policies, especially fiscal, wage and social protection policies, and progressively achieve greater equality

SUSTAINABLE DEVELOPMENT INDICATORS:

Sustainable development indicators are quantitative or qualitative measures used to assess progress towards achieving sustainable development goals. These indicators are used to monitor and evaluate the social, economic, and environmental aspects of development to ensure that it is sustainable. Sustainable development indicators provide valuable information for policymakers, stakeholders, and the public to make informed decisions and take appropriate actions to promote sustainable development.

Here are some examples of sustainable development indicators:

1. **Greenhouse gas emissions:** This indicator measures the amount of greenhouse gases, such as carbon dioxide, methane, and nitrous oxide, emitted into the atmosphere by human activities. It helps assess progress towards mitigating climate change, a key aspect of sustainable development.
2. **Poverty rate:** This indicator measures the proportion of the population living below the poverty line, which is an important social aspect of sustainable development. It helps assess progress towards poverty eradication and improving social equity.
3. **Gender equality index:** This indicator measures the extent to which men and women have equal access to opportunities, resources, and services, such as education, healthcare, and

employment. It helps assess progress towards achieving gender equality and empowering women, which is an important aspect of social sustainability.

4. **Biodiversity index:** This indicator measures the diversity and abundance of species, ecosystems, and genetic resources, which are important components of environmental sustainability. It helps assess progress towards conserving biodiversity and protecting ecosystems.
5. **Renewable energy consumption:** This indicator measures the proportion of energy consumed that is generated from renewable sources, such as solar, wind, and hydropower. It helps assess progress towards promoting clean and sustainable energy sources and reducing reliance on fossil fuels.
6. **Water quality index:** This indicator measures the quality of freshwater resources, such as rivers, lakes, and groundwater, which are important for human well-being and ecosystem health. It helps assess progress towards protecting water resources and ensuring their sustainable use.
7. **Human development index:** This indicator measures the overall well-being and standard of living of a population, taking into account factors such as income, education, and life expectancy. It provides a holistic assessment of social and economic development, which is a key aspect of sustainable development.
8. **Waste generation and recycling rate:** This indicator measures the amount of waste generated and the proportion of waste that is recycled, which is an important aspect of environmental sustainability. It helps assess progress towards reducing waste generation, promoting recycling, and managing waste effectively.
9. **Sustainable consumption and production patterns:** This indicator measures the level of resource use, waste generation, and environmental impact associated with production and consumption patterns. It helps assess progress towards promoting sustainable production and consumption practices that minimize resource depletion and environmental degradation.
10. **Access to basic services:** This indicator measures access to basic services, such as clean water, sanitation, healthcare, education, and housing, which are fundamental to human well-being and social development. It helps assess progress towards ensuring equitable access to basic services for all, which is a key aspect of sustainable development.

SUSTAINABLE INTERVENTION

INTERVENTION: the action of becoming intentionally involved in a difficult situation, in order to improve it or prevent it from getting worse

A sustainable intervention refers to a planned action or initiative that is designed to promote sustainable development, meaning it supports economic growth, social progress, and environmental protection in a balanced and integrated manner, here are some examples of sustainable interventions:

1. Renewable energy projects: Investing in renewable energy sources such as solar, wind, hydro, and geothermal power can reduce reliance on fossil fuels, mitigate climate change, and promote sustainable energy production and consumption.

2. Sustainable agriculture and food systems: Implementing sustainable agricultural practices such as organic farming, agroforestry, and regenerative agriculture can improve soil health, protect biodiversity, reduce chemical inputs, and promote sustainable food production and supply chains.
3. Conservation and restoration of ecosystems: Protecting and restoring natural ecosystems such as forests, wetlands, and coral reefs can enhance biodiversity, carbon sequestration, and ecosystem services, while supporting local livelihoods and maintaining cultural values.
4. Sustainable urban planning and transportation: Designing cities and transportation systems with a focus on public transportation, active transportation (e.g., walking and cycling), green spaces, and energy-efficient buildings can reduce greenhouse gas emissions, air pollution, and congestion, while promoting livability and accessibility for all.
5. Education and capacity building: Providing education and training programs that focus on sustainable development principles, such as environmental conservation, social equity, and economic resilience, can build local capacity, promote awareness, and empower communities to make informed decisions and take sustainable actions.
6. Water resources management: Implementing sustainable water management practices, such as rainwater harvesting, water use efficiency, and integrated water resources management, can ensure access to clean water, protect water quality, and enhance water security in a changing climate.
7. Disaster risk reduction and climate adaptation measures: Implementing measures to reduce vulnerability and enhance resilience to disasters and climate change, such as early warning systems, infrastructure upgrades, and community-based adaptation strategies, can protect lives, livelihoods, and assets in a sustainable manner.
8. Corporate sustainability practices: Adopting sustainable business practices, such as responsible resource management, ethical supply chain management, and stakeholder engagement, can promote sustainable economic growth, innovation, and corporate social responsibility.

These are just a few examples of sustainable interventions, and there are many other strategies, approaches, and actions that can contribute to sustainable development. The key is to consider the social, economic, and environmental dimensions of development in an integrated and balanced manner, and ensure that interventions are designed and implemented with a long-term perspective to meet the needs of the present and future generations.

CLIMATE CHANGE

The average weather in a particular place over many years is called Climate. Climate change is a shift in those average conditions. The rapid climate change we are now seeing is caused by humans using oil, gas and coal for their homes, factories and transport. When these fossil fuels burn, they release greenhouse gases - mostly carbon dioxide (CO_2). These gases trap the Sun's heat and cause the planet's temperature to rise. The world is now about 1.1^0C warmer than it was in the 19th Century - and the amount of CO_2 in the atmosphere has risen by 50%

CAUSES / REASONS OF CLIMATE CHANGE:

Generating power: Generating electricity and heat by burning fossil fuels causes a large chunk of global emissions. Most electricity is still generated by burning coal, oil, or gas, which produces carbon dioxide and nitrous oxide – powerful greenhouse gases that blanket the Earth and trap the sun's heat.

Manufacturing goods: Manufacturing and industry produce emissions, mostly from burning fossil fuels to produce energy for making things like cement, iron, steel, electronics, plastics, clothes, and other goods. Mining and other industrial processes also release gases, as does the construction industry.

Cutting down forests: Since forests absorb carbon dioxide, destroying them also limits nature's ability to keep emissions out of the atmosphere. Deforestation, together with agriculture and other land use changes, is responsible for roughly a quarter of global greenhouse gas emissions.

Using transportation: Most cars, trucks, ships, and planes run on fossil fuels. That makes transportation a major contributor of greenhouse gases, especially carbon-dioxide emissions. Road vehicles account for the largest part, due to the combustion of petroleum-based products, like gasoline, in internal combustion engines. But emissions from ships and planes continue to grow.

Producing food: Producing food causes emissions of carbon dioxide, methane, and other greenhouse gases in various ways, including through deforestation and clearing of land for agriculture and grazing, digestion by cows and sheep, the production and use of fertilizers and manure for growing crops, and the use of energy to run farm equipment or fishing boats, usually with fossil fuels. All this makes food production a major contributor to climate change. And greenhouse gas emissions also come from packaging and distributing food.

Powering buildings: Globally, residential and commercial buildings consume over half of all electricity. As they continue to draw on coal, oil, and natural gas for heating and cooling, they emit significant quantities of greenhouse gas emissions. Growing energy demand for heating and cooling, with rising air-conditioner ownership, as well as increased electricity consumption for lighting, appliances, and connected devices, has contributed to a rise in energy-related carbon-dioxide emissions from buildings in recent years.

EFFECTS OF CLIMATE CHANGE:

Hotter temperatures: As greenhouse gas concentrations rise, so does the global surface temperature. The last decade, 2011-2020, is the warmest on record.

More severe storms: Destructive storms have become more intense and more frequent in many regions. As temperatures rise, more moisture evaporates, which exacerbates extreme rainfall and flooding, causing more destructive storms. The frequency and extent of tropical storms is also affected by the warming ocean. Cyclones, hurricanes, and typhoons feed on warm waters at the ocean surface.

Increased drought: Climate change is changing water availability, making it scarcer in more regions. Droughts can also stir destructive sand and dust storms that can move billions of tons of

sand across continents. Deserts are expanding, reducing land for growing food. Many people now face the threat of not having enough water on a regular basis.

A warming, rising ocean: The ocean soaks up most of the heat from global warming. The rate at which the ocean is warming strongly increased over the past two decades, across all depths of the ocean. As the ocean warms, its volume increases since water expands as it gets warmer. Melting ice sheets also cause sea levels to rise, threatening coastal and island communities. Global patterns of wind and ocean current also gets disturbed by climate change.

Loss of species: Climate change poses risks to the survival of species on land and in the ocean. Forest fires, extreme weather, and invasive pests and diseases are among many threats related to climate change. Some species will be able to relocate and survive, but others will not.

