Environment and Ecosystem

Lecture 1 comprises of the following

i. Environment Definition
ii. Earth-life support system.
iii. Ecosystem definition, the various components and types of ecosystem.

1.The Environment :

The word Environment originated from the French word **Environner (encircle or Surroundings**).

1.1: The Definition of Environment, as per Environment (Protection) Act, 1986

The sum of water, air, and land and the inter-relationships that exist among them and with the human beings, other living organisms and materials

From this **word etymology** we understand that environment means all that **surrounds** us.

So simply putting it together,

ENVIRONMENT is defined as the social, cultural and physical conditions that surround, affect and influence the survival, the growth, and the development of people, animals or plants.
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2. Understanding the Terminologies

2.1 Environmental Science:-

Environmental science is the study of the environment, its biotic & abiotic component's & their relationship.

Wikipedia defines Environmental Sciences: as an interdisciplinary academic field that integrates Physics, Biology and Geography to the study of the environment, and the solution of environmental problems.

In simple words: **Environmental science** is an interdisciplinary study of how humans interact with the living and non-living parts of their environment.

2.2 Environmental Engineering:-

Environmental Engineering is the application of engineering principles to the protection & enhancement of the quality of the environment and to the enhancement and protection of public health & welfare.

2.3 Environmental Studies (or) Environmental education:-

Environmental studies is the process of educating the people for preserving the quality of the environment.

- **Scope *and Importance of* Environmental *Science***

3.1 Scope of Environmental Science:

1) To be aware and sensitive to the total environment & its related problems.

2) To motivate active participation in environmental protection & improvement.

3) To develop skills to identify & solve environmental related problems.

4) To know the necessity of conservation of natural resources.

5) To evaluate environmental programmes in terms of social, economic, ecological & aesthetic factors.

6) To promote the value & necessity of local, national & international co-operation in the prevention and solution for environmental problems.

7) To give a clear picture about the current potential of resources & environmental situations.

8) Environmental studies gives us an idea and understanding of the interdependent connection of nature and people.

3.2 Importance of Environmental Sciences

1) It has a direct relation to the quality of life we live.

2) People understand the need of development without destruction of the environment.

3).People gain knowledge of different types of environment & effects of different environmental hazards.

4) People are informed about their effective role in protecting the environment by demanding changes in laws and enforcement systems.

5) It develops a concern & respect for the environment.

- **Earth life support systems**

The earth system is itself an integrated system, but it can be sub-divided into four main components, sub-systems or spheres: the **geosphere, atmosphere, hydrosphere and biosphere**. These components are also systems in their own ways and they are tightly interconnected. Life is sustained by the flow of energy from the sun through the biosphere, the cycling of nutrients within the biosphere and gravity

The main components (called **spheres**) of the environment are:

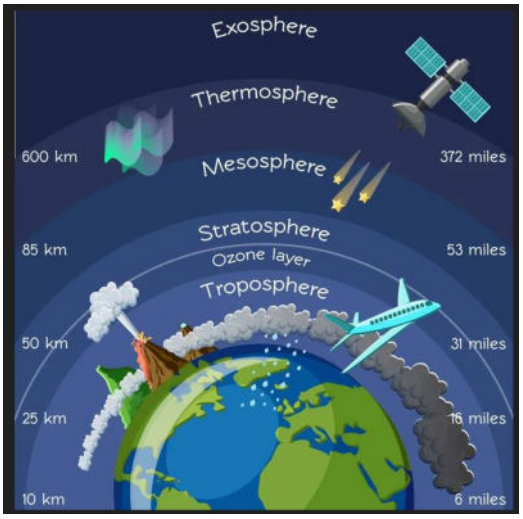
i. Atmosphere: The blanket of air that surrounds us.
ii. Hydrosphere: The various water bodies on the earth for eg the oceans, the rivers, lakes and ponds.
iii. Lithosphere talks of the various types of soil and rocks on the earth's surface.
iv. Biosphere: It contains all living organisms, their interactions with the environment and all that is capable of supporting life.

4.1.Atmosphere:

The blanket of air upto 1500 km surrounding the earth is known as atmosphere

4.1.1 Layers of the Atmosphere

Based on the distribution of temperature with height, our atmosphere is said to have the following layers.



4.1.2 Importance of the Atmosphere:

(i) Oxygen is very important for the living beings.
(ii) Carbon dioxide is very useful for the plants.
(iii) Dust particles present in the atmosphere create suitable conditions for the precipitation
(iv) The amount of water vapour in the atmosphere goes on changing and directly affects the plants and living beings. (v) Ozone protects all kinds of life on the earth from the harmful ultra violet rays of the sun.

4.2 Hydrosphere:is the discontinuous layer of water at or near the Earth's surface. It includes all liquid and frozen surface waters, and groundwater held in the soil

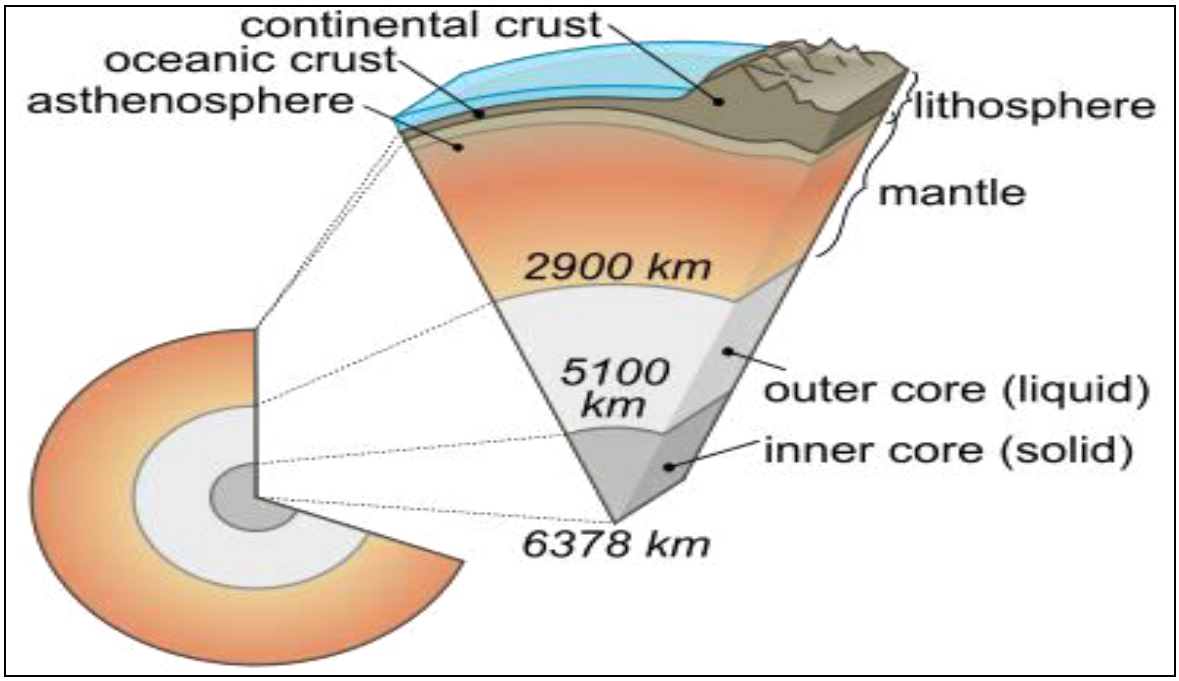
The existence of hydrosphere depends on an important phenomenon called the water cycle or the hydrological cycle.

4.2.1 Importance of the hydrosphere

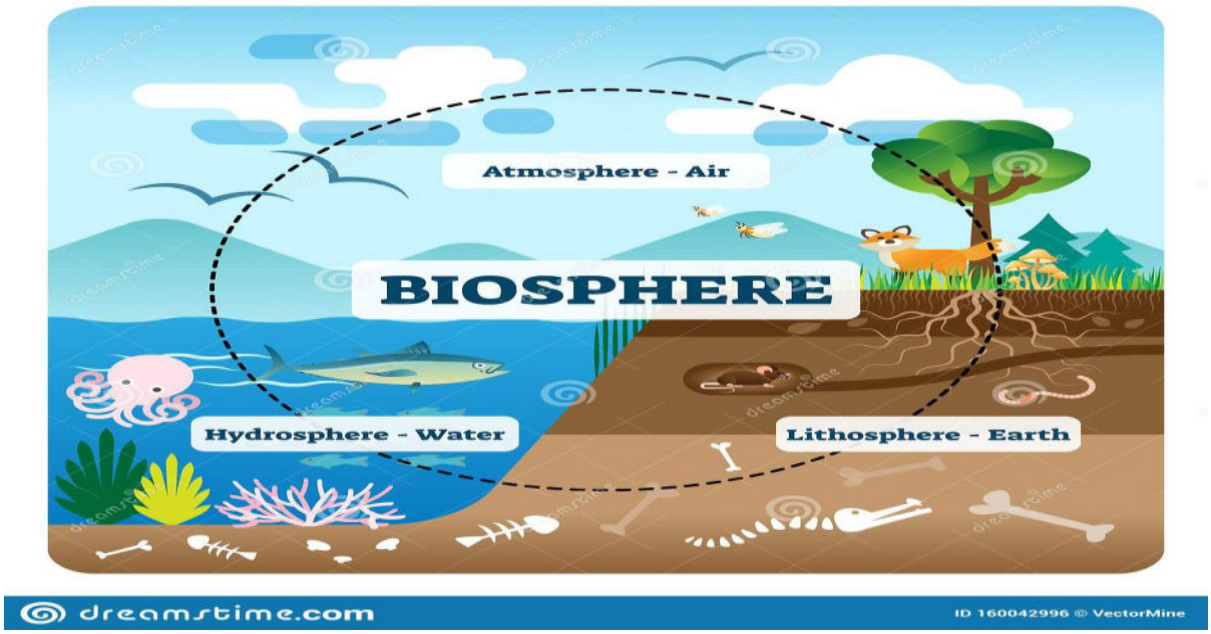
(i) One of the Basic Needs of Human
(ii) Part of a Living Cell
(iii) Habitat for Many Organisms
(iv) Regulates Temperature
(v) Atmosphere Existence

4.3Lithosphere: is the solid rock that covers the planet. This includes the crust, as well as the uppermost part of the mantle, which is the solid rock. The significance of the lithosphere is the activity of the tectonic plates.

The lithosphere



4.4The biosphere: is the zone where the lithosphere, the hydrosphere and the atmosphere interact with each other. This narrow sphere of the Earth supports life due to the presence of land, water and air. Therefore, the biosphere is important for living organisms as it supports life.



Source courtesy: dreamstime.com

These four components are main earth-life support system and constitute to make our earth A Living planet.

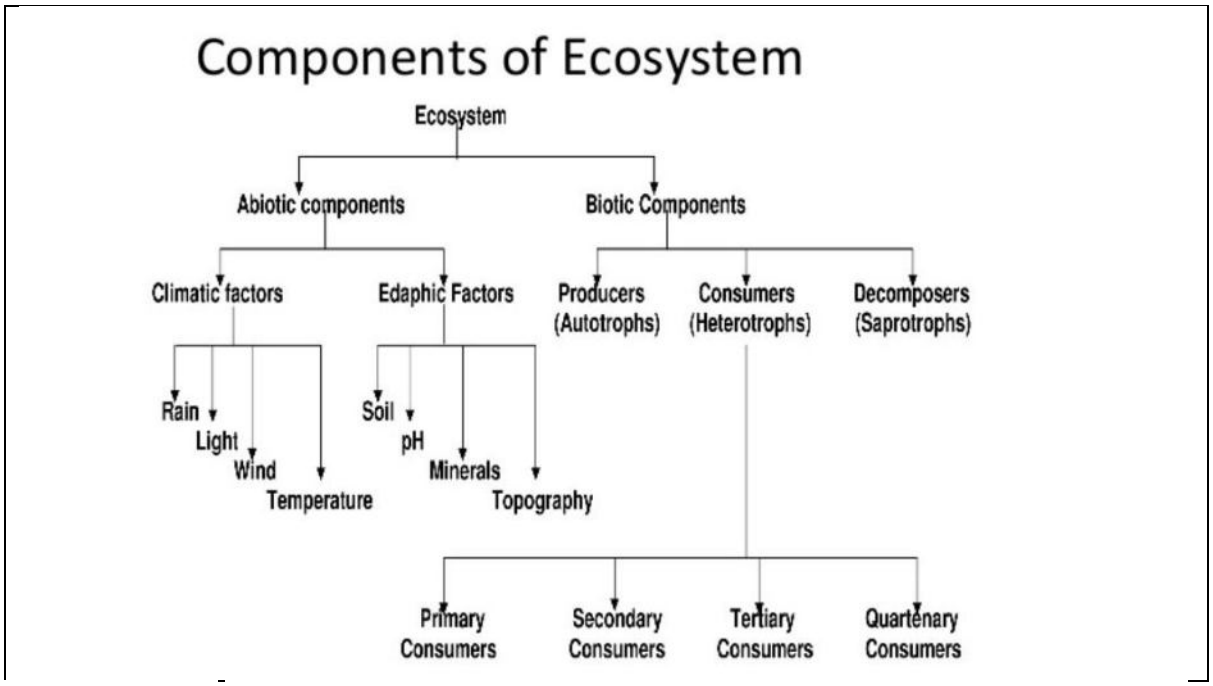
5. ECOSYSTEM

The term Ecosystem was first coined by **AG Tansley** in 1935. It is made up of 2 words: Eco meaning environment and system means a complex coordinated unit.

An **ecosystem** is defined as a natural unit that consists of the biotic components (living) and the non-living parts which interact with each other , probably allow exchange of materials to form a stable system. Eg. Pond ecosystem

Ecosystem is the basic functional unit of the organisms.

5.1 Structure and composition of an ecosystem:



Source courtesy: https://www.jagranjosh.com/general-knowledge/components-of-ecosystem

5.1.1 Ecosystems: Fundamental Characteristics

•**Structure**:

| | Living (biotic)

| | Nonliving (abiotic)

•**Process:**

| | Energy flow

| | Cycling of matter (chemicals)

• **Change**:

| | Dynamic (not static)

| | Succession, etc.

5.1.2 Components of an ecosystem ●

Ecosystem=biotic components + abiotic components

Abiotic Components: constitute the following

♦ Climatic factors: light, temperature, precipitation, wind, humidity ♦ Edaphic(soil) factors: soil pH, soil moisture, soil nutrients ♦ Topographic factors: aspect, altitude

Biotic Components: constitute the following
♦ Producers: green plants, algae
♦ Consumers: herbivores, carnivores, omnivores
♦ Decomposers: bacteria, fungi
Any ecosystem is made up of

Biotic Structure

- •**Producers(Autotrophs)** – Green plants which can synthesize their food themselves (Plants), chemoautotrophs

- .**Autotrophs** :• A groups of organisms that can use the energy in sunlight to convert water and carbon dioxide into Glucose (food) Autotrophs are also called Producers because they produce all of the food that heterotrophs use Without autotrophs, there would be no life on this planet **Examples**: Plants and Algae. **Photoautotrophs**(photosynthesis) **Chemoautotrophs**(chemical energy) Chemoautotrophs – Autotrophs that get their energy from inorganic substances, such as salt – Live deep down in the ocean where there is no sunlight – **Examples**: Bacteria and Deep Sea Worms

- **Consumers** – All organisms which get their organic food by feeding upon other organisms (Rabbit, man) **Heterotrophs** • Organisms that do not make their own food • Another term for heterotroph is consumer because they consume other organisms in order to live • Example: Rabbits, Deer, Mushrooms

- **Decomposers** – They derive their nutrition by breaking down the complex organic molecule to simpler organic compound (earthworms, ants).

5.2 Functions of an ecosystem:

- It regulates flow rates of biological energy.
- It regulates flow rates of nutrients, by controlling the production and comsumption of minerals and materials.
- It helps in biological regulation like nitrogen-fixing organism.

6.Types of Ecosystem

A natural ecosystem is a setup of animals and plants which functions as a unit and is capable of maintaining its identity. A natural ecosystem is totally dependent on solar energy. There are two main categories of ecosystems. They are:

6.1Terrestrial ecosystem – Ecosystems found on land e.g. forest, grasslands, deserts, tundra.