Poverty and displacement: Climate change increases the factors that put and keep people in poverty. Floods may sweep away urban slums, destroying homes and livelihoods. Heat can make it difficult to work in outdoor jobs. Water scarcity may affect crops.

Possible Solutions to Climate change:

1. Burning of fossil fuels like coal, oil and gas must be avoided
2. Renewable energy sources like solar, wind, tidal, etc. must be used instead of fossil fuels.
3. Electric vehicles can be used to stop the emission of greenhouse gases.
4. Heating and cooling can be done by greenways like insulating walls, using solar energy.
5. Planting more trees to absorb more carbon
6. Protect forest
7. Reducing the overall consumption.
8. Avoid the usage of plastics
9. Reduce the carbon emission

CASE STUDIES: Climate change problems and adapted solution
(https://climate-adapt.eea.europa.eu/en/about/climate-adapt-10-case-studies-online.pdf)

This case study explains the two most occurring problems (Excessive rainfall & Excess heat/Heat wave) of climate change and its solutions in the European countries (Copenhagen & Barcelona)

1. Barcelona trees tempering the Mediterranean city climate, Spain

Barcelona's main climate change challenges include temperature rise, a decrease in rainfall and an increase in extreme events such as droughts and heatwaves. The high urban density of Barcelona can exacerbate the heat island effect. Barcelona has committed to becoming a global model of a sustainable city in response to the urban development challenges related to climate change. For many years, Barcelona has had a focus on planting and managing trees. Trees can moderate the urban climate by cooling it in two different ways. Reflection of sunlight and transpiration by the leaves lower the air temperature, and shade reduces the surface temperature

and protects people from the sun, especially during the hottest months. Furthermore, trees can prevent local flooding by helping to reduce the amount of storm water runoff. *Besides climate-related benefits, city trees can also provide co-benefits: removing air pollutants, storing carbon, reducing noise pollution, regulating humidity and balancing the water cycle, creating ecological connectivity, providing habitat for urban biodiversity and creating a pleasant urban landscape.*

Barcelona's Green Infrastructure and Biodiversity Plan 2020 (BGIBP) seeks to connect various areas of the city with green infrastructure. In line with the BGIBP goals, Barcelona's Tree Master Plan for 2017-37 identifies a number of actions to expand tree coverage and improve the climate resilience of the urban trees. These actions include the selection of tree species that are more resilient to water and heat stresses, diversification of tree species, increased use of runoff water for watering trees, automatic irrigation and control of water leaks.

2. The economics of managing heavy rains and stormwater in Copenhagen — The Cloudburst Management Plan, Denmark

Copenhagen experienced four major rainfall events in the period 2011-2016, resulting in severe damage that was expensive to repair. These types of events are expected to be more intense and more frequent as a result of climate change. The city has drawn out a Cloudburst Management Plan that aims to reduce the impacts of flooding due to heavy rains. The plan included an assessment of the costs of different measures (traditional versus new options including adaptation measures), the cost of the damage despite the measures and the resulting financial impact. The results showed that continuing to focus on traditional sewerage systems would result in a societal loss compared with the alternative solution. The alternative adaptation measures aim to store or drain excess water at ground level. The plan consists of four surface solutions as well as pipe-based solutions, including:

- Storm water roads and pipes that transport water towards lakes and the harbor, e.g. in the built-up area of central Copenhagen;
- retention roads for storing waters;
- retention areas to store very large water volumes, e.g. parks that could turn into lakes during flood events;
- green roads to detain and hold back water in smaller side streets.

The traditional sewerage system was estimated to cost DKK 20 billion (EUR 2.6 billion) compared with DKK 13 billion for the alternative solution. Despite capital investments in the traditional sewerage system, financial losses from flooding would remain high (net loss of DKK 4 billion). On the other hand, the chosen combined solution — consisting of expanding the sewer network and surface projects focusing on water retention and drainage — would result in a net saving of DKK 3 billion. The plan is also likely to contribute to a growth in property values, increased employment, upgrade of urban spaces and increased tax revenues. The Cloudburst Management Plan was developed during 2013 and includes 300 surface projects. The projects have started to be implemented at around 15 projects per year for the next 20-30 years. The projects are prioritized according to the level of flood risk, a socio-economic assessment and the availability of co-benefits.

CARBON CREDIT

A carbon credit is a tradable permit or certificate that represents the right to emit a set amount of CO_2 (or) 1 ton of CO_2 (or) the equivalent amount of greenhouse gas.

Concept: The Kyoto Protocol was an international agreement that aimed to reduce carbon dioxide (CO2) emissions and the presence of greenhouse gases (GHG) in the atmosphere. Kyoto protocol introduced the concept of carbon credits. According to this a country should reduce carbon emission in the atmosphere.

- A carbon credit is a tradable certificate that allows its holder to emit greenhouse gas.
- One carbon credit is equal to one ton of carbon dioxide.
- Countries need to reduce their emissions by 5.2% compared to the numbers recorded.
- Countries and companies need to be designed to reduce carbon emissions without the need to buy credits.
- Less the purchase, less will be the carbon release into the atmosphere.

Types of Carbon Credit:

- **Voluntary Emissions Reduction (VER):** It is a carbon offset that is exchanged in the voluntary market for credits.
- **Certified Emissions Reduction (CER):** is **a certificate issued by the United Nations to member nations for preventing one ton of carbon dioxide emissions**. These are usually issued to member states for projects achieving greenhouse gas reductions through the use of Clean Development Mechanisms (CDM).

Advantages of carbon credit:

1. **Encourages emission reduction:** Carbon credits create an economic incentive for companies to reduce their greenhouse gas emissions.
2. **Promotes investment in clean technologies:** The carbon market can encourage the development and adoption of clean technologies that can help reduce greenhouse gas emissions.
3. **Supports sustainable development:** The Clean Development Mechanism (CDM) encourages investment in projects that improve energy access, promote rural development, and reduce poverty.

4. **Provides a flexible approach to emissions reduction:** Carbon credits offer a flexible approach to emissions reduction, allowing companies to offset their emissions by investing in emissions reduction projects in other countries.

Disadvantages of carbon credit:

1. **Can lead to "greenwashing":** Some companies may use carbon credits as a way to portray themselves as environmentally responsible without making substantial efforts to reduce their carbon footprint.
2. **Can be subject to fraud:** The carbon credit market is vulnerable to fraud, with some companies producing fake carbon credits. This undermines the integrity of the carbon credit system and can lead to a loss of confidence in the market.
3. **Can be complex and expensive:** The process of creating and verifying carbon credits can be complex and expensive. The cost of carbon credits can also be volatile, making it difficult for companies to budget for emissions reductions.
4. **May not result in actual emissions reductions:** Some critics argue that carbon credits do not actually result in emissions reductions because they allow companies to continue emitting greenhouse gases while investing in emissions reduction projects elsewhere. This is known as "offsetting" and can lead to a "lock-in" of high-carbon infrastructure and technologies.

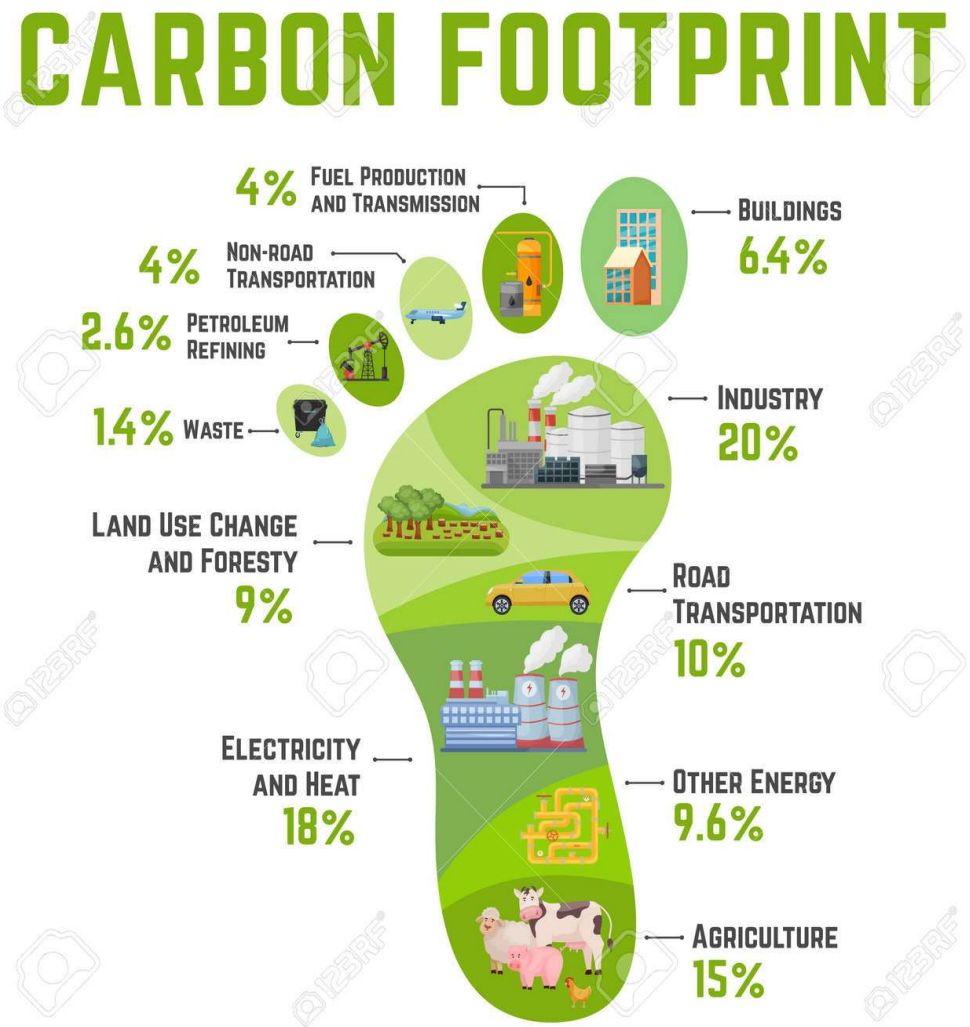
CARBON FOOTPRINT

A carbon footprint is **the total amount of greenhouse gases (including carbon dioxide and methane) that are generated by our actions**.

Smaller the carbon footprint better for the future and bigger carbon footprint will have bigger negative impact in environment.

Sources of Carbon Footprint:

1. **Energy production:** The burning of fossil fuels such as coal, oil, and gas for energy production is a significant source of greenhouse gas emissions. This includes emissions from power plants, industrial processes, and transportation.
2. **Agriculture:** The agricultural sector is a major source of methane and nitrous oxide emissions, primarily from livestock, fertilizers, and manure management.
3. **Land use and forestry:** Deforestation and land-use changes are major sources of greenhouse gas emissions.
4. **Industrial processes:** Chemical and manufacturing processes, including cement production, are significant sources of greenhouse gas emissions.
5. **Waste management:** Methane emissions from landfills and wastewater treatment plants are significant contributors to greenhouse gas emissions.
6. **Transportation:** Transportation, including cars, trucks, planes, and ships, is a major source of greenhouse gas emissions, primarily from the burning of fossil fuels.



(Sources of Carbon Footprint)

10 Ways to reduce carbon footprint:

1. Calculate your carbon footprint
2. Switch to electric or hybrid car
3. Switch to renewable energy
4. Consider solar panels
5. Get energy efficient appliances
6. Unplug electrical devices when not in use
7. Buy locally produced food
8. Start a home garden
9. Don’t waste water
10. Reduce, reuse and recycle.

ENVIRONMENTAL MANAGEMENT

An Environmental Management System (EMS) is **a set of processes and practices that enable an Organization / Industry to reduce its environmental impacts and increase its operating efficiency**.

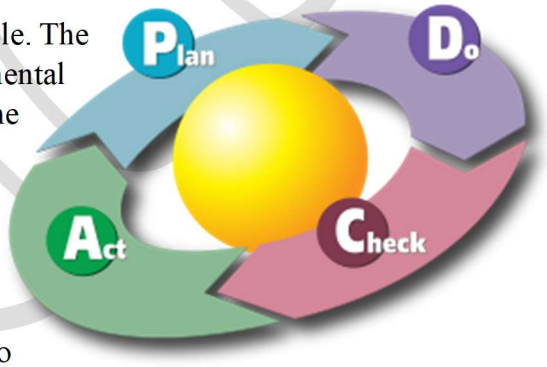
The goals of EMS are

- To increase compliance and reduce waste
- Reduce resource usage
- Reduce pollution

The EMS helps to develop, implement, manage, coordinate and monitor environmental policies. Waste reduction begins at the design phase through pollution prevention and waste minimization. Waste can be limited by 'reduce, reuse & recycle.

EMS Model

An EMS follows a Plan-Do-Check-Act, or PDCA, Cycle. The diagram shows the process of first developing an environmental policy, planning the EMS, and then implementing it. The process also includes checking the system and acting on it. The model is continuous because an EMS is a process of continual improvement in which an organization is constantly reviewing and revising the system. This is a model that can be used by a wide range of organizations – from manufacturing facilities to service industries to government agencies.



The PDCA cycle

EMSs assist companies in making sound environmental decisions as part of daily business practices. As a result, an EMS can help a company to,

- use energy and other resources efficiently,
- better manage the risk associated with using hazardous chemicals
- practice extended product and process responsibility, and
- integrates environmental and worker safety and health requirements.

https://www.epa.gov/sites/default/files/2014-01/documents/iems_case_study_1_manage_environmental_concerns.pdf

CASE STUDY: (Environmental Management System)

Case Study: Implementation of an Environmental Management System (EMS)

Company: XYZ Manufacturing

XYZ Manufacturing is a medium-sized manufacturing company that specializes in producing consumer goods. The company is committed to sustainable practices and minimizing its environmental impact. To formalize and enhance its environmental efforts, **XYZ Manufacturing decided to implement an Environmental Management System (EMS) based on the ISO 14001 standard.**

Objectives:

1. Improve environmental performance and minimize negative environmental impacts.
2. Comply with environmental regulations and legal requirements.
3. Increase resource efficiency and reduce waste generation.
4. Enhance employee engagement and awareness regarding environmental responsibilities.
5. Establish a framework for continuous improvement in environmental performance.

Implementation Process:

1. **Initial Assessment:** XYZ Manufacturing conducted an initial assessment to identify existing environmental aspects and impacts associated with its operations. This included evaluating energy consumption, water usage, waste generation, emissions, and potential environmental risks. The assessment helped in understanding the company's current environmental performance and establishing a baseline for improvement.
2. **Policy Development:** A team comprising representatives from various departments (operations, maintenance, and environmental health and safety) was formed. They collaborated to develop an Environmental Policy. The policy was communicated to all employees and stakeholders to create awareness.
3. **Objective Setting:** Based on the initial assessment, XYZ Manufacturing established specific environmental objectives and targets aligned with the company's overall goals. These objectives focused on reducing energy consumption, water usage, and waste generation, as well as improving recycling and promoting eco-friendly practices. The objectives were measurable, time-bound, and regularly reviewed to track progress.
4. **Implementation and Operational Controls:** The company implemented a range of operational controls and procedures to manage and mitigate its environmental impacts.
    a. Energy Management: XYZ Manufacturing invested in energy-efficient equipment and implemented energy conservation measures, such as optimizing production processes and installing energy-saving lighting systems.
    b. Waste Management: The company implemented a waste management plan to reduce, segregate, and properly dispose of waste generated during operations. Recycling programs were established for materials like paper, plastics, and packaging.
    c. Water Conservation: XYZ Manufacturing implemented water-saving measures, such as installing water-efficient fixtures and optimizing water usage in production processes.

d. Emissions Control: The company implemented measures to reduce emissions, such as optimizing combustion processes, monitoring air emissions, and maintaining equipment to minimize leaks.

e. Training and Awareness: Regular training sessions and awareness campaigns were conducted to educate employees about environmental responsibilities, best practices, and the importance of their individual contributions.

5. **Monitoring and Measurement:** XYZ Manufacturing established a system to monitor and measure its environmental performance regularly. Data was collected, analysed, and reported to identify trends, evaluate progress against objectives, and identify areas for improvement.
6. **Internal Audits and Management Review:** Internal audits were conducted periodically to assess the effectiveness of the EMS implementation and identify opportunities for improvement. The findings were documented, and corrective actions were implemented as required. Additionally, top management conducted regular management reviews to evaluate the overall performance of the EMS and make necessary adjustments.

Results and Benefits:

1. **Compliance:** XYZ Manufacturing ensured compliance with relevant environmental regulations and legal requirements, reducing the risk of penalties and negative reputational impact.
2. **Resource Efficiency:** The implementation of energy-saving measures and water conservation practices resulted in significant reductions in energy consumption and water usage, leading to cost savings.
3. **Waste Reduction:** The waste management plan and recycling initiatives helped minimize waste generation, leading to cost savings and reducing the company's environmental footprint.
4. **Employee Engagement:** The training and awareness campaigns increased employee engagement and fostered a culture of environmental responsibility throughout the organization.
5. **Continuous Improvement:** The EMS provided a framework for ongoing improvement in environmental performance. The regular monitoring, measurement, and review processes allowed the company to identify areas for further optimization and set new objectives to drive progress.

By implementing an EMS, XYZ Manufacturing demonstrated its commitment to environment protection, achieved operational efficiencies, and reduced its environmental impact.

The case study highlights the importance of a systematic approach to environmental management and the benefits it can bring to organizations seeking sustainable practices.

UNIT V SUSTAINABILITY PRACTICES

Zero waste and R concept, Circular economy, ISO 14000 Series, Material Life cycle assessment, Environmental Impact Assessment. Sustainable habitat: Green buildings, Green materials, Energy efficiency, Sustainable transports. Sustainable energy: Non-conventional Sources, Energy Cycles carbon cycle, emission and sequestration, Green Engineering: Sustainable urbanization-Socioeconomical and technological change.