6.2 Aquatic ecosystem – Plants and animal communities that are found in water bodies. These can be further classified into two subgroups.

- Freshwater ecosystems, such as rivers, lakes and ponds.
- Marine ecosystems, such as oceans, estuaries.

All Ecosystems are either land-based (terrestrial) or water-based (aquatic)

6.1.1 FOREST ECOSYSTEM:

In the Indian continent, forests can be classified as coniferous and broadleaved forests. The type of the forests will depend upon abiotic factors such as soil, sunlight and soil nature in a particular region.

Depending upon the tree species: evergreen, deciduous, xerophytic and mangroves, forests classification can be attempted.

The structure and components of the forest ecosystem:

A. **Biotic Components**: The living components in a forest ecosystem are in the following order:

Producers: Different types of trees, shrubs and ground vegetation are the producers. Based on the climatic conditions, they are classified as: tropical, subtropical, temperate and alpine forests.

Consumers:

Primary: Herbivores such as ants, flies, spiders, dogs, beetles, elephants, deer, mongooses.

Secondary: Snakes, birds, foxes

Tertiary: Owl, peacock, lion, tiger.

Decomposers: Fungi and bacteria, essential to nature as they decompose the dead organisms of and release the essential nutrients for reuse.

B. **Abiotic components**: Soil, air, sunlight, inorganic and organic components and decaying organic matter.

6.1.2 GRASSLAND ECOSYSTEM

Grasslands are areas dominated by grasses. They occupy about 20% of the land on the earth surface. Grasslands occur in both in tropical and temperate regions where rainfall is not enough to support the growth of trees. The low rainfall prevents the growth of numerous trees and shrubs but is sufficient to support the growth of grass cover during the monsoon

Grasslands are found in areas having well-defined hot and dry, warm and rainy seasons.

Grasslands are one of the intermediate stages in ecological succession and cover a part of the land on all the altitudes and latitudes at which climatic and soil conditions (soil depth and quality) do not allow the growth of trees. The types of plants that grow here greatly depend on what the climate and soil are like.

Different Names of Grasslands

Grasslands are known by various names in different parts of the world.

The common ones are:

The Prairies of North America, The Steppes of Eurasia, The Savannas of Africa, The Pampas of South America,The Savanna of India and The Downs of Australia.

Tropical grasslands are commonly called Savannas. They occur in eastern Africa, South America, Australia and India. Savannas form a complex ecosystem with scattered medium-size trees in grasslands.

The structure and components of the grassland ecosystem:

Biotic Components

- **Producers** – In grassland, producers are mainly grasses; though, a few herbs & shrubs also contribute to the primary production of biomass.
- **Consumers** – In a grassland, consumers are of three main types:
    - **Primary Consumers** – The primary consumers are herbivores feeding directly on grasses. Herbivores such as grazing mammals (e.g., cows, sheep, deer, rabbit, buffaloes, etc), insects (e.g., Dysdercus, Coccinella), some termites and millipedes are the primary consumers.
    - **Secondary Consumers** – These are carnivores that feed on primary consumers (Herbivores). The animals like foxes, jackals, snakes, frogs, lizards, birds etc., are the carnivores feeding on the herbivores. These are the secondary consumers of the grassland ecosystem.
    - **Tertiary Consumers** – These include hawks etc. which feed on secondary consumers.
- **Decomposers** – These include bacteria of death and decay, moulds and fungi (e.g., Mucor, Penicillium, Aspergillus, Rhizopus, etc). These bring the minerals back to the soil to be available to the producers again.

Abiotic Components

- These include the nutrients present in the soil and the aerial environment.
- The elements required by plants are hydrogen, oxygen, nitrogen, phosphorus and sulphur.
- These are supplied by the soil and air in the form of CO2, water, nitrates, phosphates and sulphates.
- In addition to these, some trace elements are also present in the soil.

Flora and Fauna of Grassland Ecosystem

- Grasses are the dominating plants, with scattered drought resistant thorny trees in the tropical grasslands.
- Badgers, fox, ass, zebra, antelope are found grazing on grasslands that support the dairy and leather industries.
- Grasslands also support the large population of rodents, reptiles and insects.

Functions of Grassland Ecosystem

- Energy flow through the food chain
- Nutrient cycling (biogeochemical cycles)
- Ecological succession or ecosystem development
- Homeostasis (or cybernetic) or feedback control mechanisms
- To increase the fertility of the soil and to regulate the productivity of the ecosystem.
- To reduce the leaching of minerals due to low rainfall.

Economic Importance of Grasslands

- Grasslands are the grazing areas of many rural communities.
- Farmers who keep cattle or goats, as well as shepherds who keep sheep, are highly dependent on grasslands.
- Domestic animals are grazed in the 'common' land of the village.
- Fodder is collected and stored to feed cattle when there is no grass left for them to graze in summer.
- The grass is also used to thatch houses and farm sheds.
- The thorny bushes and branches of the few trees that are seen in grasslands are used as a major source of fuelwood.
- Overgrazing by huge herds of domestic livestock has degraded many grasslands.
- Grasslands have diverse species of insects that pollinate crops.
- There are also predators of these insects such as small mammals like shrews, reptiles like lizards, birds of prey, and amphibia such as frogs and toads.
- All these carnivorous animals help to control insect pests in adjoining agricultural lands.

Classification of Grasslands

As climate plays an important role in the formation of grasslands, it is generally used as a basis to divide the world's grasslands into two broad categories: those that occur in the **temperate region** and those that occur in the **tropical regions.**

Tropical Grasslands

- These occur on either side of the equator and extend to the tropics.
- This vegetation grows in areas of moderate to a low amount of rainfall.
- The grass can grow very tall, about 3 to 4 metres in height.

- Savannah grasslands of Africa are of this type.
- Elephants, zebras, giraffes, deer, leopards are common in tropical grasslands

Temperate Grasslands

- These are found in the mid latitudinal zones and in the interior part of the continents.
- Usually, the grass here is short and nutritious.
- Wild buffaloes, bison, antelopes are common in the temperate region.

Grasslands in India

- In India, grasslands are found as village grazing grounds (Gauchar) and extensive low pastures of dry regions of the western part of the country and also in Alpine Himalayas.
- Perennial grasses are the dominant plant community.
- In the Himalayan mountains, there are high, cold Himalayan pastures.
- There are tracts of tall elephant grass in the low-lying **Terai belt** south of the Himalayan foothills.
- There are semi-arid grasslands in Western India, parts of Central India, and the Deccan Plateau.
- Grasslands support numerous herbivores, from minute insects to very large mammals.
- Rats, mice, rodents, deer, elephants, dogs, buffalo, tigers, lions, ferrets are some common mammals of grasslands.
- In northeast India, the one-horned rhinoceros is amongst the threatened animal of grassland in this region.

6.1.3 Desert Ecosystems: are found in regions where the annual rainfall is in the range of 250 to 500 mm and the rate of evaporation is very high. Occupy about 30% of the land area. They are characterized by extremely hot days and cold nights. The desert soils have very little organic matter and are rich in minerals. The desert plants have adapted to the dry conditions by having few or no leaves.

The structure and components of the desert ecosystem:

Biotic components:Producers: include xerophytic plants like cacti, shrubs, bushes, grasses, few trees, mosses and lichens.

Consumers: Primary Birds, camel, mouse.

Secondary: Lizards, snakes, birds.

Tertiary: Jungle cats, jackals, panthers

Decomposers: Some fungi and bacteria.

Functions of desert ecosystem

The dry condition of deserts helps **promote the formation and concentration of important minerals**. Gypsum, borates, nitrates, potassium and other salts build up in deserts when water carrying these minerals evaporates. Minimal vegetation has also made it easier to extract important minerals from desert regions.

6.2 Aquatic Ecosystems

Aquatic ecosystem is a water-based habitat. Many organisms rely on water for their livelihood and other life functions.

- The aquatic ecosystem is the basic functional unit facilitating the sustenance of aquatic organisms.
- The unique physicochemical features of this ecosystem allow the material transfer, carrying out significant chemical reactions, and other key functions needed for the survival of the life forms.
- Nekton, plankton, and benthos are some of the most prevalent aquatic creatures.
- Lakes, oceans, ponds, rivers, swamps, coral reefs, wetlands, and popular examples of freshwater aquatic ecosystems.
- While marine habitats include oceans, intertidal zones, reefs, and the seabed.

Types of Aquatic Ecosystems:

6.2.1 Freshwater ecosystems only cover about 1 percent of the earth's surface.

- Lakes, ponds, rivers and streams, marshes, swamps, bogs, and ephemeral pools are all . examples of freshwater.

- Freshwater ecosystems are divided into three types: lotic, lentic, wetlands, and swamps.

Lentic habitats are bodies of standing water such as lakes, ponds, pools, bogs, and other reservoirs. Flowing water bodies such as rivers and streams are represented by **lotic** ecosystems.

Lotic: Lotic ecosystems primarily refer to unidirectional, quickly flowing waterways such as rivers and streams.

- Several insect species, such as beetles, mayflies and stoneflies, as well as several fish species, such as trout, eel, and minnow, live in these settings.
- These ecosystems also include mammals such as beavers, river dolphins, and otters, in addition to aquatic species.

Lentic ecosystems:encompass all ecosystems with standing water.

- The principal examples of the Lentic Ecosystem are lakes and ponds.
- The term lentic is used to describe water that is stationary or relatively still.
- Algae, crabs, shrimps, amphibians like frogs and salamanders, rooted and floating-leaved plants and reptiles like alligators and other water snakes can all be found in these

6.22Marine Ecosystem: The marine environment covers the majority of the earth's surface area.

- Oceans, seas, the intertidal zone, reefs, the seabed, estuaries, hydrothermal vents, and rock pools make up two-thirds of the earth's surface.
- Aquatic animals cannot exist outside of water.
- Salt concentrations are higher in the marine habitat, making it difficult for freshwater creatures to survive.
- In addition, marine species are unable to survive in freshwater.
- Their bodies are designed to survive in salt water and will swell if placed in less salty water due to osmosis..
- They can be further classified as ocean ecosystems, estuaries, coral reefs, and coastal ecosystems.

6.2.3 Ocean Ecosystems:

- The Pacific, Indian, Arctic, and Atlantic Oceans are the five primary oceans on earth.
- The Pacific and Atlantic Oceans are the largest and deepest of these five oceans.
- More than five lakh aquatic species call these oceans home.
- Shellfish, sharks, tube worms, crabs, turtles, crustaceans, blue whales, reptiles, marine mammals, seagulls, plankton, corals, and other ocean plants are just a few of the organisms that live in these environments.
- **6. 2.4 Estuaries Ecosystems**
- Estuaries are critical forms of natural habitats which are typically formed where the sea and the rivers meet.
- The transition from land to sea happens in this region.

- As a result, the water here is more saline in comparison to freshwater ecosystems but more dilute than the marine ecosystems.
- Estuaries have more economic importance as they are capable of trapping plant nutrients and generating quality organic matter in comparison to all other land-based ecosystems.
- Estuaries today have also become hot spots for recreational activities and scientific studies.
- Some examples are tidal marshes, coastal bays, and river mouths.

6.2.5 Coral reefs

Coral reefs are underwater structures built from the skeletons of marine vertebrate, and are also called corals.These are found in most of the world's oceans.

- These corals form reefs called hermatypic or hard reefs as they give out hard calcium carbonate exoskeletons that protect their structure and support important life functions. Sea anemones are classic examples of hard coral reefs. The other species form soft reefs that are comparatively flexible organisms like plants and trees. Sea fans and sea whips are some of the most found varieties of soft reefs.
- The environmental conditions needed for the survival of coral reefs are warm, shallow, clear, and moving waters with ample sunlight.
- The Great Barrier Reef in Australia is the world's largest coral reef with a length of approximately 1500 miles.

6.2. A.Functions of Aquatic Ecosystem

- Allows nutrients to be recycled more easily.
- Aids in the purification of water
- Recharges thegroundwater table
- Provides a home for aquatic vegetation and fauna.
- Prevents flooding

Key environmental problems

Environmental problems: are issues caused by human activities and cause damage to the environment.

Definition of environmental problems:

It is any change or disturbance to the environment considered to be undesirable or dangerous. It brings down or reduces the capacity of the environment to meet the social and ecological needs.

Environmental problems can be categorized into **2** major factors:

1) A **natural factor**: like drought, sea storms, volcanic eruptions etc.
2) **anthropogenic factors**: means man made activities: which include deforestation industrialisation, urbanisation actually causing damage to the elements of the Earth which is air water and soil.

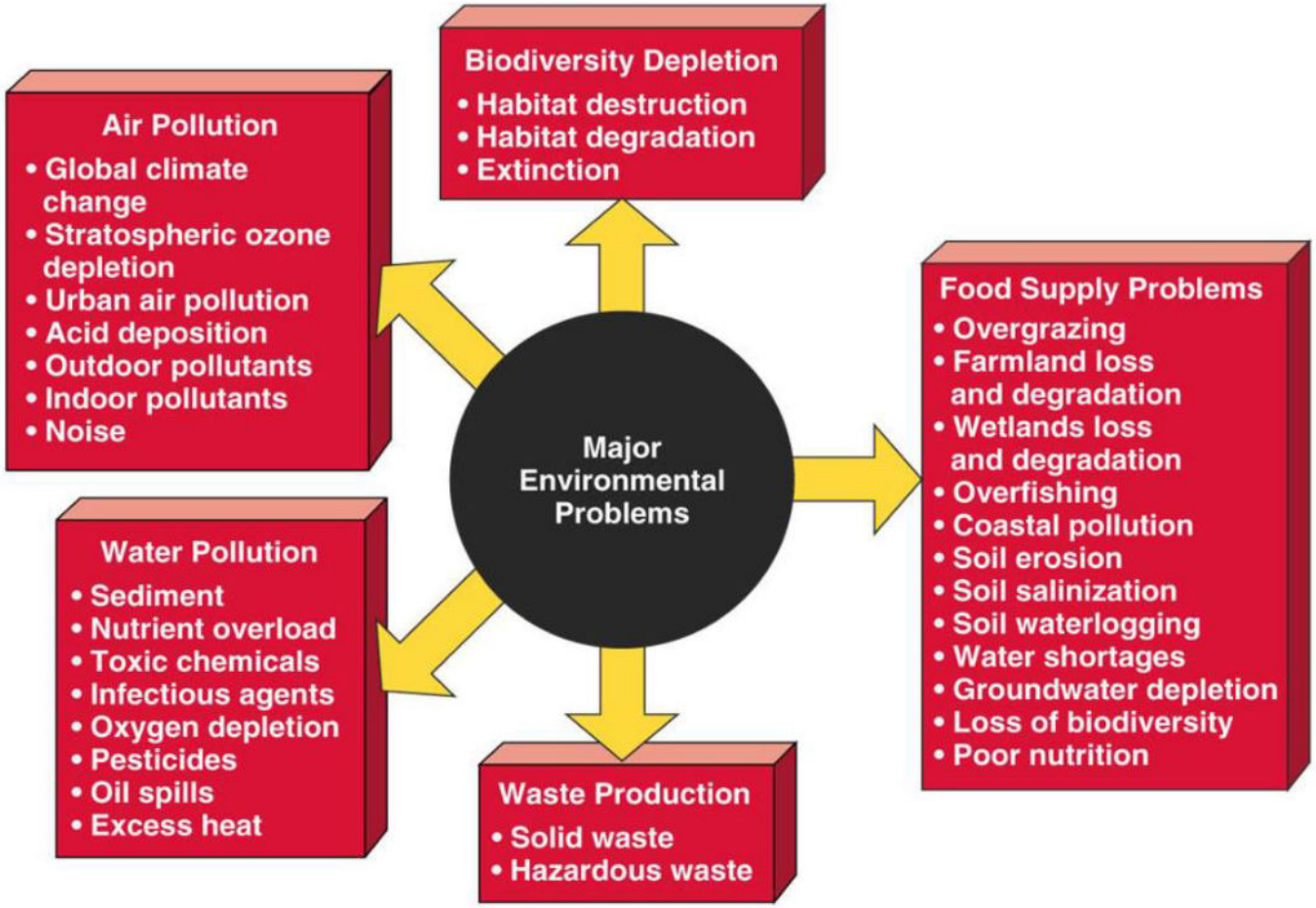
Causes of Environmental Problems: There are several causes: Like population, ozone layer depletion, acid rain, food scarcity, biodiversity loss, waste production, and use of unsustainable resources.