OBJECTIVE:

- To inculcate and embrace sustainability practices and develop a broader understanding on green materials, energy cycles and analyze the role of sustainable urbanization.

OUTCOME:

- To demonstrate the knowledge of sustainability practices and identify green materials, energy cycles and the role of sustainable urbanization.

ZERO WASTE and R Concept

1. Define Zero waste. (2 mark)

["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."

(or)

Zero waste is a philosophy and lifestyle that aims to reduce the amount of waste generated by individuals, households, and businesses to as close to zero as possible. The concept of zero waste is based on the principles of the circular economy, which seeks to eliminate waste and keep resources in use for as long as possible.]

Features of Zero Waste:

The main feature of zero waste is the aim to eliminate waste by minimizing the generation of waste in the first place. Here are some key features of the zero waste approach:

1. Reducing consumption: Avoiding unnecessary purchases and by reducing consumption, we can minimize the amount of waste generated.
2. Reusing items: Instead of throwing items away after use, we can find ways to reuse them. This can include repairing and repurposing items, donating them to charity, or selling them second-hand.
3. Recycling: Recycling involves turning waste materials into new products.
4. Composting: Composting involves turning organic waste, such as food scraps and yard waste, into nutrient-rich soil, provide a sustainable source of fertilizer.
5. Redesigning products and packaging: By designing products and packaging to be more sustainable, we can reduce waste and minimize the environmental impact of manufacturing and production.
6. Mindful consumption: Zero waste encourages mindful consumption by making us more aware of the impact of our choices and purchases on the environment. This can lead to more sustainable and responsible behavior, both as individuals and as a society.

R-Concept:

2. What is R-Concept? (2 mark)

[Refuse, Reduce, Reuse, Recycle, Rot – these are the "5 Rs" that make up the basic rules of zero waste.]

1. **Refuse:** By refusing, a lot of waste is eliminated at the source. The idea is to refrain from accepting free stuff that becomes instant waste. There are some things you can choose to refuse on a daily basis:
   - disposable coffee cups
   - plastic utensils

(Graphical representation of 5R Concept)

2. **Reduce:** This involves reducing the amount of waste generated by using fewer resources and products.
3. **Reuse:** This involves finding ways to reuse items instead of throwing them away, such as repairing or repurposing items, donating them to charity, or selling them second-hand.
4. **Recycle:** This involves recycling waste materials by turning them into new products.
5. **Rot (what's left over):** Composting food scraps, paper pieces, and wooden or bamboo toothbrushes returns nutrients and fiber back to the earth.

CIRCULAR ECONOMY

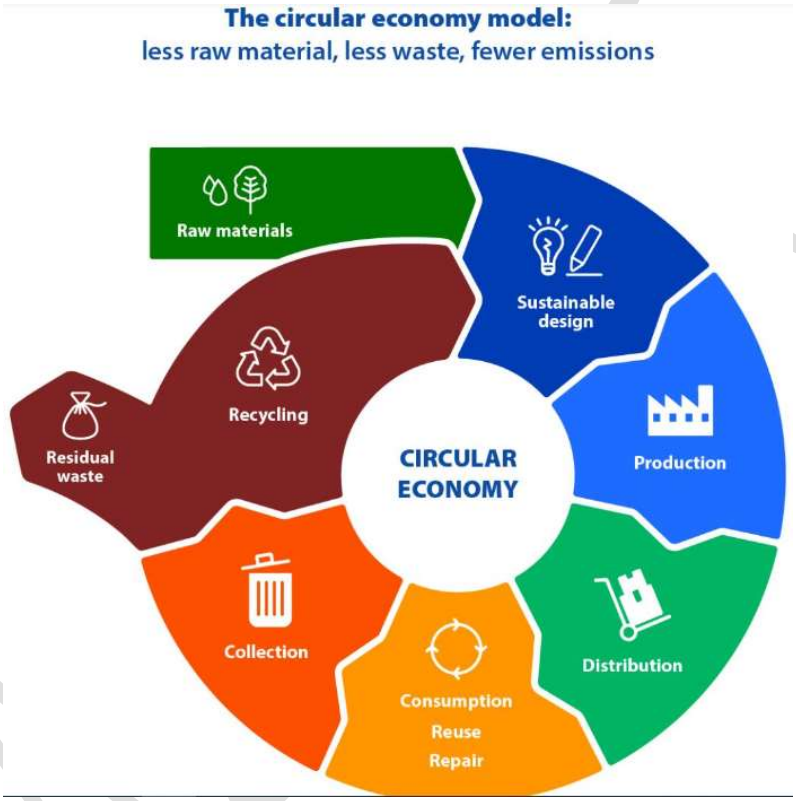
3. Explain circular economy concept (2 mark)

[The circular economy aims to create a more sustainable and regenerative system that mimics natural processes, where resources are continuously cycled and regenerated. It involves rethinking the way products are designed, manufactured, and consumed, with a focus on reducing waste, maximizing resource efficiency, and minimizing environmental impact.]

The circular economy is based on four key principles:

1. **Designing out waste and pollution:** This principle involves designing products and processes to minimize waste and pollution throughout their lifecycle. This can include designing products for reuse or recycling, using non-toxic materials, and reducing the use of non-renewable resources.

2. **Keeping products and materials in use:** This principle involves keeping products and materials in use for as long as possible, through strategies such as reuse, repair, refurbishment, and recycling. This can involve creating closed-loop systems where waste from one process becomes the input for another.
3. **Regenerating natural systems:** This principle involves restoring and regenerating natural systems, such as forests, oceans, and soils, through sustainable land use and resource management practices. This can include promoting regenerative agriculture and sustainable forestry practices, and protecting biodiversity and ecosystems.
4. **Fostering collaboration and innovation:** This principle involves fostering collaboration and innovation across different sectors and stakeholders, to create new business models



Benefits of Circular Economy:

The circular economy offers several benefits, including:

1. Reduced waste and pollution: By keeping products and materials in use for as long as possible, the circular economy reduces waste and pollution, reducing the environmental impact of production and consumption.
2. Resource efficiency: The circular economy maximizes the use of resources by designing products and processes for durability, reparability, and recyclability, reducing the need for new resources and promoting resource efficiency.
3. Economic growth and job creation: The circular economy creates new business opportunities and jobs in areas such as repair, refurbishment, and recycling, contributing to economic growth and development.

4. Increased resilience: The circular economy promotes resilience by reducing dependence on finite resources, increasing resource security, and building more sustainable supply chains.
5. Improved social outcomes: The circular economy can benefit communities by promoting local production and consumption, creating job opportunities, and reducing environmental and health impacts on vulnerable populations.

Linear Economy: The traditional linear economy model, which is based on the "take-make-dispose" approach. In the linear economy, resources are extracted, used to manufacture products, and then disposed of as waste.

Linear Economy Vs Circular Economy:

Linear Economy	Circular Economy
Materials flow in a straight line from resource extraction to manufacturing and then to landfill. Value is created by producing and selling as many product as possible Characterized by wasted resources, excessive pollution, ecosystem degradation, wealth concentration and social inequalities.	Mimics natural processes, where resources are continuously cycled and regenerated. Circular business model builds economic, natural and social capital. Characterized by best utilization of resources, protection of ecosystem and social equalities.

ISO 14000 Series

ISO 14000 is a set of standards created to help companies to reduce their impact on the environment. It's a framework for environmentally-conscious quality management systems by organizations. The ISO 14000 series of standards was introduced in 1996 by the International Organization for Standardization (ISO) and most recently revised in 2015.

The primary objective of ISO14000 series of standard is to promote effective environmental management systems in organizations.

List of ISO 14000 series standards

- **ISO 14001** Environmental management systems - Requirements with guidance for use
- **ISO 14004** Environmental management systems - General guidelines on implementation
- **ISO 14005** Environmental management systems - Guidelines for a flexible approach to phased implementation
- **ISO 14006** Environmental management systems - Guidelines for incorporating eco design
- **ISO 14015** Environmental management - Environmental assessment of sites and organizations (EASO)

- **ISO 14020** to **14025** Environmental labels and declarations
- **ISO/NP 14030** Green bonds -- Environmental performance of nominated projects and assets; discusses post-production environmental assessment
- **ISO 14031** Environmental management - Environmental performance evaluation - Guidelines
- **ISO 14040** to **14049** Environmental management - Life cycle assessment; discusses pre-production planning and environment goal setting
- **ISO 14050** Environmental management - Vocabulary; terms and definitions
- **ISO/TR 14062** Environmental management - Integrating environmental aspects into product design and development
- **ISO 14063** Environmental management - Environmental communication - Guidelines and examples
- **ISO 14064** Greenhouse gases; measuring, quantifying, and reducing greenhouse gas emissions
- **ISO 14090** Adaptation to climate change — Principles, requirements and guidelines

MATERIAL LIFE CYCLE ASSESSMENT

Life Cycle Assessment (LCA) is an analysis **to assess environmental impacts associated with all the stages of a product's life**, which is from raw material extraction through materials processing, manufacture, distribution, and use. LCA is commonly referred to as a cradle-to-grave analysis.