However, **four major causes** of environmental problems are:

- Population growth
- Poverty
- Affluence based on wasteful and unsustainable resource use
- Exclusion of harmful environmental costs from the market prices of goods and services.

The below illustrations brings to us a plethora of environmental problems:

Environmental Problems



One must know about **Natural Resources and Natural Services – key components in nature's sustainability**

• **Natural resources** are materials and energy in nature that are essential or useful to humans. They are often classified as renewable resources (such as air, water, soil, plants, and wind) or non-renewable resources (such as mineral ores, oil, coal).

• **Natural services** are processes in nature, such as purification of air and water and renewal of topsoil, which support life and human economies.

Natural capital is the world's stock of natural resources, which includes geology, soils, air, water and all living organisms. Natural capital assets provide people with a wide range of **free goods and services**, often called ecosystem services, which underpin our economy and society and some of which even make human life possible.

Optimal utilization of natural capital

• In economic terms, *capital refers to money and* other forms of wealth that can support a person, a population, or an economy. It can provide a sustainable income if we use it properly—that is, if we do not spend it too quickly. If we protect capital by careful investment and spending, it can last indefinitely. • Similarly, **natural capital** can support the earth's diversity of species as long as we use its natural resources and services in a sustainable fashion.

Overuse of natural capital – causes Unsustainability • Over exploitation of non-renewable resources - petroleum - coal - natural gas – minerals

Ecological Footprints: A Model of Unsustainable Use of Resources • Supplying people with renewable resources results in wastes and pollution, and can have an enormous environmental impact this is taken as an **ecological footprint.**

• **Ecological footprint is nothing but the amount of** biologically productive land and water needed to provide the people in a particular country or area with an indefinite supply of renewable resources and to absorb and recycle the wastes and pollution produced by such resource use. It considers only renewable resources though use of non-renewable resources also causes pollution.

- **Population growth**: A population is defined as a group of individuals of the same species living and interbreeding within a given area. The population rely on similar resources and get subjected to similar environmental constraints and depend on the availability of the other members to persist over time. Therefore one must limit the population explosion and use the natural resources wisely.
- **Affluence** comes from the Latin verb affiliate meaning receiving an incoming flood of riches In terms of environmental science, affluence is the abundance of wealth and goods or the consumption of high volumes of goods, those taken from the Earth.
- One must be conscious of how we utilize the natural resources judiciously

- **Affluence Has Harmful Environmental Effects** ●The lifestyles of many consumers in more-developed countries and in less-developed countries such as India and China are built upon growing affluence, which results in high levels of consumption and unnecessary waste of resources. Such affluence is based mostly on the assumption—fueled by mass advertising—that buying more and more material goods will bring fulfillment and happiness.

- The harmful environmental effects of affluence are dramatic. The U.S. population is only about one-fourth that of India. But the average American consumes about 30 times as much as the average Indian and 100 times as much as the average person in the world's poorest countries. As a result, the average environmental impact, or ecological footprint per person, in the United States is much larger than the average impact per person in less-developed countries.

- The authors of the book, Minimalism stresses us to identify the essentials and eliminate the rest.

- **Poverty:** It is a state of being poor, always in want of money, living space and access to quality air, water, food and basic sanitation.

Environmental Impact: is very challenging. Desperate for short-term survival, some individuals in poverty degrade potentially renewable forests, soils, grasslands, fisheries, and wildlife at an ever-growing demand. Poaching for animal skins for a large price, succumbing to unethical practices for some quick money all these impact the earth. The poor have a tendency to have larger families. This leads to over exploitation of natural resources too! We musts act and achieve a world of **ZERO Poverty**—the first sustainable development goal.

- **Excluding cost of environment and natural resources:** Prices Do Not Include the Value of Natural Capital. Companies using resources to provide goods for consumers generally ignore the harmful environmental costs of supplying such goods. Like the leather industry does not worry about the chromium impacts or the ecological index.

- **Consumerism:** is the latest addict affecting the world. The responsible human being must buy only what he needs. Imbibing a culture of green consumerism will benefit us and the earth too!

- **Global warming and climate change:** The green house effect is a natural process that heats up the earth's surface and the atmosphere. Green house gases CO_2, H_2O vapour and CH_4 impact the energy balance of the planet. The amount of heat energy added to the atmosphere by green house effect is controlled by the concentration of greenhouse gases like CO2, CFCs, nitrous oxide, methane etc. in the earth's atmosphere. As a result of this higher concentration, the green house effect will be enhanced and the earth's climate will become warmer and this is referred to as global warming.

These issues can be addressed only by responsible citizens and the ecological index can be promising only with all our cumulative effort. May we live and bequeath this planet in a better way.

ENERGY FLOW IN AN ECOSYSTEM

The transfer of energy from the source in plants through a series of organisms by eating and being eaten constitutes **food chains**. At each transfer, a large proportion of energy is lost in the form of heat. These food chains are not isolated sequences but are inter-connected with each other. This interlocking pattern is known as the **food web**. Each step of the food web is called a **trophic level**. Hence green plants occupy the first level, herbivores the second level, carnivores the third level and secondary carnivores the fourth level. These trophic levels to-together form the ecological pyramid.

The food chains

The most obvious aspect of nature is that energy must pass from one living organism to another. When herbivorous animals feed on plants, energy is transferred from plants to animals. In an ecosystem, some of the animals feed on other living organisms, while some feed on dead organic matter. At each linkage in the chain, a major part of the energy from the food is lost for daily activities. Each chain usually has only four to five such links. However, a single species may be linked to a large number of species.

The food chains are mostly sequential and begin from green plants followed by herbivores and two successive sets of carnivores or predate. Such food chains are called Grazing food chain or Predator food chain (Fig. 1a). In addition, the food chains that start from dead organic materials that are consumed by a series of parasites and hyperparasites is called Detritus food chain or the Saprophytic food chain (Fig. 1b). These food chains are invariably linked to one another in nature (Fig. 1c).

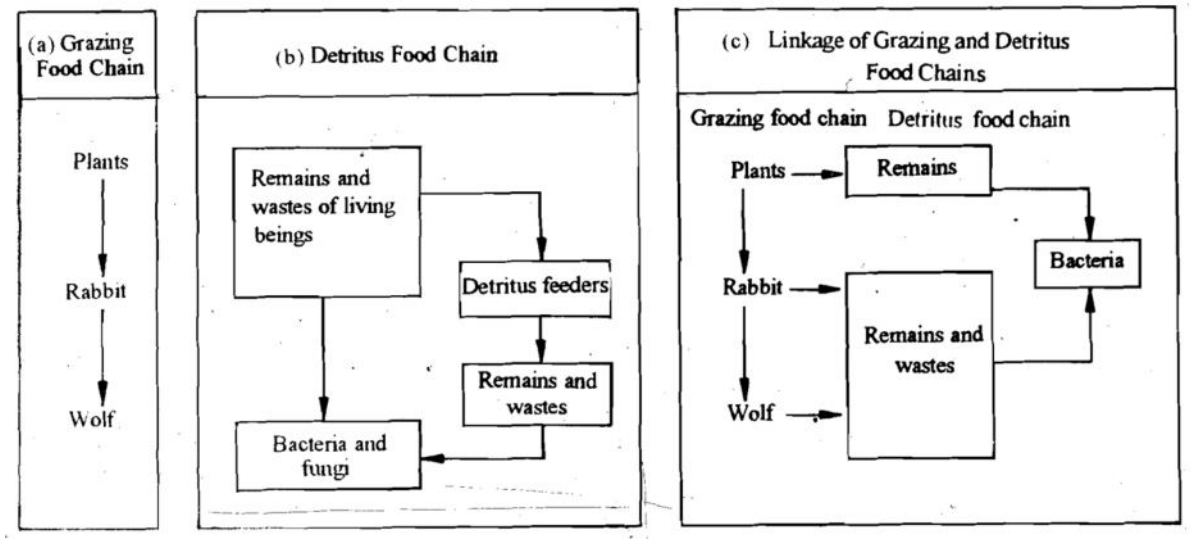


Figure 1. (a) Grazing food chain; (b) Detritus food chain. Bacteria and other organisms fed on plants and animals remain; (c) The Grazing and Detritus food chains are linked.

How Food Chains Work

Every biological community can have multiple and diverse food chains, but every food chain starts with a primary source of energy. The most obvious source of energy is the big ball in the sky, the sun. Other food chains may begin with a boiling-hot deep sea vent as a source of energy.

The next organism to benefit from this initial source is called the primary producer. These are organisms that can create their own food from the main energy source. Some examples include plants and algae. For example, plants are primary producers because they can harness and use the energy from the sun through a process called photosynthesis.

After the plant goes through the work of photosynthesis, another organism may come along and eat the plant, taking its energy to use as its own. As human beings, we are not primary producers because we cannot create our energy to survive, and must consume energy from other sources, like plants. By eating plants, we are part of the next sequence in the food chain, called the primary consumer, or organisms that consume primary producers.

With each transition of energy, the food chain moves up levels. These levels are called trophic levels. Here is a list of the order of trophic levels.

Primary Producers: The one that gathers energy from an energy spot such as the sun; an example may be grass.
Primary Consumer: The one that gets its energy directly from the primary producer, such as a grasshopper who eats the grass
Secondary Consumer: The one that gets its energy directly from the primary consumer, such as the rat who eats the grasshopper
Tertiary Consumer: The one that gets its energy directly from the secondary consumer, such as the snake who eats the rat
Quaternary Consumer: I think you are catching on now. This is the one that gets its energy directly from the tertiary consumer, such as the hawk that eats the snake.

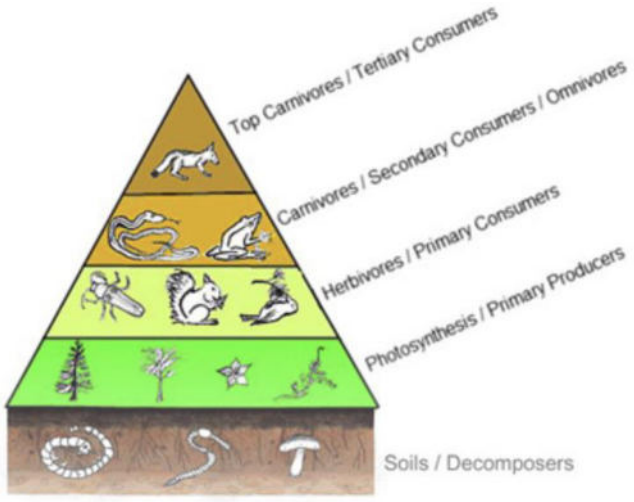


Figure 2. Examples of trophic levels some species may be on.

The Flow of Energy in the Food Chain

As we go along the trophic levels, at each step, a large portion of the energy is lost as heat and only a small fraction about 10% goes on to the next level. Therefore, the quantity of energy decreases successively at a rapid rate from primary producers to the top consumer (carnivores). This explains why the food chains have fewer links. After the fourth or fifth link, not enough energy is available to support another trophic level.

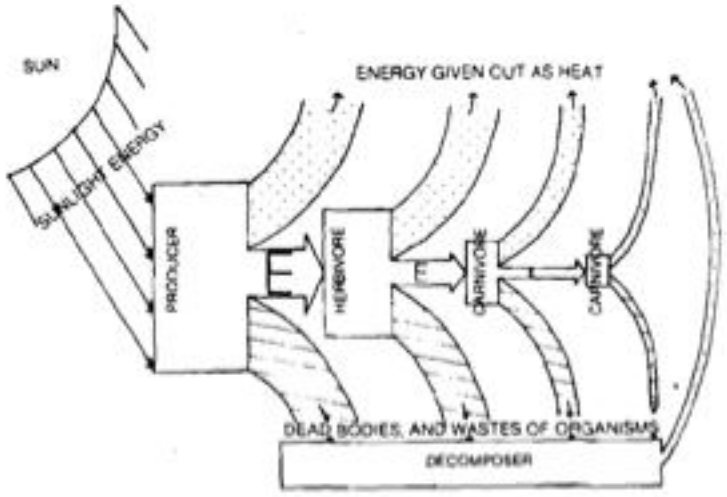


Figure 4. Energy flow in a food chain.

Extending this concept a bit further, in case we want to support more human population on earth, this could be possible by providing them with a vegetarian diet rather than non-vegetarian food. This way maximum energy can be made available as it involves one step in the energy transfer from a primary producer, thus minimizing energy loss at subsequent transfer.

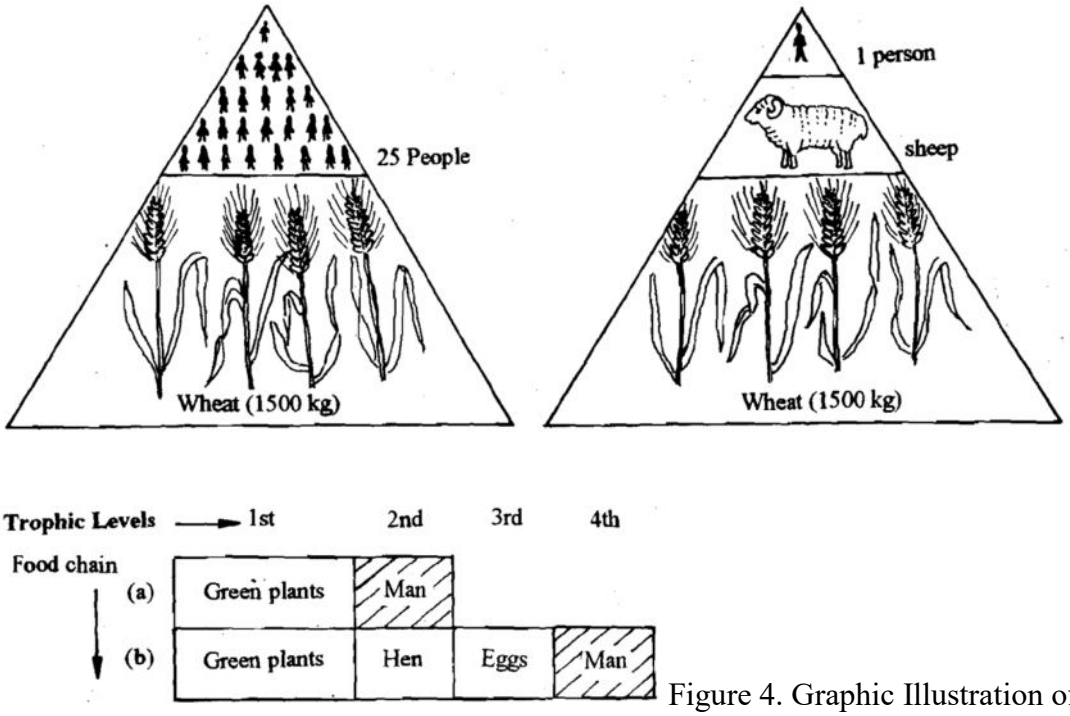


Figure 4. Graphic Illustration of vegetarian and carnivorous diet for supporting the human population.

The Food Web

From the above discussion, you should not be tempted to believe that the food relations in an ecosystem are simple having only linear food chains. Actually, in nearly all natural ecosystems, the patterns of consumption are so complicated that there are many cross-links connecting various organisms. So when the consumers have more than one food source, this results in branching off of food chains, In this way chains become interconnected to form a food web (Fig. 5). The food web is a composite of all the food chains giving us a complete picture of who consumes whom own ecosystem. Food webs represent the transfer of energy and nutrients among the organisms through the ecosystem, whereas a food chain traces only one pathway or represents one strand of the food web.