Stages of a Life Cycle Assessment:

Following are five stages of a life cycle assessment

1. Raw materials (resources) extraction and processing
2. Manufacturing
3. Transportation and Distribution
4. Usage and retail
5. Waste disposal

Benefits of life cycle assessment (LCA), including:

1. Identifying environmental impacts: LCA helps to identify the potential environmental impacts of a product or process over its entire life cycle, allowing companies and policymakers to make informed decisions about how to reduce those impacts.
2. Comparison of alternatives: LCA enables the comparison of different product designs, materials, and production processes, providing insight into which options are more environmentally friendly.
3. Improved product design: LCA can inform product design, enabling companies to develop products that are more sustainable and have a reduced environmental impact.

4. Reduced costs: LCA can help companies identify opportunities to reduce costs by reducing waste, improving production efficiency, and using less energy and resources.
5. Improved brand image: Companies that use LCA to inform their sustainability efforts can improve their brand image and reputation, attracting environmentally conscious consumers and stakeholders.

Overall, LCA provides a holistic approach to sustainability, allowing companies to evaluate the environmental impact of their products and processes and make informed decisions to reduce their environmental footprint.

ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

Environmental Impact Assessment is a process through which an environmental impact of a proposed development is evaluated. While undertaking Environmental Impact Assessment (EIA), the inter-related socio-economic, cultural, and human-health impacts are considered. This is used to predict the environmental impacts of a project in the pre-planning stage itself so that decisions can be taken to reduce the adverse impacts.

Objectives of Environmental Impact Assessment

1. Identifying, predicting, and evaluating economic, environmental, and social impacts of development activities.
2. Providing information on the environmental consequences for decision making.
3. Promoting environmentally sound and suitable development by identifying appropriate alternatives and mitigation measures.

The **EIA process** typically involves several stages:

1. ***Screening:*** The initial stage of EIA involves determining whether a proposed project or development is likely to have significant environmental impacts that require a full EIA study.
2. ***Scoping:*** The scoping stage involves identifying the potential environmental impacts of a project or development, as well as the environmental factors that should be considered in the EIA study.
3. ***Impact assessment:*** The impact assessment stage involves identifying and evaluating the potential environmental impacts of a project or development, including both direct and indirect impacts.
4. ***Mitigation:*** The mitigation stage involves developing measures to minimize or mitigate the potential environmental impacts of a project or development.
5. ***Review and approval:*** The final stage of EIA involves review and approval of the EIA study by relevant authorities, which may include regulators, stakeholders, and the public.

The goal of EIA is to ensure that proposed projects and developments are environmentally sustainable and that their potential environmental impacts are effectively managed and minimized.

Major benefits of the EIA process are

- Cost-saving modifications in project design.
- Increased project acceptance.
- Avoided impacts and violations of laws and regulations.
- Improved project performance.
- Avoided treatment/clean up costs.

SUSTAINABLE HABITAT

A ***sustainable*** **habitat** is an ecosystem that produces food and shelter for people and other organisms, without resource depletion ie., no external waste is produced. A sustainable habitat involves several key principles, including:

1. **Energy efficiency:** Sustainable habitats are designed to be energy-efficient, minimizing the use of non-renewable energy sources and reducing greenhouse gas emissions.
2. **Water conservation**: Sustainable habitats conserve water through measures such as low-flow fixtures, rainwater harvesting, and water-efficient landscaping.
3. **Waste reduction**: Sustainable habitats reduce waste through measures such as recycling, composting, and the use of sustainable materials.
4. **Sustainable materials**: Sustainable habitats use environmentally friendly materials such as locally sourced, non-toxic, and recyclable materials.
5. **Social equity**: Sustainable habitats promote social equity by providing access to affordable housing, healthcare, education, and other basic needs.
6. **Biodiversity**: Sustainable habitats promote biodiversity by preserving natural habitats, providing green spaces, and encouraging the use of native plants.
7. **Green transportation**: Using green fuel like biodiesel

GREEN BUILDINGS

Green building is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction.

Impacts of the built environment:

Aspects of Built Environment:	**Consumption:**	**Environmental Effects:**	**Ultimate Effects :**
Siting Design Construction Operation Maintenance Renovation Deconstruction	Energy Water Materials Natural Resources	Waste Air pollution Water pollution Indoor pollution Heat islands Storm water runoff Noise	Harm to Human Health Environment Degradation Loss of Resources

Green buildings are designed to reduce the overall impact of the built environment on human health and the natural environment by:

- Efficiently using energy, water, and other resources
- Protecting occupant health and improving employee productivity
- Reducing waste, pollution and environmental degradation

Benefits:

- Protect and enhance the biodiversity and ecological system.
- Reduces the wastage of water and energy.
- Lower construction cost and higher property value.

- Improves occupants' health and overall productivity.
- Saves utility and other household bills by efficient use of water and energy.

Criteria for Green Building:

- Building s are encouraged to build on previously developed land rather than developing new land.
- Building site should be smaller because there is less environmental footprint.
- Consumption of water should be reduced by built-in design by using low-flow toilets, grey water systems.
- Buildings should be constructed using clean energy like geothermal, solar, wind energies.
- Building should be constructed by using natural materials and should reduce material usage.

Features of Green Building:

1. **Energy efficiency:** Green buildings are designed to be energy-efficient, reducing the amount of energy needed to heat, cool, and light the building. This can be achieved through the use of high-performance insulation, energy-efficient lighting and appliances, and renewable energy sources such as solar or wind power.
2. **Water conservation:** Green buildings are designed to conserve water, reducing the amount of water used for landscaping, washing, and other activities. This can be achieved through the use of low-flow fixtures, water-efficient landscaping, and rainwater harvesting.
3. **Sustainable materials:** Green buildings are constructed using sustainable, environmentally friendly materials such as recycled content, rapidly renewable materials, and locally sourced materials. This reduces the amount of waste generated during construction and reduces the building's impact on the environment.
4. **Indoor environmental quality:** Green buildings promote healthy indoor environments by using materials and products that are low in volatile organic compounds (VOCs) and by providing adequate ventilation and daylight. This can improve the health and well-being of occupants and increase their productivity.
5. **Site selection and planning:** Green buildings are located in areas that minimize the impact on the environment and promote sustainable transportation options, such as public transit, biking,

and walking. This can reduce the building's carbon footprint and improve the health of the surrounding community.

6. **Waste reduction:** Green buildings reduce waste through the use of recycling and composting programs, and through the design of buildings that are easy to deconstruct and recycle at the end of their useful life.
7. **Optimization of operation and maintenance:** Operation and maintenance of building should be performed by trained professionals, to reduce the environmental impact.

Thus any building can be a green building whether it is a home, an office, a school, a hospital, a community center provided it includes features listed above.

GREEN MATERIALS

Green materials are materials that are environmentally friendly and have a lower impact on the environment than traditional building materials. Due to the properties of non-toxic, organic and recycling, green materials (like wood, ceramics, clay, sand, stone) are widely used.

Criteria for green materials:

Following criteria can be used to identify the green materials

i. Local availability of materials
ii. % of recycled (or) waste materials used.
iii. Rapidly renewable materials
iv. Contribution in energy efficiency of building
v. Recyclability of materials
vi. Durability
vii. Environmental impact.

Characteristics of Green materials:

a. Green materials are energy efficient products
b. It lowers the energy cost and lessen pollution
c. Renewable and can be regenerated again and again
d. Green materials are recyclable or made from recycled material. So, they save energy and reduce waste.
e. Green materials are non-toxic
f. They are durable and no need to upgrade or repair
g. Green materials are cost effective
h. Materials can be locally sourced, so transport cost can be reduced.

Green materials example:

1. Stone: Living in a stone structure is low maintenance and eco-friendly, and any extra stone leftover from the build can be used for home finishing such as countertops or tile. Benefits of stone: **Low maintenance, Durable**

2. Cob: It is a mud mixture made of multiple natural ingredients such as soil, sand, straw and sometimes even lime. Benefits of cob: **Cheap & Energy-efficient:** Cob homes slow down the rate of heat transfer.

3. Bamboo: The strength and look of bamboo can help you achieve a distinctive style to make your home stand out. It's also one of the fastest-growing plants on the planet, so it's more sustainable than most! Benefits of bamboo: **Durable & Lightweight.**

4. Cork: It is one of the lightest solid substances, cork comes from cork oak trees, which are mainly harvested in Europe. This sustainable material has been used in construction in Europe for many years. Because 50 percent of cork cell volume consists of air. Benefits of cork**: Thermal insulation & Mold-resistant.**

5. Adobe brick: adobe bricks are made of clay and straw. Adobe insulation helps keep home temperatures consistent. Benefits of adobe brick: **Low sound transmission & Unique design.**

6. Straw bale: Straw-bale construction is a building method that uses bales of straw (commonly wheat, rice, rye and oats straw) as structural elements, building insulation, or both. This unique natural build is affordable and sustainable, but be wary of pests and potential allergens. Benefits of straw bale: **Easily renewable & Cheap.**

7. **Earth bags:** Also known as sandbags, this natural material is made of (mostly) earth that is then filled into bags and piled on top of each other in a method similar to bricklaying. Benefits of earth bags: Insulation and locally sourced.