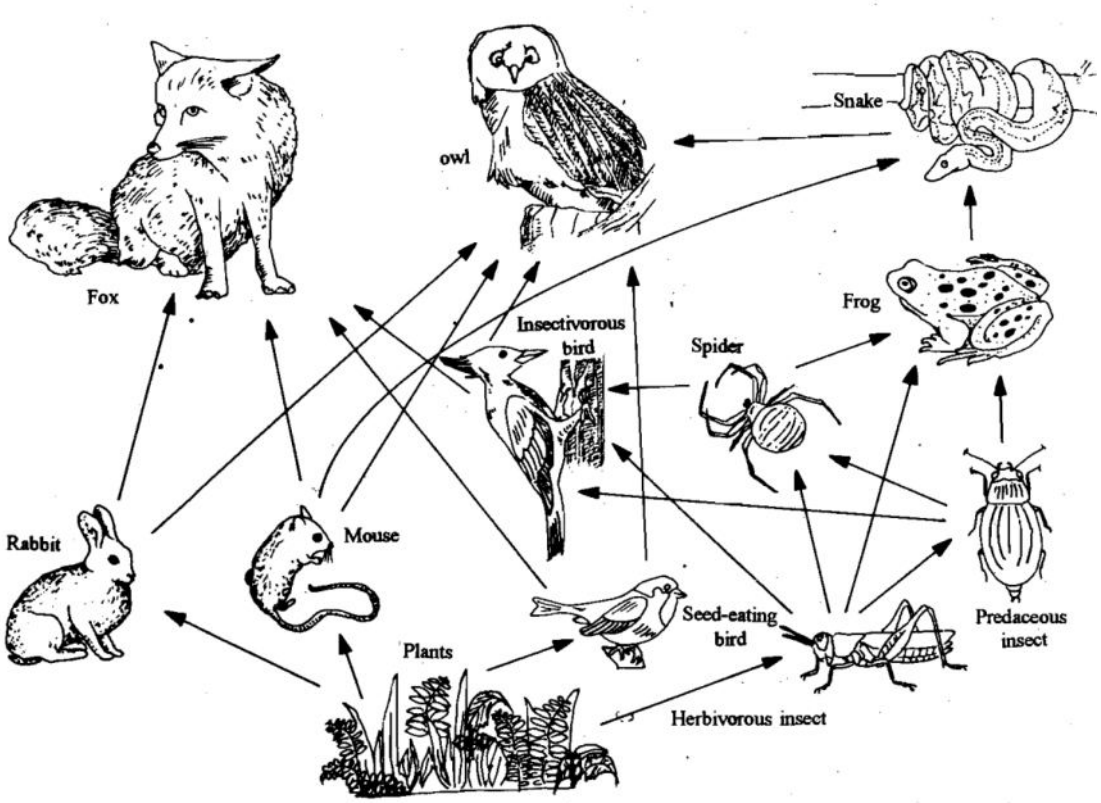


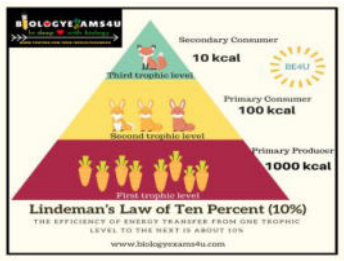
Figure 5. A simplified food web showing the interconnected network of food chains.

In a food web, many species can occupy more than one trophic level. They are known as multilevel consumers or omnivores. Humans are good examples of this situation. Humans, when they consume food derived from plants - they are primary consumers occupying the 2nd trophic level, and when they consume animal products they may occupy 3rd or higher trophic levels.

Energy flow in the ecosystem

- energy is needed for each and every biological activity
- The transfer of energy from one trophic level to another trophic level is called energy flow. Solar energy is transformed into chemical energy by process called photosynthesis. In a biological world the energy flows from the sun to the plants and

then to all heterotrophic organisms like Nitro- organisms, that is energy flows from the producers to the consumers

- Only 1% of total light falling on the green plants is utilized for photosynthesis. This is sufficient to maintain all life on this earth. There is no 100% flow of energy from one trophic level to the other. Some energy is always lost to the environment, because of this energy cannot be recycled in an ecosystem. It can only flow one way and can never take place in the reverse direction. Energy flow is unidirectional.
- Sun is the ultimate source of energy. A large amount of energy is lost at each Tropic level. It is estimated that upto 90% energy is lost during transfer from one trophic level to another. Therefore the amount of energy available decreases from each trophic level to the other. When a food chain is very small or short the final consumer may receive a large amount of energy, but in a food chain which is long the final consumer may get very less energy.
- This law of 10% was proposed by Lindeman in the year 1942 says that only 10% of food energy is transferred to the next level of consumers the rest is wasted.
- 

- Source courtesy:biologyexams4u.com

The illustration shows the progressive loss of energy in a food chain

The flow of energy follows the **two** laws of thermodynamics

The **I law** of thermodynamics states that energy can neither be created nor be destroyed but can be transformed from one form to another

For example: the plants which are the producers utilize the solar energy and convert this energy through photosynthesis into biochemical energy, later the consumers feed on the plants and uses this biochemical energy for their mechanical activities

II law of the second law of thermodynamics: states that energy transformation involves degradation or dissipation of energy from a concentrated to a dissipated form .We see that energy is lost at each and every trophic level

This energy flow supplies energy to all organisms at each trophic level.

Consequences of Food Webs: Biological Magnification

One of the most important consequences of ecosystem dynamics in terms of human impact is biomagnification. **Biomagnification** is the increasing concentration of persistent, toxic substances in organisms at each successive trophic level. These are substances that are fat soluble, not water soluble, and are stored in the fat reserves of each organism. Many substances have been shown to biomagnify, including classical studies with the pesticide dichlorodiphenyltrichloroethane (DDT), which was described in the 1960s bestseller, **Silent Spring by Rachel Carson**. DDT was a commonly used pesticide before its dangers to apex consumers, such as the bald eagle, became known. In aquatic ecosystems, organisms from each trophic level consumed many organisms in the lower level, which caused DDT to increase in birds (apex consumers) that ate fish. Thus, the bird's accumulated sufficient amounts of DDT to cause fragility in their egg shells. This effect increased egg breakage during nesting and was shown to have devastating effects on these bird populations. The use of DDT was banned in the United States in the 1970s.

Other substances that biomagnify are polychlorinated biphenyls (PCB), which were used as coolant liquids in the United States until their use was banned in 1979, and heavy metals, such as mercury, lead, and cadmium. These substances are best studied in aquatic ecosystems, where predatory fish species accumulate very high concentrations of toxic substances that are at quite low concentrations in the environment and in producers.

ECOLOGICAL SUCCESSION

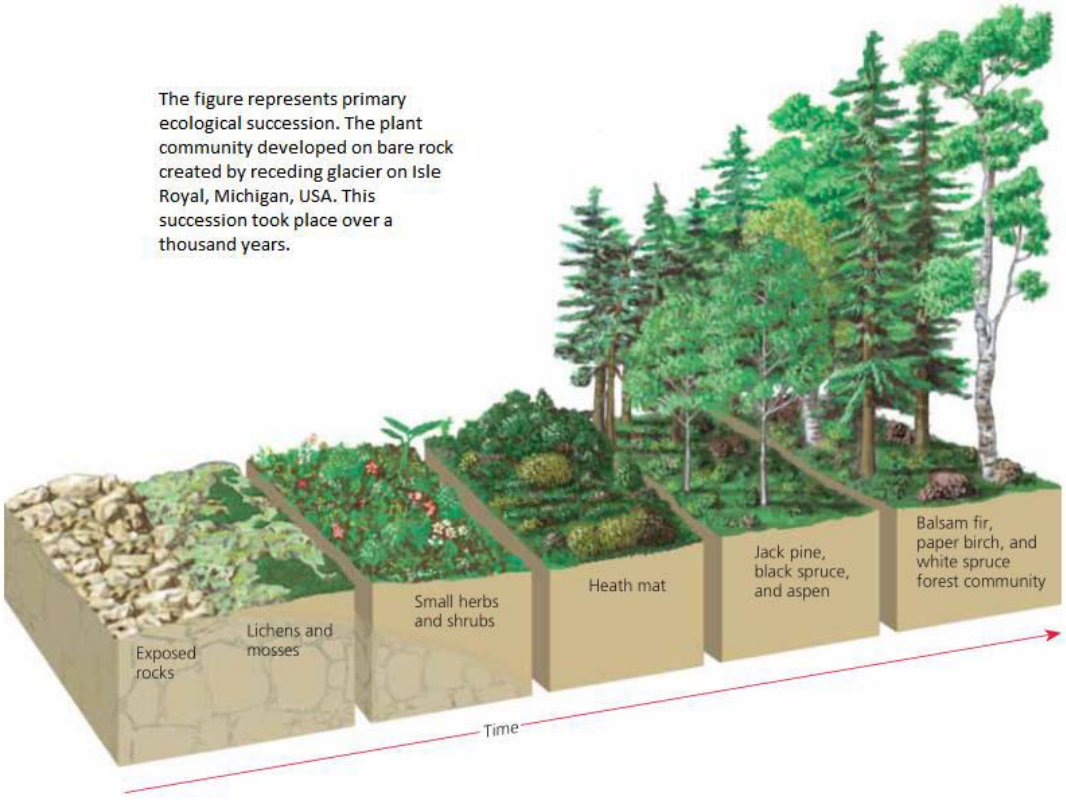
Gradual changes happening in species composition and processes of communities over time is known as ecological succession or community development. It is important to learn the process, rates, and pattern of ecological succession for the management of ecosystems.

Ecological succession can be divided into two major categories

(i) Changes occurring over geological timescale (millions of years); also called paleo-ecological changes and
(ii) Changes occurring over medium timescale (1 – 1000 years)

In another way, succession can also be classified into two types such as Primary and Secondary successions. Primary successions begins at a bare land where there is no life, whereas the secondary succession occurs at a place where the pre-existed ecosystem was either partially or fully destroyed by natural or unnatural means.

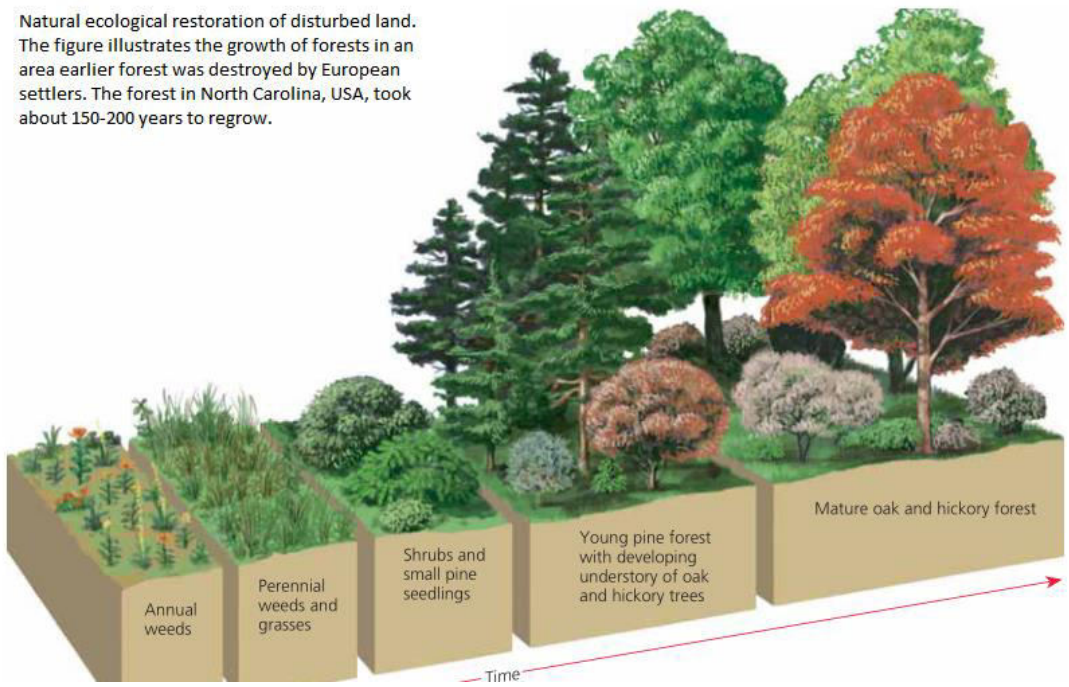
Primary Ecological Succession



In primary succession, the slow process of soil formation begins with pioneer or early successional species, which arrive and attach themselves to inhospitable patches of the weathered rock. Lichens and mosses are examples of pioneer species. These species secrete mild chemicals and acids that penetrate the rocks and eventually make the soil fertile. Over time, the soil may be fertile and moist enough to support other plant species. Mid successional species such as herbs, grasses and low shrubs grow in the environment after lichens and mosses. Next, trees replace these shrubs over the next hundred to thousand years.

Secondary Ecological Succession:

In the secondary succession process, plant species grow in an area that has earlier been destroyed by natural wildfires, floods, or human intervention. Even though the surface species are destroyed, life remains under the soil, which eventually take foothold after the area is abandoned. We can consider the example of mature oak and pine forests of North Carolina, USA, which were destroyed by European settlers. They used the cleared forest for farming. As the nutrients of the land started to dwindle, the settlers moved on. The abandoned farmland underwent secondary succession as shown in the figure below.



Secondary succession can take place 5-10 times faster than primary successions are most of the nutrients in the soil is still present, albeit at a much lower level than what is found at a live forest. The species that take hold as the leader at the end of the succession is called climax species.

The process of succession takes place via these steps:

1. **Nudation**: In this, the bare area is formed by one of several factors: volcanic eruption, landslide, flooding, fire, or other catastrophic event
2. **Invasion**: In this process, the arrival of an organism or many to the bare land takes place. These immigrant species are called “pioneers”
3. **Competition**: When the number of living organisms increases, the space, nutrients, etc. in the area are shared. The competition or struggle for existence can be intraspecific or interspecific. Because of the competition, the environment is modified unsuitably for existing community, which is eventually replaced by the immigrant species. Co-action and co-existence is another seral that follows the competition seral.
4. **Climax**: The end process is called “climax” or “stabilization”. When the climax community takes hold, the environment does not undergo further change unless by natural catastrophes or human intervention.

There are several other types of succession as well:

a. Hydrosere – succession starting in a water environment
b. Xerosere – succession starting in a dry, waterless environment
c. Lithosere – succession starting in rocks
d. Halosere – succession starting in a saline environment

Difference between xerosere and hydrosere

Xerosere (Dry)	Lithoseres	where the plants colonise bare rock	e.g. after glacial retreat, Snowdonia or a rocky shore, Oxwich Point, Gower or a newly created volcanic island (e.g. Surtsey, Iceland)
	Psammosere	where plants colonise coastal sand dunes	e.g. The south Gower - Oxwich Bay.
Hydrosere (Wet)	Hydroseres	where the plants colonise fresh water, as at a pond margin	e.g. Llanfihangel Gobion, Monmouthshire - ox-bow lakes
	Haloseres	where plants colonise salt marshes and sea estuaries	e.g. The North shore of the Gower, Lanrhidian salt marsh

Source courtesy: https://qsstudy.com/difference-hydrosere-xerosere/

Hydrosere

- Succession takes place in wet habitats
- Its first step is the submerged plant stage
- Plants of the first stage are- Elodia, Hydrilla, etc.
- Succession is limited to six steps such as- Submerged stage, floating stage, reed swamp stage, woodland stage, and climax forest stage.
- A hydrosere is a plant succession which occurs in an area of fresh water such as in oxbow lakes and kettle lakes.