ENERGY EFFICIENCY

Energy efficiency is the use of less energy to perform the same task (or) produce the same result. Energy efficient homes and buildings use less energy to heat, cool and run appliances and electronic equipments.

Here are some examples of energy-efficient measures that can be implemented in buildings:

1. **Lighting:** The use of energy-efficient lighting systems, such as LED bulbs, can significantly reduce the amount of electricity required to light a building. Additionally, lighting controls such as motion sensors and timers can help ensure that lights are only used when needed.
2. **Heating, ventilation, and air conditioning (HVAC) systems:** Energy-efficient HVAC systems, such as variable refrigerant flow systems or geothermal heat pumps, can reduce energy consumption while providing high levels of comfort. Properly insulating and sealing the building envelope can also help reduce the amount of energy required to heat or cool the building.
3. **Appliances and equipment:** Energy-efficient appliances and equipment, such as Energy Star certified products, use less energy than conventional products, without sacrificing performance.
4. **Building design:** Energy-efficient building design, such as orientation, shading, and the use of high-performance insulation and windows, can significantly reduce the amount of energy

required to operate a building. The use of passive solar design strategies can also help to reduce energy consumption.

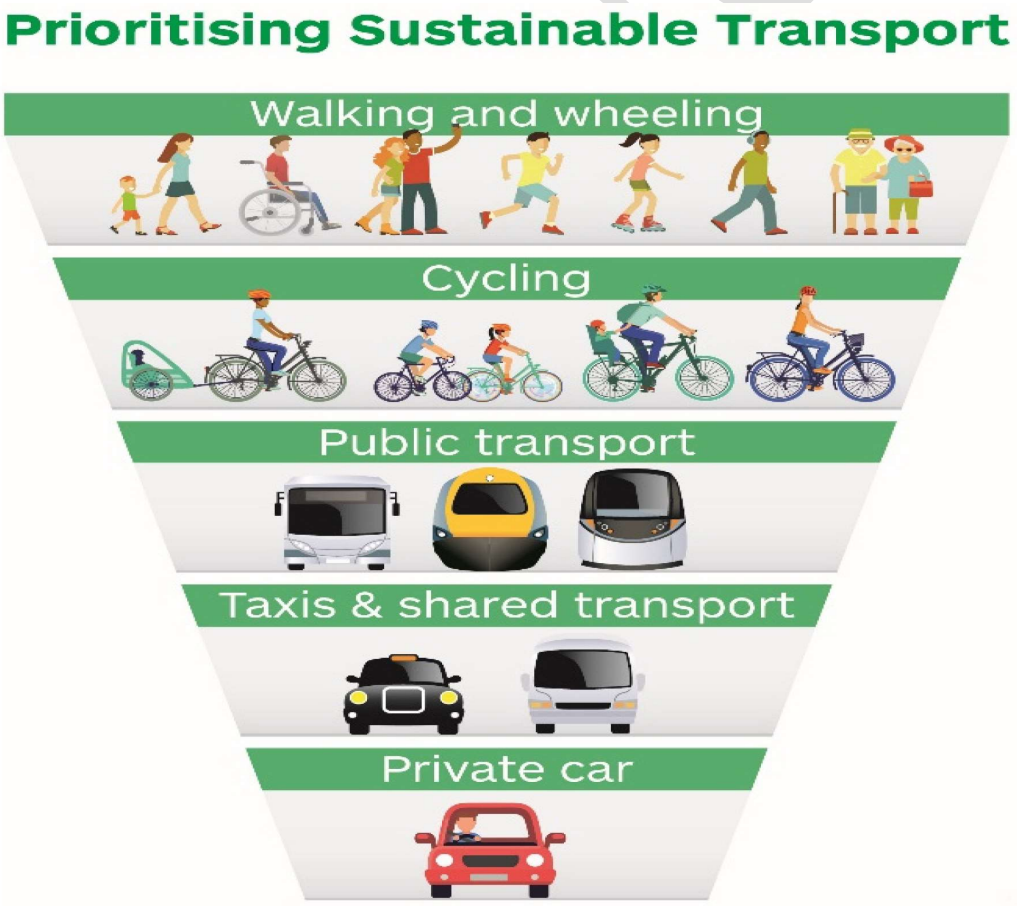
5. **Renewable energy:** The use of renewable energy, such as solar or wind power, can help buildings generate their own electricity and reduce their reliance on grid-supplied electricity.

Benefits of Energy efficiency:

- Energy efficiency is an effective way to save money.
- Increased energy efficiency can lower greenhouse gas.
- Provides long term benefits by lowering overall electricity demand.
- Increased property value: Energy-efficient buildings may have higher property values due to their reduced operating costs, improved comfort, and environmental benefits.
- Improved reputation: Energy-efficient buildings and systems can improve the reputation of the building or organization.

SUSTAINABLE TRANSPORTS

Sustainable transport refers to any means of transportation that is green and has low impact on the environment.



Some examples of sustainable transport:

1. **Active transport:** Walking and cycling are considered sustainable modes of transport, as they do not emit greenhouse gases and promote physical activity, which can have positive health benefits.
2. **Public transport:** Public transport, such as buses, trains, and subways, can be a sustainable alternative to private car use, as it can reduce the number of cars on the road and lower greenhouse gas emissions.
3. **Electric vehicles:** Electric vehicles (EVs) are becoming increasingly popular as a sustainable mode of transport, as they emit zero or very low levels of greenhouse gases. Additionally, the use of renewable energy sources to charge EVs can further reduce their carbon footprint.
4. **Carpooling and ridesharing:** Carpooling and ridesharing can reduce the number of cars on the road, and the associated greenhouse gas emissions and congestion.
5. **Efficient transportation systems:** Efficient transportation systems, such as intelligent transportation systems (ITS) and traffic management systems, can optimize the flow of traffic, reduce congestion, and lower greenhouse gas emissions.

Key elements of Sustainable transport:

A. **Fuel economy:** It is a measurement of fuel use. This measures how far a car can go using a set amount of fuel. It is achieved by Making engines more efficient & Vehicles lighter and bodies more aerodynamic.
B. **Electrification:** Most important pathway to low carbon transport
C. **Pedal power:** Cycles reduces the carbon emission.

Advantages of Sustainable transport:

1. It creates job
2. Provides safer transportation
3. Emits less pollution
4. Promotes health
5. It saves energy
6. Saves money
7. Decrease congestion
8. Conserves land

SUSTAINABLE ENERGY

Sustainable energy refers to forms of energy that are renewable and have a minimal impact on the environment. The most common sources of sustainable energy include solar, wind, hydro, geothermal, and biomass. These sources of energy are considered sustainable because they are constantly replenished and do not produce harmful emissions or pollutants that contribute to climate change.

One of the main benefits of sustainable energy is that it reduces our reliance on non-renewable energy sources like coal, oil, and natural gas, which are finite and contribute to greenhouse gas emissions. By using sustainable energy, we can reduce our carbon footprint and minimize our impact on the environment.

Some of the key technologies used to generate sustainable energy include solar panels, wind turbines, hydroelectric power plants, and geothermal systems. These technologies are becoming increasingly efficient and affordable, making them more accessible to individuals and businesses.

In addition to reducing our reliance on non-renewable energy sources, sustainable energy can also provide economic benefits. The growth of the sustainable energy industry has created new jobs and spurred innovation in areas like energy storage and grid management.

There are many benefits to using sustainable energy. Here are some of the key advantages:

1. **Reducing greenhouse gas emissions:** Sustainable energy sources do not produce greenhouse gas emissions, which are a major contributor to climate change. By using sustainable energy, we can significantly reduce our carbon footprint and mitigate the impacts of climate change.
2. **Cost-effective:** While the initial installation costs for some sustainable energy technologies may be higher than traditional energy sources, the long-term costs are often lower. For example, solar panels can provide a return on investment over time, and wind turbines can generate electricity at a lower cost than fossil fuels.
3. **Energy security:** Sustainable energy sources are often decentralized, meaning that they can be generated locally and reduce dependence on centralized energy systems. This can increase energy security and resilience, particularly in areas prone to natural disasters or political instability.
4. **Job creation:** The transition to sustainable energy is creating new jobs in areas like manufacturing, installation, and maintenance. This can provide economic benefits for local communities and contribute to the growth of the green economy.
5. **Health benefits:** Sustainable energy sources do not produce harmful emissions, which can lead to improved air quality and public health outcomes. This is particularly important in areas with high levels of pollution.