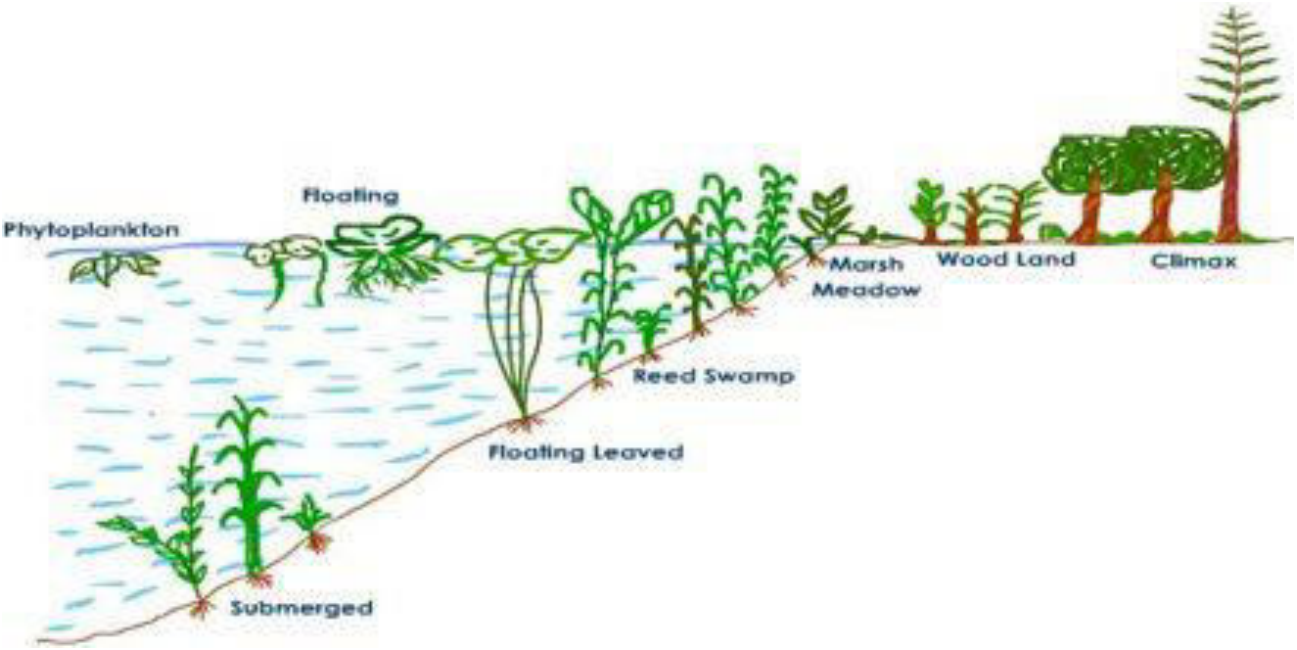


Fig: The different stage of Hydrosere (**Source courtesy:** https://qsstudy.com/difference-hydrosere-xerosere/)

Xerosere

- Succession begins with bare rocks, deserts; example: dry places.
- Its first step is the blue-green algae as well as thalloid licken plant stage
- Plants of the first stage are Rhizocarpon, Rhinodina, etc.
- This succession is ended by six stages, such as – thalluid, licken stage, leafy licken stage, moss stage, herb stage, shrub stage, and climax forest Stage.
- The xerarch succession of ecological communities originated in the extremely dry situation such as sand deserts, sand dunes, salt deserts, rock deserts, etc.

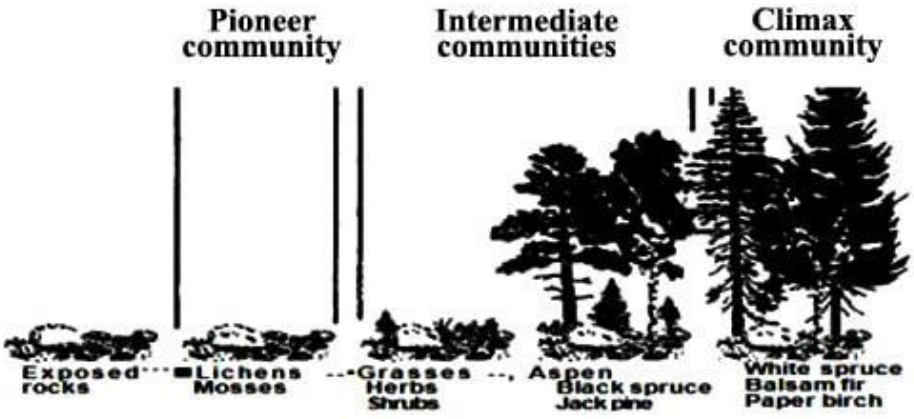


Fig: The different stage of Xerosere(**Source courtesy:** https://qsstudy.com/difference-hydrosere-xerosere/)

CLIMAX THEORY

1. MONOCLIMAX THEORY

- This Theory was given by F.E. Clemens.
- According to this theory, within a given region all land surface is eventually covered by a single type of community. This type of climax is determined by climate.

2. POLYCLIMAX THEORY

- This theory was given by Tansley.
- In this type, the climax vegetation does not consist of numerous type vegetation controlled by many factors .

FEATURES OF PIONEER SPECIES

The pioneer species should:

- have the habit of exploring new habitat.
- should be agile in nature.
- have greater ability to adapt to new environment.
- Have a wide choice of food.
- be a good breeder.
- be a tolerant species .

Summary:

The process of succession shows how a new community is established.

By the process of succession and by of the species of that area the factors responsible for succession can be determined.

The process of succession helps us in the conservation of the climax community.

Differences between primary and secondary succession

Primary succession	**Secondary succession**
Occurs in areas where there is no life and barren	Occurs in areas that were previously occupied, but devastated completely
Takes more than 1000 plus years	Takes just 50 to 100 years
No humus as no soil is seen in the initial step	Humus is present as there were previous occupants and decomposition took place between organisms that existed.
Goes through several seral communities	Less number of seral communities when compared to primary succession
Unfavourable starting point	Favourable and conducive environment
Eg: Bare rock, ponds, desert	Eg. The area affected by natural calamities, covered under deforestation

Biodiversity

Biodiversity: definition, levels and importance

Biodiversity is a combination of two words – biological and diversity, meaning diversity of life forms.

Bio = Life;

Diversity = Variety;

The 1992 Earth Summit in Rio de Janeiro defined biodiversity as:

The variability among living organisms from all sources, including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems.

Biodiversity is the variety of life on Earth and the essential interdependence of all living things among themselves and with their environment. Biodiversity is an important factor for the successful functioning of the ecosystem.

Current estimates of no. of species on earth:

- 10-14 million
- Till date the scientists have identified more than 2 million species. Tens of millions -- remain unknown
- ~1 million are insects
- 99.9% (5 billion) of species extinct since the beginning of life on earth

What is biodiversity and why is it important?

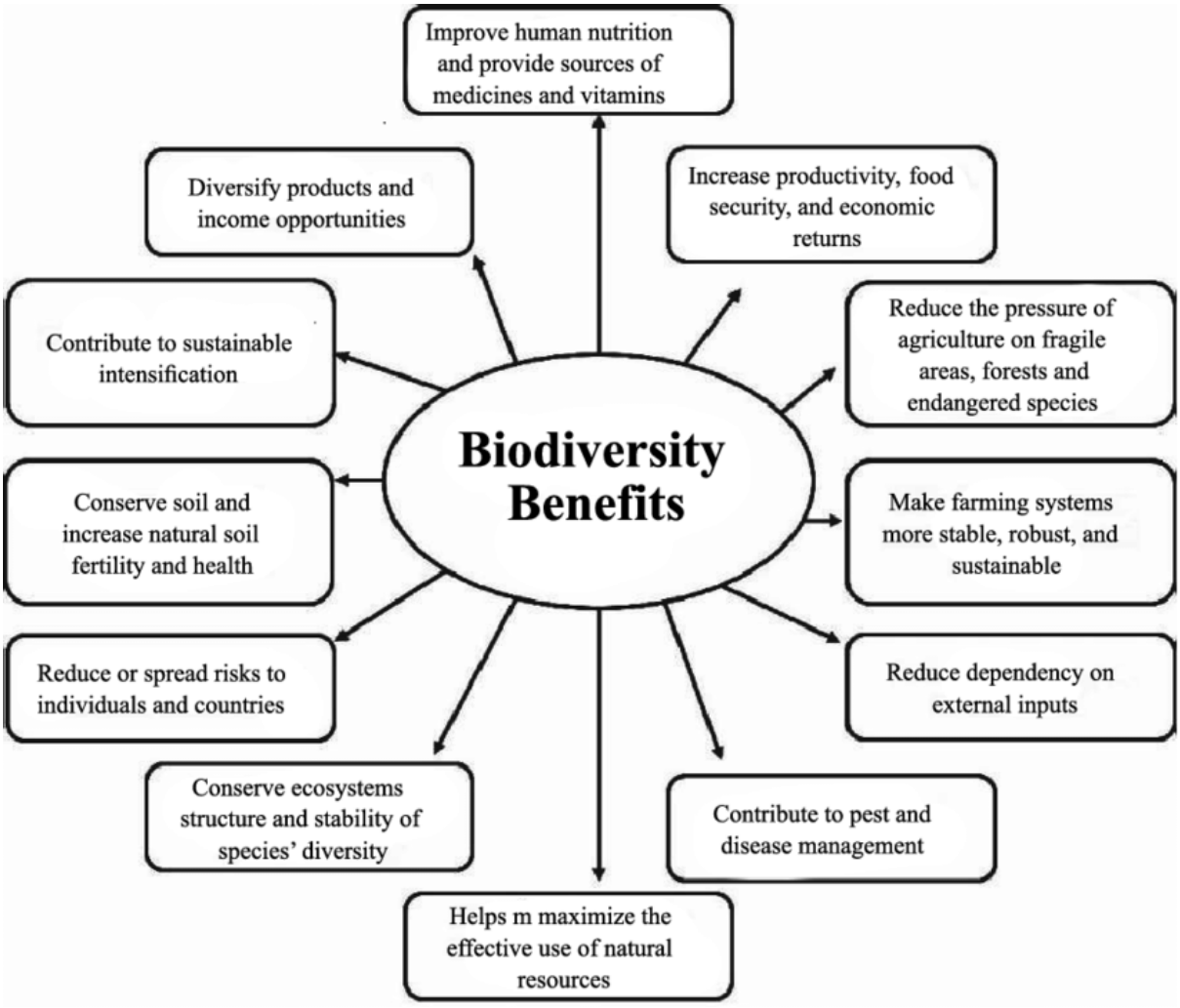
Biodiversity is generally defined as the number and variability of all the life forms pertaining to plants, animals and micro-organisms and the ecological complex they inhabit.

The two documented benefits of biodiversity are:

I. Consumptive and productive uses - grains, vegetables, fruits, plants, medicines, timber, oils, forest products, milk products, eggs, the list of items on this account is endless.
II. Non consumptive benefit where we have biodiversity's role in providing raw materials for biotechnology, regulation of water and other nutrient cycles, regulation of climatic conditions, carbon fixation etc.

The economic value of biodiversity is also of great benefit. "Each species is of potential value to humans. So are healthy ecosystems. The global collection of genes, species, habitats and ecosystems is a resource that provides for human needs now, and is essential for human

survival in the future. Human depend on other species for all of their food and for many medicines and industrial products.



There are three levels of diversity 1) Genetic diversity, 2) Species diversity, 3) Ecosystem diversity

1. Genetic Diversity:

Genetic diversity is the "fundamental currency of diversity" that is responsible for variation. Genetic diversity is defined as genetic variability present within the species. It is the ability of an organism to adapt to changes in the local environment. They adapt by possession of different alleles suitable to the environment.

E.g., Different breeds of dogs, different varieties of roses, wheat, rice, mangoes, etc

Biodiversity

Genetic diversity is very important. It will ensure the survival and adaptability of the species during unfavorable survival conditions in the environment such as disease, or climate change

2. Species Diversity:

Species diversity is a major component of biodiversity and tends to increase the sustainability of some ecosystems. It is the most visible component of biodiversity as implied by the word 'species' which literally means outward or visible form.

How we will define the species diversity: Species diversity is the number of different species that are represented in a given community.

Or

Species diversity is defined as the number of different species present in an ecosystem and relative abundance of each of those species.

Diversity is greatest when all the species present are equally abundant in the area. There are two constituents of species diversity: i.e 1) Species richness, 2) Species evenness

Species richness:

The number of different species present in an ecosystem is species richness. Tropical areas have greater species richness as the environment is helpful for a large number of species.

Species evenness:

Species evenness is a description of the distribution of abundance across the species in a community. Species evenness is highest when all species in a sample have the same abundance. Evenness approaches zero as relative abundances vary.

It is possible in an ecosystem to have high species richness, but low species evenness.

Example:

In a forest, there may have a large number of different species (high species richness) but have only a few members of each species (low species evenness)

In a forest, there may be only a few plant species (low species richness) but a large number of each species (high species evenness)

Species richness increases with increasing explored area.

Why the species diversity is very important: Greater species diversity ensures sustainability in an ecosystem. Since each species is intertwined intricately uniquely with the ecosystem, each performing a unique role, extinction of even one species can have countless ripple effects on the entire ecosystem.

3. Ecosystem Diversity:

Ecosystem Diversity can be defined as the variety of different habitats, communities and ecological processes. A biological community is defined by the species that occupy a particular area and the interactions between those species. Groups of organisms and their non-living

environment, and the interactions between them, form functional dynamic and complex units that are termed ecosystems. These systems help maintain life processes vital for organisms to survive on earth.

Species are not evenly distributed around the globe. Some ecosystems such as tropical rain forests and coral reefs are very complex and host a large number of species. Other ecosystems such as deserts and arctic regions have less biodiversity but are equally important.

Variations in food webs, nutrient cycles, trophic structure etc, this diversity has developed along with evolution

Eg: Tropical rainforests, deserts, ponds, oceans etc.

Prairies, Ponds, and tropical rain forests are all ecosystems. Each one is different, with its own set of species living in it.

How ecosystem diversity is very Importance: Biodiversity is the variety of life in an area that is determined by the number of different species in that area.

- Biodiversity increases the stability of an ecosystem and contributes to the health of the biosphere.
- Variations in ecosystems in a region, and its overall impact on human existence and environment

E.g: deserts, forests, grasslands, wetlands, oceans

- Greater diversity ensures sustainability and ecosystems capable of withstanding environmental stresses like floods, draughts, pests etc.
- Ecosystem diversity ensures availability of oxygen by photosynthesis
- In an aquatic environment, water purification is carried out by the various plant species
- Greater variety of plants, means a greater variety of crops

An ecosystem having higher diversity means the number of species and interactions between them which constitute the food web, is large. In such a situation, the elimination of one species would have little effect on ecosystem balance. In sharp contrast, the number of species in the food web of a simple ecosystem is small. So, loss of any one species has far more serious repercussions for the integrity of the ecosystem itself.

Values of biodiversity:

It has two different values. i. e intrinsic and utilitarian values

Intrinsic Value = Something that has value in and of itself

Utilitarian Value = It is useful to others

Biodiversity is the most precious gift of nature. We all know that all the organisms in an ecosystem are interlinked and interdependent. The importance of biodiversity in the life of all the organisms including humans is huge.

We all are getting benefits from biodiversity mainly in two ways.

Biodiversity

Firstly, biodiversity is directly used as a source for food, fibre, fuel and other extractable resources.

Secondly, biodiversity plays an important role in ecosystem processes providing the regulating, cultural and supporting services.

For example, vegetation cover protects the soil from erosion by binding soil particles and minimizing the effects of water runoff. Similarly, cultivation of crops is to a large extent dependent on the availability of pollinating insects.

Biodiversity has a fundamental value to humans because we are so dependent on it for our cultural, economic, and environmental well-being.

In the field of medicine alone, approximately 50% of current prescription medicines are derived from or modelled on natural substances. The health and diversity of ecosystems can have a significant effect on the overall stability of nearby communities.

Some of the major values of biodiversity are as follows:

Direct values:

Direct use values are for those goods that are ensured directly e.g. food and timber. Maintaining a wide range of components of biological diversity can be of direct use, especially in the fields of agriculture, medicine and industry. Direct use can involve the use of forests, wetlands or other ecosystems for timber extraction, collection of non-timber products, fishing, etc. Direct use values could be due to extractive use where resources are extracted and consumed, or due to non-extractive use when there is no extraction or removal of the resource that is used (e.g. bird watching, scientific research in an ecosystem).

Generally, it divided into two categories-

1. Consumptive use value
2. Productive Use Value

Indirect values:

1. Cultural and Social Value
2. Ecosystem Services
3. Economic Value
4. Ethical and Moral Value
5. Aesthetic Value.

Biodiversity

Direct values:

1. Consumptive use value:

These are direct use values where the biodiversity products are consumed or harvested directly. E.g.: fuel, food, drugs, fibre etc.

Humans use at least 40,000 species of plants and animals on a daily basis. Many people around the world still depend on wild species for most of their needs like food, shelter and clothing. The tribal people are completely dependent on the forests for their daily needs.

2. Productive Use Value

These are commercially usable values where the product is marketed and sold, often resulting in the exploitation of rich biodiversity.

This is assigned to products that are commercially harvested and marketed. Almost all the present date agricultural crops have originated from wild varieties. Biodiversity represents the original stock from which new varieties are being developed. The biotechnologists continuously use the wild species of plants for developing new, better yielding and disease resistant varieties.

Indirect values:

1. Cultural and Social Value:

Social value of biodiversity refers to its religious and cultural importance.

Certain customs and religious practices utilize plants for their rituals, and worship them as well. It revolves around utilization of either plants and/or animals for either rituals or are worshipped

Example: Trees like Peepal, Banyan and Tulsi are still worshipped. Ladies offering water to Tulsi daily is considered good and there are festivals when ladies tie sacred threads around Peepal and Banyan trees and pray for the welfare of their families.

Flowers and tulsi leaves are offered during poojas

Animals such as cows, snakes and other animals are worshipped in different religions

2. Ecosystem Services:

These services also support human needs and activities such as intensely managed production ecosystems.

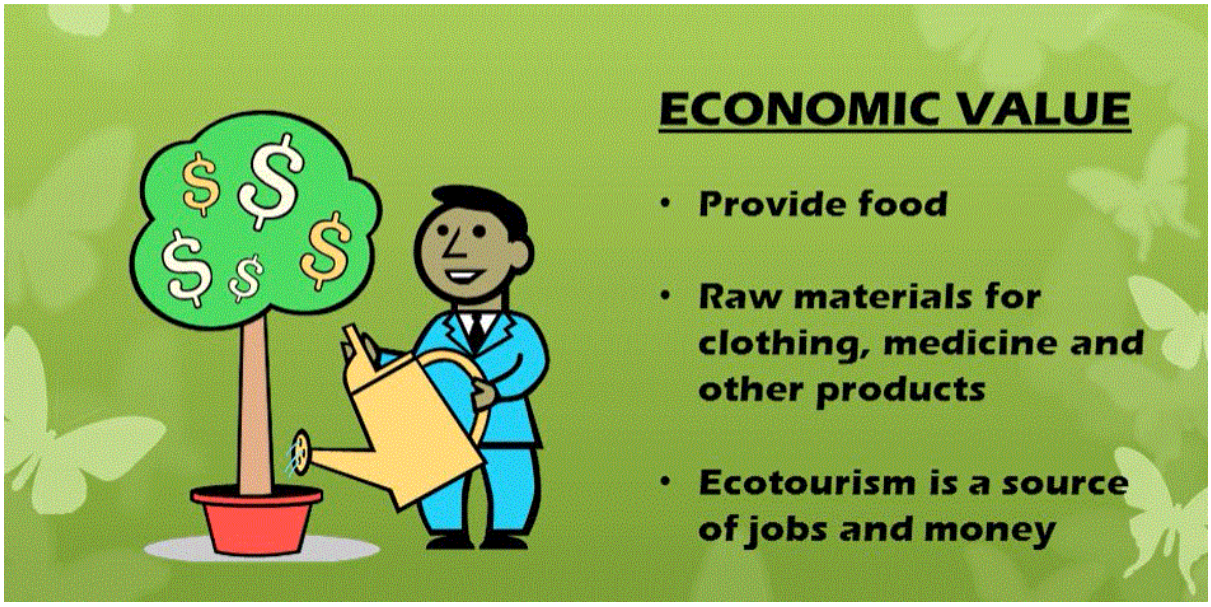
Ecosystem service includes:

1. The production of oxygen by land-based plants and marine algae.
1. The provision of native species and genes used in industry research and development, for instance, in traditional breeding and biotechnology applications in agriculture, forestry, horticulture, mariculture, pharmacy, chemicals production and bioremediation;

2. Pollination of agricultural crops, forest trees and native flowering plants by native insects, birds and other creatures;
3. Maintenance of habitats for native plants and animals; and Maintenance of habitats that are attractive to humans for recreation, tourism and cultural activities and that has spiritual importance.

3. Economic Value:

The economic potential of biodiversity is immense in terms of food~~, fodder~~, medicinal, ethical and social values. Biodiversity forms the major resource for different industries, which govern the world economy.



The salient features regarding the economical potential of biodiversity are given below:

1. The major fuel sources of the world including wood and fossil fuels have their origin due to biodiversity.

2. It is the source of food for all animals and humans.

3. Many important chemicals have their origin from the diverse flora and fauna, used in various industries.

4. Ethical and Moral Value:

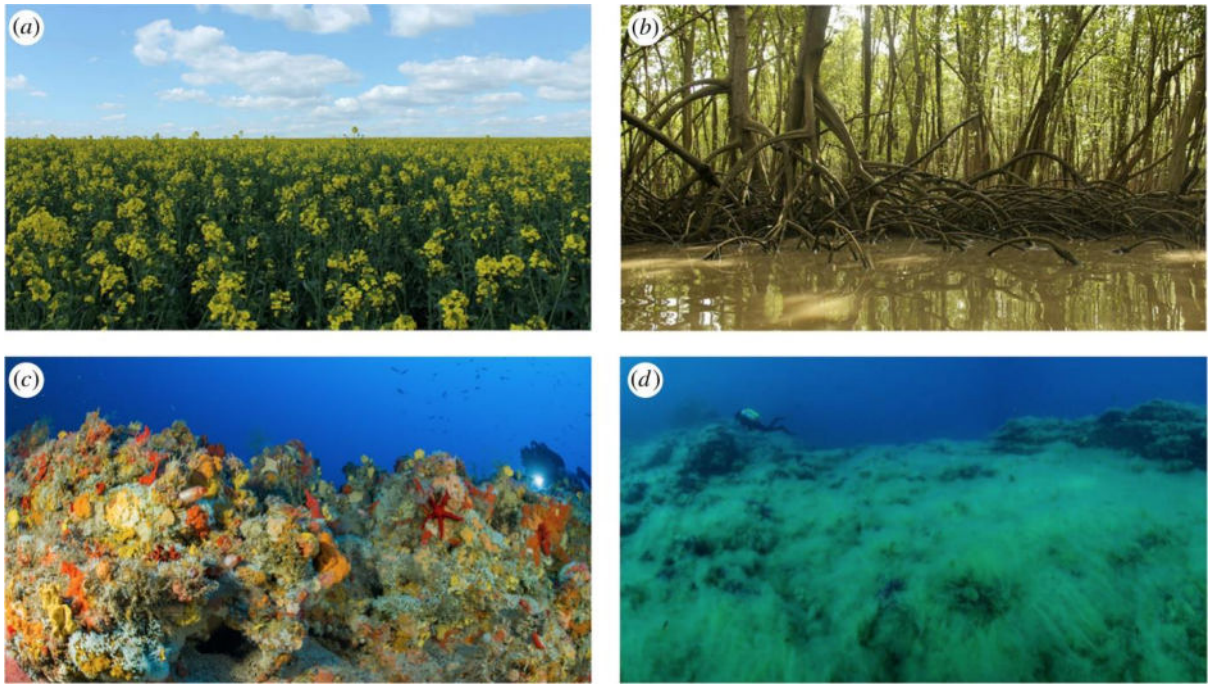
It is based on the principle of 'live and let others live'. Ethical values related to biodiversity conservation are based on the importance of protecting all forms of life. All forms of life have the right to exist on earth. Man is only a small part of the Earth's great family of species.

Morality and ethics teach us to preserve all forms of life and not to harm any organism unnecessarily. Some people take pleasure in the hunting of animals. People also sometimes degrade and pollute the environment by their unethical actions.

Biodiversity

5. Aesthetic Value:

The beauty of our planet is because of biodiversity, which otherwise would have resembled other barren planets dotted around the universe. Biological diversity adds to the quality of life and provides some of the most beautiful aspects of our existence. Biodiversity is responsible for the beauty of a landscape.



People go far off places to enjoy the natural surroundings and wildlife. This type of tourism is referred to as eco-tourism, which has now become a major source of income in many countries. In many societies, the diversity of flora and fauna has become a part of the traditions and culture of the region and has added to the aesthetic values of the place.

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"There is enough for everyone's need but not for anyone's greed"

-Mahatma Gandhi

Biodiversity

Species: roles; Types: extinct, endemic, endangered and rare species

Roles of species: Each species plays a specific ecological role called its ecological niche.

The roles of the species are classified into 5 types.

1. Native species
2. Non-native species
3. Indicator species
4. Keystone species
5. Foundation species

1. Native species: Those that live and develop in a particular ecosystem.

E.g.: Lions in the forest,

2. Non-native species: Those that are either accidently or forcefully introduced into a different environment. These may be migratory as well.

E.g.: Domesticated species such as cattle, chicken.

3. Indicator species: Those that provide information about the change in the environment and climate of a particular ecosystem.

Amphibians, like frogs, toads and salamanders, are known as indicator species. They are extremely sensitive to changes in the environment and can give scientists valuable insight into how an ecosystem is functioning.

4. Keystone species: Those that are abundant and have a great effect on other species.When the activities of a species determine community structure that species is called keystone species. For example, consider the case of the starfish, Pisaster ochraceous. When this starfish removed from the rocky intertidal areas of western north America, the mussel Mytilus californianus was able to occupy the space and excluded other invertebrates and algae which require attachment sites. However, under natural conditions, predation of mussels by starfish keeps their population under control and does not allow it to become dominant. This permits other species requiring attachment sites to survive in such habitats. Other examples of a keystone species could be of the African elephant wolves, leopards, alligators.

Keystone species may be relatively rare in natural communities or may not be easily recognised. At present, few terrestrial communities are believed to be organised by keystone species, but in aquatic community's keystone species may be common.

Biodiversity

5. Foundation species: Those that have a large contribution towards creating and maintaining habitats that support other species.

E.g.: corals, earthworms,

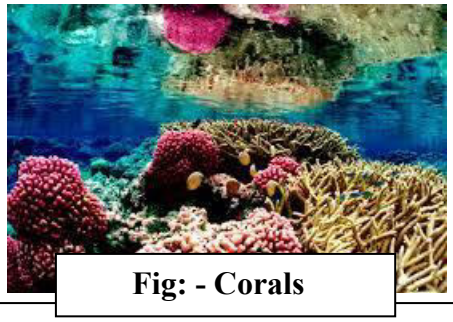


Fig: - Corals

Types of species:

1. Endemic
2. Extinct
3. Endangered
4. Rare
5. Exotic

1. Endemic species:

- Native to a particular place. E.g.: Asiatic Lion, Red Panda
- Endemic species are those plants/animals unique to a defined geographic location, such as an island, nation, or a defined zone or habitat type.
- Areas containing endemic species are often isolated in some way preventing easy spread of species to other areas
- E.g., Islands in Hawaii, New Zealand and southern tip of Africa contain almost 90% endemic species
- Due to the geographic restrictions of such species, endemic species are often endangered

2. Extinct species:

- Species where the last remaining member of the species has died, or is presumed beyond reasonable doubt to have died.
- If not seen for 50 years. Used for species which are no longer known to exist in the world. E.g.: Dinasour, Dodo, Himalayan Quail, Indian Cheetah Extinction of an animal or plant occurs when no more individuals of that species are alive anywhere in the world.
- This is a natural part of evolution, but certain extinctions happen at a much faster rate.

- E.g., the end of the Cretaceous period 65 million years ago saw a mass extinction that caused the death of several plants and animals, including dinosaurs.
- Why this extinction happens so fast. Human interference in the form of hunting, over-exploitation and habitat destruction is also causing rapid extinction.

3. Endangered/vulnerable species:

- Endangered or threatened species is one that is considered at the risk of extinction.
- A species can be listed as endangered at the state, national or international level.
- We can save those species if we identify them in the early stage.

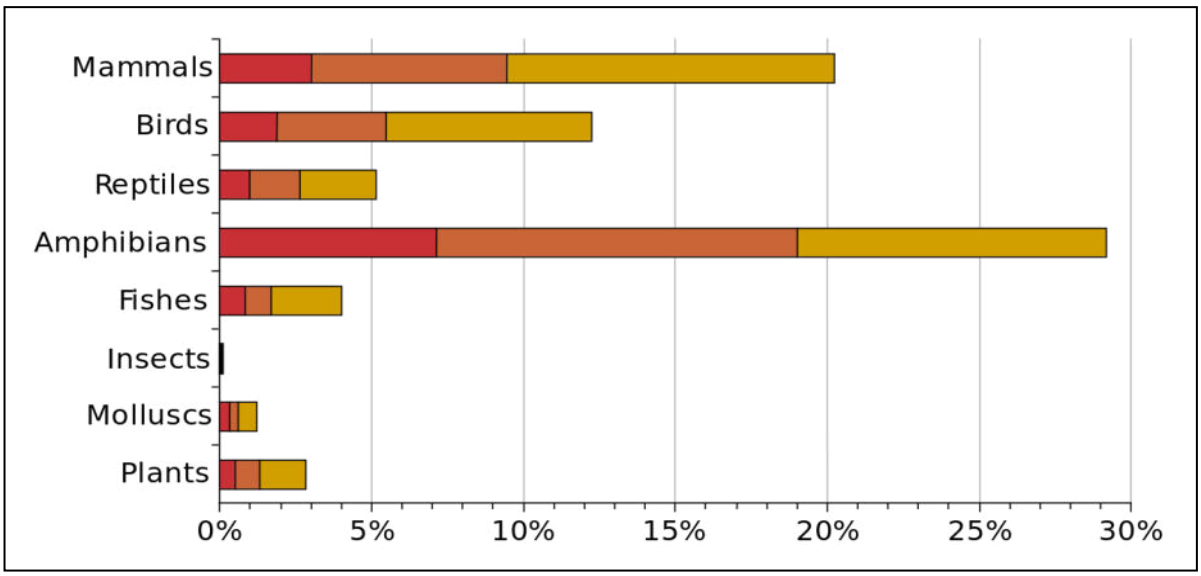


Fig: - Endangered species

4. Rare species:

- Species with small world populations that are not at present endangered or vulnerable but are at risk. E.g.: Sparrows, black buck.
- This is distinct from the term endangered or threatened. Rare species are a group of organisms that are uncommon, scarce or infrequently encountered.
- They are normally species with small populations, and several move into the endangered category if negative factors operate against them

5. Exotic species:

- Non- native species which have been moved by human being from their native place to non-native environment. E.g.: Orchids, Cacti.
- Exotic species are a group of organisms that are non-native, moved into the particular area by humans from their native environment.
- E.g., orchids, cacti, caged animals in zoos, etc.

Fig: - Caged animal

Species interactions:

Biological interaction is the effect that a pair of organisms living together in a community have on each other. They can be of the same species (intraspecific) or different species (interspecific).

The effects may be **short-term** like pollination and predation or **long-term**, strongly influencing the evolution of the other species.

Important types of interactions:

- Predation
- Parasitism
- Competition

Predation:

- In addition to competing for food or space, species in a community may interact by predation which literally means plundering.
- Requires one organism, the predator, to kill and eat another organism, its prey.
- In most cases, both are animals, both of different species (inter-specific); but if both are of same species, (intra-specific), it is called cannibalism.
- It is a short-lived interaction, but very durable in terms of influence on the evolution of both partners, resulting in both partners co-evolving.
- predators have sharp claws or jaws to grip the prey, with other adaptations to improve hunting efficiency.

Ex: Crocodiles are some of the evolutionarily oldest and dangerous predators

The effect of predation on population has been studied theoretically and practically because it has economic implication for our own species. Predation may affect populations mainly in three ways: restricts distribution or reduces abundance affects structure of community is a major selective force, and many adaptations that we see in organisms such as mimicry or warning colouration have their explanation in predator - prey coevolutions.

2. Parasitism:

Parasitism is a relationship between species where one organism, the parasite, lives on/in another organism, the host, causing it harm, and is adapted structurally to this way of life.

Ex: A tick living on a dog is an example of parasitism. In this relationship, the tick gains a food source by drinking the dog's blood.