NON-CONVENTIONAL SOURCES

Non-conventional sources of energy, also known as renewable sources of energy, are sources of energy that are replenished naturally and can be used without being depleted. These sources of energy are often considered to be more sustainable than conventional sources of energy, such as fossil fuels. Here are some examples of non-conventional sources of energy:

1. **Solar Energy:** Solar energy is a type of non-conventional or renewable energy that is harnessed by capturing the energy of the sun and converting it into usable forms of electricity or heat. Solar energy is considered to be one of the most abundant and sustainable sources of energy available, and it is becoming increasingly popular for residential, commercial, and industrial use.

There are two primary ways that solar energy is used:

- *Solar photovoltaic (PV) systems:* Solar PV systems use solar panels to capture the energy of the sun and convert it into electricity. The panels are made up of solar cells, which are made from silicon and other materials. When sunlight hits the solar cells, it creates an electric current that can be used to power homes or businesses.
- *Solar thermal systems:* Solar thermal systems use the energy of the sun to heat water or other fluids. The heated fluid can then be used to provide hot water for homes or businesses, or it can be used to generate electricity through a steam turbine.

2. **Wind energy:** Moving air is called wind. Energy recovered from the force of the wind is called wind energy. Wind energy is generated by wind turbines, which convert the kinetic energy of the wind into electricity. Minimum speed required for satisfactory working of a wind generator is 15 km/hr.

   Wind mills: The windmill is an old method of energy conversion. The mechanical energy produced by the windmill is used in different applications like grinding The strike of blowing wind on the blades of the wind mill makes it rotating continuously.

Windmill

Versus

Wind Turbine

Wind turbine: Wind turbine converts the wind energy into electrical energy by driving a generator connected to it. The wind turbine is a renewable method of electricity generation. The wind turbine technology of electric power generation is one of the most reliable, clean and inexpensive technologies used for generation of large amount of electrical power.

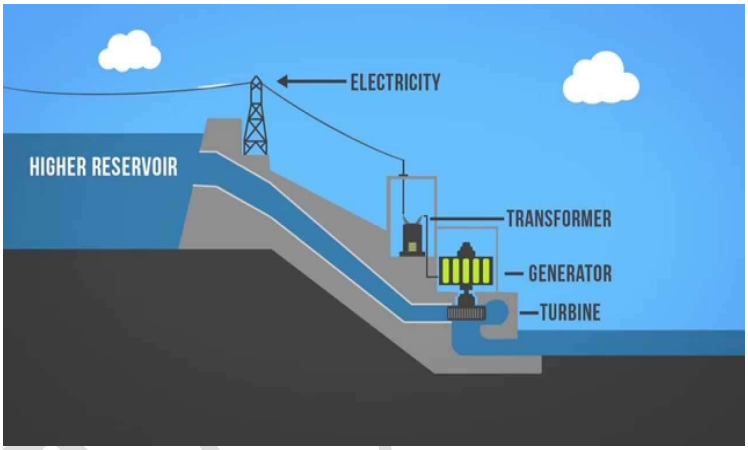
*A **wind farm*** is a *collection* of these wind turbines in a given location, used collectively for the generation of electricity.

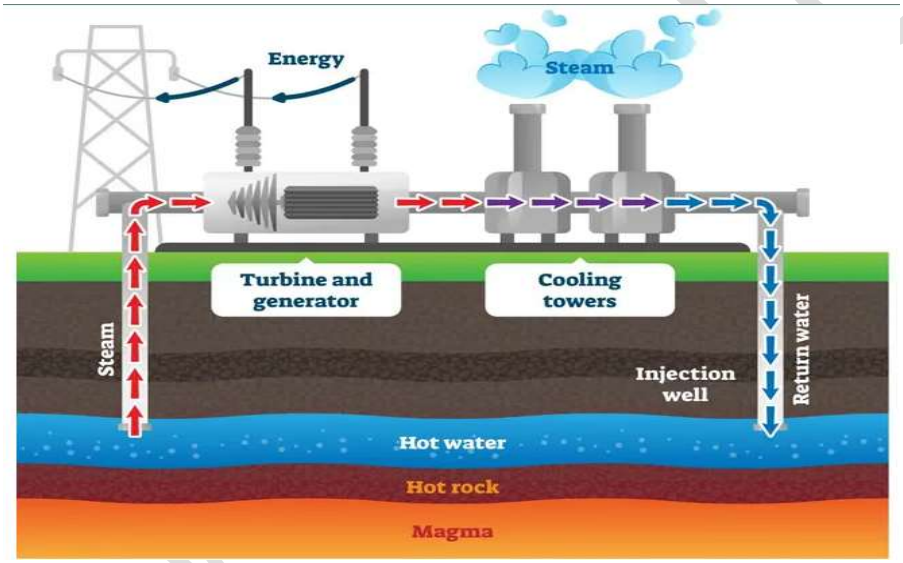
Advantages:

 Reduced electricity costs: Once a wind turbine is installed, it can generate electricity for many years with very little maintenance. This can help to reduce electricity costs over the long term.
 Reduced carbon footprint: Wind energy is a clean and renewable source of energy, meaning that it does not produce harmful emissions that contribute to climate change.
 Energy independence: By generating their own electricity through wind turbines, individuals and businesses can reduce their dependence on centralized energy systems.

3. **Hydroelectric energy:** Hydroelectric energy is generated through the use of turbines, which are driven by the force of moving water. The turbines are connected to generators, which produce electricity. Hydroelectric energy can be generated from a variety of sources, including:

- *Run-of-river hydroelectricity:* This type of hydroelectricity is generated by diverting a portion of a river's flow through a channel or penstock, which drives a turbine and generates electricity.
- *Dammed hydroelectricity:* This type of hydroelectricity is generated by building a dam on a river, which creates a reservoir of water. The water is then released through turbines, which generate electricity.





4. **Geothermal energy:** Geothermal energy is generated from the heat of the Earth's core. This energy source can be used to generate electricity or to heat buildings. Temperature of the earth increases at a rate of 25^0C per km when we move down from the earth surface. Geothermal resources are reservoirs of hot water that exist or are human made at varying temperatures and depths below the Earth's surface. Wells, ranging from a few feet to several miles deep, can be drilled into underground reservoirs to tap steam and very hot water that can be brought to the surface for use in a variety of applications, including electricity generation, direct use, and heating and cooling.

5. **Biomass energy:** Biomass energy is a type of renewable energy that is generated from organic materials, such as plants and trees, agricultural and forestry residues, and animal waste. Biomass energy can be used for heating and electricity production. There are several ways to convert biomass into energy. One common method is through combustion, where the biomass is

burned to produce steam that drives a turbine to generate electricity. Another method is through gasification, where the biomass is converted into a gas that can be burned to generate electricity or used as a fuel for vehicles.

Biomass energy is considered renewable because the organic materials used to produce it can be replenished over time. It also has the potential to reduce greenhouse gas emissions when compared to traditional fossil fuels, as the carbon dioxide released during the combustion of biomass is balanced by the carbon dioxide absorbed by the plants during their growth.

ENERGY CYCLE

The term "energy cycle" can refer to different types of cycles that involve the production, transformation, and consumption of energy. Here are some examples:

1. *Carbon cycle:* The carbon cycle is an energy cycle that involves the movement of carbon through the Earth's atmosphere, oceans, and ecosystems. Carbon is released into the atmosphere through the burning of fossil fuels and other human activities, and is absorbed by plants through photosynthesis. The carbon is then passed on through the food chain as organisms consume other organisms, and eventually returns to the atmosphere through respiration, decomposition, and other natural processes.

2. *Water cycle:* The water cycle is another energy cycle that involves the movement of water between the Earth's surface, atmosphere, and underground reservoirs. Energy from the sun drives the evaporation of water from the surface of the Earth, which forms clouds that eventually release precipitation back to the surface. This precipitation is then used by plants and animals, and eventually returns to the atmosphere through evaporation and transpiration.

CARBON CYCLE:

The carbon cycle is the process through which carbon moves and circulates between the Earth's atmosphere, land, oceans, and living organisms.

It involves a series of interconnected processes, including carbon dioxide (CO2) absorption, release, and transformation. The carbon cycle plays a crucial role in regulating the Earth's climate and is vital for sustaining life on our planet.

Sources of CO_2 in atmosphere:

1. During respiration plants (during night), humans and animals liberates CO_2 in the atmosphere.
2. Combustion of fuels
3. Volcanic eruptions

Key processes in the carbon cycle include:

1. **Carbon Dioxide Uptake by Photosynthesis:** Plants, algae, and some bacteria capture carbon dioxide from the atmosphere through the process of photosynthesis. They convert carbon dioxide and sunlight into organic compounds, releasing oxygen as a byproduct.
2. **Carbon Release through Respiration:** Plants, animals, and microorganisms respire, releasing carbon dioxide back into the atmosphere as a byproduct of cellular respiration. This is the opposite process of photosynthesis.
3. **Decomposition:** When plants and animals die, their organic matter decomposes. During decomposition, bacteria and fungi break down the organic material and release carbon dioxide into the atmosphere.
4. **Fossil Fuel Combustion:** Some of the **carbon that is not released back into the atmosphere become fossil fuels.** Burning fossil fuels (coal, oil, and natural gas) for energy releases stored carbon dioxide into the atmosphere. This process significantly contributes to the increase in atmospheric carbon dioxide concentrations and is a primary driver of climate change.
5. **Carbon Sequestration:** Carbon sequestration refers to the process of capturing and storing carbon dioxide from the atmosphere. It occurs naturally through the absorption of carbon dioxide by plants and the ocean. Additionally, certain human activities, such as reforestation, afforestation, and carbon capture and storage (CCS) technologies, aim to enhance carbon sequestration and reduce atmospheric carbon dioxide levels.
6. **Carbon Exchange between the Atmosphere and Oceans:** The oceans act as a significant reservoir for carbon. Carbon dioxide dissolves in seawater, and marine organisms like phytoplankton absorb carbon dioxide through photosynthesis. The exchange of carbon dioxide between the atmosphere and oceans helps regulate atmospheric carbon dioxide levels.
7. **Geological Processes:** Over long periods, carbon can be stored in rocks and sediment through geological processes like weathering and erosion. Carbon may also be stored in the form of fossil fuels, such as coal, oil, and natural gas.

The carbon cycle is a dynamic process, with carbon continuously moving between different reservoirs. The balance between carbon uptake and release processes determines the concentration of carbon dioxide in the atmosphere. Human activities, such as the burning of fossil fuels and deforestation, have significantly perturbed the natural carbon cycle, leading to an increase in atmospheric carbon dioxide concentrations and contributing to climate change.

Understanding and managing the carbon cycle is essential for addressing climate change and developing strategies to mitigate and adapt to its impacts. Efforts to reduce carbon emissions, promote carbon sequestration, and transition to renewable energy sources are crucial for maintaining a stable and sustainable carbon cycle.

CARBON EMISSION and SEQUESTRATION

Carbon emission and sequestration are two processes that are closely related to the carbon cycle and have significant impacts on the Earth's climate.

Carbon emissions refer to the release of carbon dioxide (CO2) and other greenhouse gases into the atmosphere. This occurs through natural processes, such as respiration and volcanic activity, as well as through human activities, such as the burning of fossil fuels and deforestation. Carbon emissions are a major contributor to climate change, as they trap heat in the Earth's atmosphere and cause temperatures to rise.

Carbon sequestration (or **carbon storage**) is the process of storing carbon (in particular atmospheric carbon dioxide) in a carbon pool. Carbon sequestration is a naturally occurring process but it can also be enhanced or achieved with technology, for example within carbon capture and storage projects.

There are several natural and artificial methods for carbon sequestration:

1. **Afforestation and reforestation:** Planting trees and preserving forests can help to increase carbon storage.
2. **Agricultural practices:** Certain agricultural practices, such as no-till farming, cover cropping, and crop rotation, can help to increase carbon storage in soil.
3. **Ocean sequestration:** The ocean absorbs and stores large amounts of carbon dioxide from the atmosphere, but this can have negative impacts on marine ecosystems.
4. **Bioenergy with carbon capture and storage (BECCS):** This involves growing biomass, such as trees or grasses, and using it to generate energy. The carbon dioxide produced during energy generation is captured and stored underground.
5. **Direct air capture:** This involves using technology to directly capture carbon dioxide from the atmosphere and store it underground.

Advantages of carbon sequestration:

1. **Mitigating climate change:** Carbon sequestration can help to reduce the overall concentration of greenhouse gases in the atmosphere, which can help to mitigate the impacts of climate change.
2. **Enhancing ecosystem services:** Certain carbon sequestration practices, such as reforestation, can enhance ecosystem services, such as biodiversity, water quality, and soil fertility.
3. **Potential economic benefits:** Carbon sequestration technologies, such as carbon capture and storage, could potentially create new industries and jobs in carbon management and storage.

Disadvantages of carbon sequestration:

1. **High cost:** Carbon sequestration technologies can be expensive, particularly when compared to other methods for reducing carbon emissions.
2. **Limited potential:** Carbon sequestration may not be able to fully address the problem of climate change

3. **Environmental impacts:** Carbon sequestration technologies, particularly those that involve underground storage, can have potential environmental impacts, such as leakage of stored carbon dioxide and disruption of local ecosystems.
4. **Technological challenges:** Carbon sequestration technologies are still in the early stages of development, and there are significant technological challenges that must be overcome before they can be widely deployed.

In summary, **carbon sequestration** has the potential to be an important tool for mitigating climate change, but it is important to carefully consider its advantages and disadvantages when evaluating its potential as a solution to this global challenge.

GREEN ENGINEERING

Green engineering is an approach to engineering that **focuses on designing and implementing technologies, systems, and processes that minimize negative environmental impacts** and promote sustainable development. **It aims to integrate environmental considerations into all stages of the engineering lifecycle**, from design and construction to operation and decommissioning.

Principles and Practices of Green Engineering:

1. **Environmental Protection:** Green engineering prioritizes the protection and preservation of the environment. It seeks to minimize pollution, reduce resource consumption, and prevent or minimize waste generation.
2. **Life Cycle Assessment (LCA):** Green engineering employs life cycle thinking, which involves assessing the environmental impacts of a product or process throughout its entire life cycle, from raw material extraction to disposal. This helps identify opportunities for improvement and sustainable alternatives.
3. **Renewable Energy and Energy Efficiency:** Green engineering promotes the use of renewable energy sources such as solar, wind, and hydropower. It also emphasizes energy efficiency measures to reduce energy consumption and minimize greenhouse gas emissions.
4. **Material Efficiency and Recycling:** Green engineering focuses on optimizing material use and promoting recycling and reuse. This includes designing products and systems that use fewer materials, selecting environmentally friendly materials, and incorporating recycling considerations into design and manufacturing processes.
5. **Pollution Prevention:** Green engineering aims to prevent pollution at the source rather than treating or managing it after it is generated. It involves implementing cleaner production techniques, using environmentally friendly materials, and adopting pollution control technologies and practices.
6. **Sustainable Water Management:** Green engineering considers the sustainable management of water resources. It includes water conservation measures, efficient water use in industrial processes, and the design of wastewater treatment systems to minimize water pollution.

7. **Green Building and Infrastructure:** Green engineering emphasizes the design and construction of sustainable buildings and infrastructure. It involves incorporating energy-efficient systems, using environmentally friendly materials, optimizing site selection, and implementing green building certifications and standards.
8. **Stakeholder Engagement and Collaboration:** Green engineering recognizes the importance of stakeholder engagement and collaboration. It involves consulting with communities, policymakers, and other stakeholders to ensure that engineering projects and solutions align with their needs and aspirations.

SUSTAINABLE URBANAIZATION

Sustainable urbanization refers to the process of designing, developing, and managing cities in a way that meets the needs of the present generation without compromising the ability of future generations to meet their own needs.

It involves creating livable, inclusive, resilient, and environmentally friendly cities that promote social, economic, and environmental well-being.

Here are key aspects and principles of sustainable urbanization:

1. **Compact and Efficient Cities:** Sustainable cities prioritize compact and efficient urban forms that minimize sprawl and promote walkability, public transportation, and mixed land-use development. This reduces the need for long commutes, conserves resources, and minimizes pollution.
2. **Resource Efficiency:** Sustainable urbanization focuses on resource efficiency, including efficient use of energy, water, and materials. It involves implementing green building practices, promoting renewable energy, adopting energy-efficient transportation systems, and encouraging water conservation measures.
3. **Social Inclusion and Equity:** Sustainable cities aim to be socially inclusive, ensuring that all residents have access to affordable housing, healthcare, education, and essential services. They promote equal opportunities, reduce inequalities, and create inclusive spaces for diverse communities.
4. **Green Spaces and Biodiversity:** Sustainable urbanization prioritizes the preservation and creation of green spaces, parks, and urban forests. These areas provide recreational spaces, enhance biodiversity, improve air quality, and mitigate the urban heat island effect.
5. **Sustainable Transportation:** Sustainable cities prioritize sustainable transportation systems, including public transit, cycling infrastructure, and pedestrian-friendly streets. This reduces reliance on private vehicles, decreases traffic congestion, and improves air quality.
6. **Climate Resilience:** Sustainable urbanization involves planning and designing cities to be resilient to climate change impacts. This includes measures such as flood management, storm water management, green infrastructure, and climate-responsive building design.
7. **Integrated Planning and Governance:** Sustainable cities adopt integrated planning approaches that consider social, economic, and environmental factors. They involve multi-

stakeholder engagement, participatory decision-making processes, and effective governance mechanisms to ensure holistic and sustainable urban development.

8. **Circular Economy:** Sustainable urbanization promotes a circular economy approach, aiming to minimize waste generation, promote recycling and reuse, and foster sustainable consumption and production patterns. It involves implementing waste management systems, promoting circular business models, and encouraging sustainable lifestyles.