3. Competition:

- Competition is the interaction between organisms where the fitness of one is lowered by the presence of the other.
- Competition occurs over resources. For plants light, nutrients, and water may be important resources. Plants may compete for pollinators or for attachment sites. Water, food and mates are possible resources for animals, and they may compete for space such as nesting sites, wintering sites or places that are safe from predators. Thus, we see that resources can be complex and diverse.
- Competition is often for a resource such as water, food, territory or access to females for reproduction.
- There are two types of competitive interactions: Exploitative or scramble competition occurs when a number of organisms of same or different species utilise common resources that are in short supply.
- Interference or contest competition occurs when organisms seeking a resource will harm one another in the process even if the resource is not in short supply.
- Competition could be intra-species competition or inter-species competition.

Fig: - Inter-species competition

Fig: - Intra-species competition

- According to evolution, the species less suited to compete for resources either adapts or dies out; competition plays an important role in natural selection.

Biodiversity

Hot spots: Significance, mega-biodiversity

The term "biodiversity hotspot" was first introduced by British Biologist **Norman Myers** in 1988. A biodiversity hotspot is a biogeographic region with significant levels of biodiversity that is threatened by human habitation.

Criteria for recognizing **biodiversity hot spots:**

1. A region must have **at least 1500 vascular plants** as endemics.
2. It must have >**70%** of its original natural vegetation threatened.

An endemic species is a species that's found in a certain area and nowhere else on earth. To identify hotspot why plants are so important? We know Plants are the primary producers. Animals go where the plants are. Plants are the base of food webs. Life attracts other life and it depends on other life. That's why the plants are very important. At the moment Conservation International formally recognizes 36 biodiversity hotspot areas on earth. The interesting thing about this is that less than three percent of the earth's land surface area is represented by these hotspots.

What is the Significance of hotspots?

- Biodiversity is the building blocks of all life on earth. Without species, there would be no air to breathe, no food to eat, no water to drink. There would be no human society at all. And as the places on Earth where the most biodiversity is under the most threat, hotspots are critical to human survival.
- There would be no life on Earth without biodiversity, making these biodiverse hotspots, even more critical for our survival
- The maps of hotspots overlap with maps of natural places that most benefit people.
- That's because hotspots are among the richest and most important ecosystems in the world — and they are home to many vulnerable populations who are directly dependent on nature to survive. By one estimate, in spite of containing 2.5% of Earth's land surface, the forests, wetlands and other ecosystems in hotspots account for 35% of the "ecosystem services" that vulnerable human populations depend on.

What are the most threatened hotspots?

- Most hotspots are located in tropical forests.
- **Atlantic forest, Brazil:** 20,000 plant species, about half of which, are endemic. Of the original 1.2 million km^2, only 8% remains.
- **Polynesia-Micronesia, South Pacific Ocean:** It includes coastal wetlands, coral atolls, savannas and tropical rainforests.

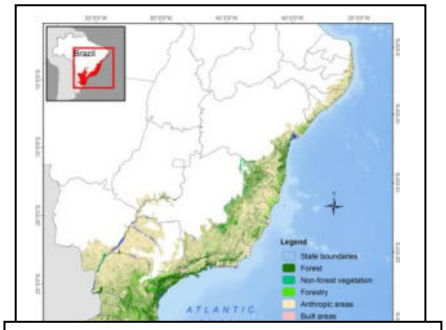


Fig: - Atlantic forest, Brazil

- Some other notable hotspots are **Columbia**, which has the highest rate of species by area unit worldwide and the largest number of endemics; ~20% species can be found here.

Mega-biodiversity:

India is one among the seventeen 'megadiversity' countries in the world, a concept which was introduced by R.A. Mittermier and T.B. Vernier. Megadiversity is a much less discussed subject than biodiversity. This term and another term 'Hot Spots' have recently been used by World Bank and other World bodies for species diversity and endemism in the World's selected few rich floral and faunal zones. "Just as the G-7 countries concentrate a major portion of the world's economic wealth, the 17 Megadiversity Countries have within their borders more than two thirds of our planet's biological wealth, its biodiversity," explains Conservation International's President Dr. Russell A. Mittermeier.

The Megadiversity concept was created in an attempt to prioritise conservation efforts around the world. More than half of the world's forests have already disappeared, and more are destroyed each year. Megadiversity is not only a concept, it is a call for action to ensure the survival of all forms of life on earth. Two spots identified as 'Megadiversity' and 'Hot Spots' in India are North-eastern

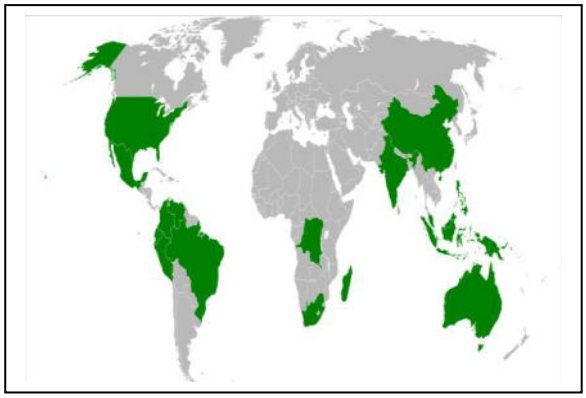


Fig: - Megadiversity of world

Himalayas and Western Ghat. But India as a whole has been marked a megadiversity area. Indians are not yet very much conscious and concerned about biodiversity loss and degradation of entire ecosystem. As the conservation need is urgent in the face of depletion India needs a well-designed strategy to protect these resources. The distribution of biodiversity in India is also important. India, which occupies just two percent (2.4%) of the total landmass of the world, harbors a rich biodiversity comprising about 8% of the known biodiversity of the world.

Conservation International identified **17 megadiverse countries** in 1998. Many of them are located in, or partially in, tropical or subtropical regions. Megadiversity means exhibiting great biodiversity. The main criterion for megadiverse countries is endemism at the level of species, genera and families. A megadiverse country must have at least 5,000 species of endemic plants and must border marine ecosystems. Nations that harbor most of Earth's species and high numbers of endemic species.

Biodiversity

Biodiversity in India:

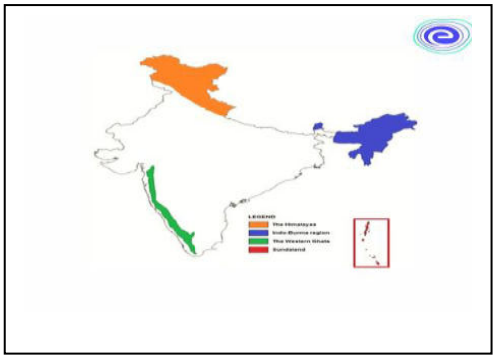
- **What makes India a mega-biodiversity nation?**

  1. Species richness
  2. Species endemism
  3. Biogeographically different regions
  4. Biodiversity Hot spots
  5. Biodiversity conservation efforts

- India has **diverse geographical features**, ranging from desert, mountains, highlands, tropical and temperate forests, swamp lands, plains and grasslands each spanning different climates.
- India has **23.39% of geographical area** under forest cover.
- 7.6% of mammalian, 12.6% of all avian, 6.2% of all reptilian, 4.4% of all amphibian, 11.7% of all fish and 6% of all flowering plant species.
- Within **2.4% of land area**, it accounts for nearly **7%** of recorded species and almost **18%** of the human population
- In terms of **species richness**, India ranks 7th, 9th in birds, 5th in reptiles.
- In terms of **endemism**, India is 10th in birds with 69 species, 5th in reptiles with 156 species and 7th in amphibians with 110 species

Biodiversity hotspots in India:

Overall, 36 biodiversity hotspot areas are there on earth. India contains **4 of the 36 biodiversity hotspots**, they are found in:



1. Western Ghats
2. Himalayas
3. Sundaland
4. Indo-Burma region

1. Western Ghats and Sri Lanka:

- The mountainous zones and the monsoons make a substantial contribution to the biodiversity of the Western Ghats which consists of a rich variety of plant, reptile, and amphibian species.
- It is among the **top 8 biodiversity hotspots** in the world.
- It has original reserve of 2 lakh km^2, only ~143,611 km^2 remain.
- 1600 km long chain of hills running along the western peninsular coast of India, including Kerala, Tamil Nadu and Karnataka.

- Western Ghats is characterized by **heavy rainfall**, and contain moist deciduous and rain forests.
- The region is home to 450 birds (species), 140 mammals, 260 reptiles and 175 amphibians, now rapidly heading towards extinction.
- **How western ghats are Importance to us:** Any reduction in rainfall due to deforestation of the Western Ghats would lead to a warming of the peninsula as well.

2. Himalayas:

- The Himalaya Hotspot has some of the **highest peaks** in the world including Mt. Everest and K2. The varied topography of this hotspot supports a wide range of ecosystems like alluvial grasslands, subtropical broadleaf forests and alpine meadows.
- Significant feature of this hotspot is the occurrence of vascular plants at altitudes as high as 6,000 meters. Vultures, tigers, elephants, rhinos and wild water buffalo are some of the species found in this hotspot.
- Region comprising **Bhutan, Northeast India, southern, central and eastern Nepal.**
- It is geologically young and shows **high altitudinal variation.**
- Of the estimated 10,000 species of plants in the Himalayan hotspot, 3160 are endemic, as well as 71 genera.
- Despite icy zones starting at ~5500-6000 m, there are some species of vascular plants occurring at such high altitudes.
- Nearly 980 birds (15 endemic), 300 mammals (12 endemic), 175 reptiles (50 endemic), 105 amphibians (40 endemic) have been observed here.

3. Sundaland:

- Sundaland is one of the biologically richest hotspots on Earth, The Sundaland hotspot has over 25,000 plants, 2,000 species of orchids and some of the world's largest flowers belonging to the Rafflesia family.
- Sundaland hotspot covers the western half of the Indo-Malayan archipelago. It includes islands of Malaysia, parts of Thailand, Singapore. It is represented by the Andaman & Nicobar Islands from India.
- Of the original reserve of 1.5 million km^2, only ~1 lakh km^2 remain.
- They have a rich terrestrial and marine ecosystem comprising mangroves, coral reefs and sea grass beds, with a wide variety of flora and fauna.

Andaman and Nicobar Islands:

- These constitute a group of **572 islands**, falling under the **Indo-Malayan biogeographic realm**, with Andaman resembling Myanmar and Thailand, while Nicobar was similar to Indonesia and South east Asia, and closer to the sundaland region.
- The islands harbour around **9130 animal species**, in terrestrial habitats, of which, 5859 are marine species.
- A high percentage of endemism (24.95%, 816 species) has been observed in terrestrial fauna, which is 4 times higher than marine habitat endemism.
- These **high rates of endemism** can be attributed to isolation of land masses, while the low rates of marine endemism can be due to continuity in the water medium.
- Some of the endangered species include **whales, dolphins, dugong, saltwater crocodile, hornbills, marine turtles, seashells of the Trochus species.**

4. Indo-Burma:

Indo-Burma: encompasses several countries, spread out from Eastern Bangladesh to Malaysia and includes Northeast India south of Brahmaputra River, covering ~ 2.4 million km^2 of tropical Asia, east of the Ganges-Brahmaputra lowlands.

- They include tropical and subtropical moist, dry and broadleaf forests, temperate and coniferous forests, mangroves, swamps and seasonally inundated grasslands.
- Most of this region is characterized by distinct seasonal weather patterns, such as cool, dry, northern winter months, and rains during spring as a result of Southwest monsoons.

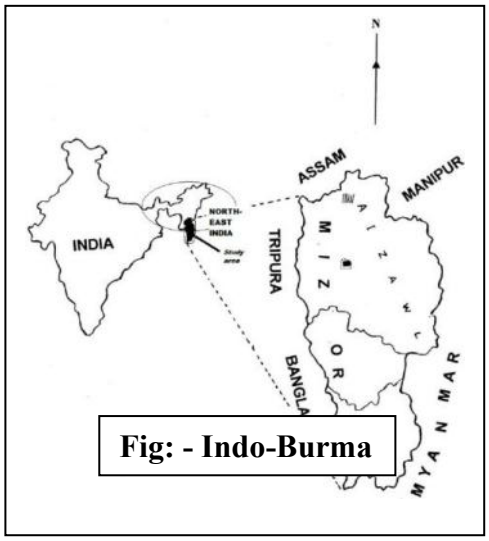


Fig: - Indo-Burma

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Biodiversity

Threats due to natural and anthropogenic activities

In 2014, the estimate was just over seven billion people on the earth. Human population growth is exponential. The more people you have, the more reproduction you have going on. If you have more reproduction happening, then the curve on a graph of population versus time is going to get steeper and steeper to the point where we're looking at about nine billion people by the year 2050. As the population increases, so does the need to exploit the natural resources, these factors that threaten the biodiversity.

There are 7 major anthropogenic activities that needs to be discussed.

1. **Habitat destruction**
2. **Poaching**
3. **Man-wildlife conflicts**
4. **Pollution**
5. **Species introductions**
6. **Global climactic change**
7. **Exploitation of resources**

1. Habitat destruction:

There are various reasons that lead to habitat destruction. They are:

a. Loss of habitat
b. Habitat fragmentation
c. Deforestation
d. Raw materials
e. Production of drugs and medicines

Fig: - Habitat destruction

a. Loss of habitat:

Forests and grasslands have been cleared for various reasons such as agriculture, pasturing, human settlement, developmental projects, etc. Because of this kind of activities, we are losing the habitat. Habitat refers to the area where species seek food, get shelter and reproduce. The greatest threat to wild plant and animal species is due to destruction or alteration of their habitat. If an animal's habitat is destroyed or disrupted, it must adapt to the new changes, move elsewhere or die. When it is forced out of its territory, and if it finds a suitable habitat there is a possibility that the habitat is already in use. Consequently, it must compete with the local population of the same species as well as other animals. The other option is that it must migrate into a marginal habitat where it may succumb to predation, starvation or disease. Some organisms such as pigeon, house sparrows, rodents (like rat and mice) and deer flourish in the modified habitats provided by human activities but many others do not. Some habitats are more vulnerable to species extinction, these are called fragile habitats. Coral reefs, oceanic islands and mountain tops are important fragile habitats.

b. Habitat fragmentation:

What is meant by habitat fragmentation? It is the removal of small sections of the habitat for reasons such as road construction, urbanization, agriculture, resulting in the division of forests into smaller fragments. This kind of activity will affect the biodiversity.

Habitat fragmentation is commonly defined as "the process whereby a large, continuous habitat is both reduced in area and divided into two or more fragments".

Fragmentation often refers to an extreme reduction in habitat area, but it can also occur when an area is reduced only by a small degree when the original habitat is divided by roads, railroads, power lines, fences, or other barriers obstructing the free movement of species. There are two ways in which the fragments differ from the original habitat – first, fragments have a greater amount of edge for the area of habitat; second, the centre of each habitat fragment is closer to an edge.

Fig: - Habitat fragmentation

In terrestrial and inland water ecosystems, human activities often lead to the fragmentation of habitats. Habitat fragmentation may speed up the decline of a population and push it to extinction by splitting an existing widespread population into two or more subpopulations, each in a restricted area. The smaller populations often experience various problems associated with their small size like inbreeding depression and genetic drift. Even though a larger area would be able to support a large population, sometimes the smaller fragments of these areas are unable to support smaller groups, which may normally be able to persist for a long period of time. Some animals such as bears and tigers need larger territories, and cannot survive when their habitat is fragmented into smaller sections.

c. Deforestation:

It is a direct cause of extinction and biodiversity. Around 18 million acres of forest are lost every year due to logging and other human practices. Deforestation is happening due to cutting trees for timber, removal of medicinal plants, dam constructions, etc. Deforestation can directly lead to biodiversity loss when animal species that live in the trees no longer have their habitat, cannot relocate, and therefore become extinct. Deforestation can lead certain tree species to permanently disappear, which affects biodiversity of plant species in an environment.

d. Raw materials:

Biodiversity contributes directly or indirectly to many aspects of human well-being, for instance by providing raw materials and contributing to health. Over the past century, many people have benefited from the conversion of natural ecosystems to agricultural land and from

the exploitation of biodiversity. Wild plants used as raw materials for the production of hybrid seeds as a result of which plant species become endangered.

e. Production of drugs:

Biodiversity plays vital roles in maintaining human and animal health. A wide variety of plants, animals and fungi are used as medicine, essential vitamins, painkillers etc. Natural products have been recognized and used as medicines by ancient cultures all around the world. Many animals are also known to self-medicate using plants and other materials available to them. More than 60% of the world population depend on almost entirely on the plant medicine for primary health care. About 119 pure chemicals are extracted from less than 90 species of higher plants and used as medicines throughout the world, for example, caffeine, methyl salicylate and quinine. Wild plants are used for production of drugs; therefore, several medicinal plants become extinct.

2. Poaching:

Poaching, in law, the illegal shooting, trapping, or taking of game, fish, or plants from private property or from a place where such practices are specially reserved or forbidden. Poaching is a major existential threat to numerous wild organisms worldwide and is an important contributor to biodiversity loss.

The hunting and export of excessive numbers of certain animal species is another important factor leading to dangerous reductions in numbers. There are three main types of hunting:

i) Commercial hunting – in which the animals are killed for profit from sale of their furs, bones or other parts;

ii) Subsistence hunting – the killing of animals to provide food for survival; and

iii) Sport hunting – the killing of animals for recreation. Although subsistence hunting was once a major cause of extinction of some species, it has now declined sharply in most areas. Sport hunting is now closely regulated in most countries; species are endangered only when protective regulation does not exist or are not enforced.

What is the main reason for poaching and killing/hunting of animals?

- Illegal trade of wild-life.
- Despite bans, animals are killed for furs, horns, tusks, skins (crocodile).
- Live specimens are smuggled.
- Existence poaching: Killing animals for food.
- Commercial poaching, hunting & killing animals to sell their products.

3. Man-wildlife conflicts

Fig: - Man-wildlife conflicts

Humans have taken care of the living beings which are useful to them through extensive breeding programmes, to derive maximum benefit of their products. During the process, the species have lost certain useful characteristics so much so that these forms cannot survive on their own in nature. A very good example is corn, which is pampered so much by human that if it is left on its own, it cannot survive.

Today human has large herds of domestic animals. These animals can also play a significant part in the reduction of animal populations by overgrazing the land, thus destroying the vegetation on which both they and the wild animals depend. The native wildlife of a particular area is capable of utilising the native plant life much more efficiently than introduced domestic cattle, and is thus much less likely to convert fertile areas into deserts.

The other important parameter is that the domestic cattle are carriers of several diseases which they can transmit to wild animals. For example, the steady rehabilitation of the Great Indian Rhinoceros was seriously hampered by the rinderpest disease which they contracted from the local domestic cattle

They arise when wildlife starts causing immense damage and danger to the man. During such conditions, it becomes very difficult for the forest department to compromise the affected villagers & gain village support for wild life conservations.

E.g.: In, Orissa, Sambalpur village 200 humans killed by elephants. In revenge the villagers killed 100 elephants

How to control this man-wildlife conflicts:

- Tiger conservation projects: Making available tranquilizers guns, binoculars and radiosets, etc., to deal with danger.
- Solar powered fencing instead of electric.
- Cropping near forests should be prevented.
- Sufficient food should be made available for animals within the forest.
- Wild animal hunting rituals should be stopped.

4. Pollution:

Fig: - Pollution

All forms of pollution pose a serious threat to biodiversity, but in particular nutrient loading, primarily of nitrogen and phosphorus, which is a major and increasing cause of biodiversity loss and ecosystem dysfunction.

Burning of fossil fuels that releases harmful chemicals, depleting the ozone layer, excessive waste production

disrupts, fragments, and degrades the ecosystem. Eutrophication, the process of accumulation of nutrients, including nitrogen, in water bodies, often results in water pollution. Nutrient overloads in aquatic ecosystems can cause algal blooms and ultimately a loss of dissolved oxygen, and of life. As ecosystems are impacted, so is the biological diversity.

5. Species introductions:

Introduction of non-native, predatory species that compete for resources can threaten endemic wildlife. Invasive alien species are animals, plants, fungi and microorganisms that entered and established in the environment from outside of their natural habitat. They reproduce rapidly, out-compete native species for food, water and space, and are one of the main causes of global biodiversity loss. For example, Western honey bee, brown rat.

6. Global climactic change:

Climate change caused by global warming represents one of the most serious threats to biodiversity. The high levels of carbon dioxide are likely to cause more extreme weather events like cyclones, hurricanes and droughts. It can also lead to warmer and shorter winters as well as unpredictable monsoons.

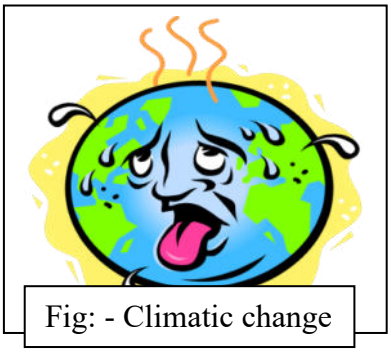

Fig: - Climatic change

The changed atmospheric conditions that result from global warming could create greater numbers of intense storms and prolonged droughts. On the other hand, the expected speed of climate changes coupled with direct loss of natural habitat may prevent some species from adapting quickly enough. They are likely to become extinct, locally or more broadly, and their roles in natural systems will be lost forever.

Rapid artificial climate change does not allow ecosystems and species to adapt. Rising ocean temperatures, diminishing Arctic Sea ice, can affect rising ocean temperatures, affecting marine biodiversity and shift vegetation zones. Rising temperatures are likely to result in widespread ecological change. Many animal and plant species are likely to become extinct as ecosystems adjust to climate change. While adaptable species will survive, the others migrate, the end result will be a lost biodiversity.

7. Exploitation of resources

The unsustainable use of natural resources and overexploitation, which occurs when harvesting exceeds reproduction of wild plant and animal species, continues to be a major threat to biodiversity. Over-hunting, over-fishing, over-harvesting, poaching, and other forms of hunting for profit contribute greatly to loss of biodiversity and death of numerous species.

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Biodiversity

Biodiversity conservation methods

There are many factors that underlie the need to conserve biodiversity, such as,

- present and potential uses of the components of biological diversity - especially as we have no way of knowing or predicting what will be of use in the future.
- biodiversity is essential to maintain the earth's life support systems that enable the biosphere to support human life.
- It is ethically important to maintain all of the earth's biological diversity, including all the other extant (currently existing) life forms.

Biodiversity conservation:

Biodiversity conservation refers to the protection, upliftment, and management of biodiversity in order to derive sustainable benefits for present and future generations. A wide variety of species will cope better with threats than a limited number of them in large populations. Even if certain species are affected by pollution, climate change or human activities, the ecosystem as a whole may adapt and survive.

It is the practice of **protecting** and **preserving** the wealth and variety of species, habitats, ecosystems and the genetic diversity on the planet.

- In addition to protection of resources, it is also the **rational use** of natural resources.
- It is essential for our health, wealth, food, fuel and services we depend on
- It also plays an important role in supporting several sectors of development.

Fig: - Biodiversity

Aim of conservation?

1. **Minimize** depletion of **resources.**
2. **Preserve resources** for use by future generations.

Approach for biodiversity conservation:

1. **In-situ conservation**
2. **Ex-situ conservation**

Ways of conservation:

- **By law:** giving protection to animals and plants or special areas of land or water

- **Restoration** of unattractive countryside like waste spills, slag heaps, etc.
- **Rewilding:** allowing areas to restore themselves naturally without human interference.
- **Alternative energy:** a need to find alternative resources to replace coal, oil, etc.
- **Nature reserves & Zoos.**
- **Recycling:** Reusing of unwanted products such as newspapers, scrap metal, glass, sewage, etc.
- **Education and awareness:** Spreading the message of conservation to schools, youth organizations and the media to achieve maximum results.

1. In-situ conservation:

In-situ conservation means "on-site conservation". It is the process of protecting an endangered plant or animal species in its natural habitat, either by protecting or cleaning up the habitat itself, or by defending the species from predators. The benefit to in-situ conservation is that it maintains recovering populations in the surroundings where they have developed their distinctive properties. Wildlife conservation is mostly based on in-situ conservation. This involves the protection of wildlife habitats. Also, sufficiently large reserves are maintained to enable the target species to exist in large numbers.

- In situ conservation is the preservation of species and populations of living organisms in a natural state in the habitat where they naturally occur.
- This can be achieved either by:
    - Protecting or cleaning up the habitat itself.
    - Defending the species from predators.

Methods of in-situ conservation:

1. Biosphere reserves
2. National parks
3. Wildlife sanctuaries
4. Tiger reserves
5. Gene sanctuaries
6. Community reserves
7. Sacred groves

1. Biosphere reserves:

Biosphere reserves cover very large areas, often **more than 5000 km^2**. They are used to protect species for a long time. Currently, there are **18 in India**.

Example: Manas (Assam), Gulf of Mannar (Tamil Nadu), Nanda Devi (U.P)

2. National parks:

A national park is an area dedicated for the **conservation of wildlife along with its environment**, including its scenery, natural and historical objects. It ranges from **100-500 km^2**. Within biosphere reserves, one or more national parks may also exist. Currently, there are **106 national parks** in India.

Example: Gir National Park (Gujarat), Bandipur (Karnataka), Periyar (Keral)

National parks are largely natural and unchanged by human activities, but many of them already had existing human impacts before they were designated for protection and human activities have often been allowed to continue. People have no rights in a National Park.

3. Wildlife sanctuaries:

A wildlife sanctuary is an area which is **reserved for the conservation of animals only**. Currently, there are **551 wildlife sanctuaries** in India. The first wildlife sanctuary was the Vedanthangal Bird Sanctuary near Madras, set up in 1878, which merely formalised the traditional protection afforded by villagers for pelicans, herons and other birds breeding at Vedanthangal. Another such sanctuary was set up at Ranganathittu near Mysore, in 1942.

Reserves for specific animals:

Several projects have been setup in our country for the protection of specific animals

Example: Project Tiger, Gir Lion Project, Crocodile Breeding Project, Project Elephant, Snow Leopard Project, etc.

4. Tiger reserves:

Project Tiger was launched in 1973 to save the tiger. Starting from 9 reserves in 1973, it has grown to 29 in 2006 covering a **geographical area of 1.17%**

E. g.: Periyar, Kanha, Corbett

5. Gene sanctuary:

Gene sanctuary is an area where plants are conserved, including both biosphere reserves and national parks. The first gene sanctuary in India has been setup in the Garo hills, Meghalaya for wild relatives of citrus.

6. Community reserves:

It is a kind of protected area to provide legal support to community/privately owned reserves that cannot be designated as national parks or wildlife sanctuaries. There are 218 existing

Community Reserves in India covering an area of 1445 km^2, which is 0.044% of the geographical area of the country. (National Wildlife Database, Dec. 2021). Keshopur chamb gurdaspur (Punjab) conservation reserve India's first community reserve.

7. Sacred groves:

They are areas of forests set aside, usually for tribal communities, where all trees and wildlife within are venerated and given total protection. The examples of sacred groves are Khasi and Jaintia Hills in Meghalaya and Aravalli Hills of Rajasthan. - India has a history of religious and cultural traditions that emphasized the protection of nature.

2. Ex-situ conservation:

Ex-situ conservation means, literally "off-site conservation". It is the process of protecting population of an endangered species of plant or animal by removing it from an unsafe or threatened habitat and placing it, or part of it, under the care of humans. While ex-situ conservation is comprised of some of the oldest and best-known conservation methods known to human, it also involves newer, sometimes controversial laboratory methods. Ex-situ conservation, while helpful in human's efforts to sustain and protect our environment, is rarely enough to save a species from extinction. It is to be used as a last resort or as a supplement to in-situ conservation because it cannot recreate the habitat as a whole: the entire genetic variation of a species, its symbiotic counterparts, or those elements which, over time, might help a species adapt to its changing surroundings. Furthermore, ex-situ conservation techniques are often costly. Plants and animals living in ex-situ breeding grounds have no natural defense to the diseases and pests new to the species.

This is usually done by **removing a part of the population** from a threatened habitat and placing it in a new location.

Different ex-situ conservation methods:

1. Botanical gardens
2. Zoos
3. Seed banking
4. Cryopreservation
5. Herbal gardens
6. Plant herbariums

1. Botanical gardens:

They are one of the most conventional methods of ex-situ conservation of plants. India has more than **100 botanical gardens** under different management systems located in different bio-geographical regions. Globally, there are around 2000 botanical gardens in ~148 countries. Central and state governments manage 33 botanical gardens that maintain the diversity in the form of plants or plant populations. These facilities provide not only **housing and care** for

specimens of endangered species, but also have an **educational value**, informing the public of the threatened status of endangered species.

Example: Hyderabad Botanical Garden (Telangana), Panjab University Botanical Garden (Chandigarh).

2. Zoos:

Zoos are some of most publicly visited ex situ conservation sites, with the WZCS (World Zoo Conservation Strategy) estimating that the 1100 organized zoos in the world receive more than 600 million visitors annually. It has been estimated to be a total of **2,107 aquaria and zoos** in **125 countries**, in addition to privately owned facilities. According to the Zoo Authority of India, there are **~164 zoos in India.** Example: national zoological park (Delhi), Rajiv Gandhi Zoological Park (Pune).

3. Seed banking:

A seed bank stores seeds to preserve genetic diversity. One of the most efficient methods of ex-situ conservation for sexually reproducing plants is the storage of conservation material in form of seeds. In this process we need to store the seeds in a temperature and moisture-controlled environment.

4. Cryopreservation:

Cryopreservation is the only ex situ conservation method for long-term preservation of species that cannot be stored in seed banks. Plant cryopreservation consist of the storage of seeds, pollen, tissue, or embryos in liquid nitrogen.

5. Herbal gardens:

Herbal gardens refer to gardens that conserve herbs, shrubs that are of **medicinal value and aromatic value.**

6. Plant herbariums:

- Herbariums preserve plant diversity for research and breeding purposes, often acting as dictionaries of plant kingdoms
- The Botanical Survey of India has the largest holding of 1,500,000 specimens.
    - E.g.: Presidency College Madras (1,00,000)
    - St. Joseph's College, Tiruchirapally (60,000)

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Biodiversity

Genetically Modified-crops: advantages and disadvantages

Genetically modified (GM) crops:

GM crops are genetically improved and contain a gene or genes from the same or a different species artificially inserted in its genome. Genetically modified crops (GM crops) are **plants used in agriculture, the DNA of which has been modified using genetic engineering methods**. GM crops contain gene(s) artificially inserted instead of the plant acquiring it through pollination or other natural methods.

Fig: - Genetically modified crops

The first GM plant was introduced in 1982, which was an antibiotic-resistant tobacco plant. The first commercially produced GM plant was introduced in the US in 1994, the *FlavrSavr* tomato, which had longer shelf-lives.

Transgenic crops and conventionally-bred crops can directly affect the environment in different ways which include: gene transfer to wild relatives or conventional crops, weediness and trait effects on non-target species. Transgenic crops can also indirectly affect the environment as they have specific requirements in terms of pesticide and herbicide use and cropping patterns which requires changes to be introduced in existing agricultural practices.

Transgenic trees are a cause of concern for the environment, more so because of their long-life cycle. Transgenic micro-organisms used in food processing are normally used under confined conditions and are generally not considered as environmental risks. Some kinds of microorganisms can be used in the environment as biological control agents or for bioremediation of environmental damage (e.g., oil spills). The implications to the environment must be assessed before such organisms are released. The main concern with transgenic fish is their potential to breed with and out- compete wild relatives. Transgenic farm animals on the other hand, are generally reared in highly confined conditions and therefore do not pose a risk to the environment.

What is the difference between Traditional vs GM

Traditional breeding methods:

Traditional plant breeding techniques allows for gene exchange via transfer of male (pollen) of one plant to the female organ of another.

Disadvantages

- This method limited to exchanges between same or very closely related species.
- Time consuming to achieve desired set of traits, which may or may not be available in related species.

Biodiversity

Advantages of GM technology

GM technology enables plant breeders to bring together useful genes for the creation of superior plant varieties, from a wide range of living sources, not limited to closely related species.

Benefits of GM crops:

1. Improved nutritional value
2. Toxin reduction
3. Stress resistance
4. Useful by-products
5. Bioremediation

1. Improved nutritional value:

The nutritional content of the crops can be altered as well, providing a more nutritional profile than what previous generations were able to enjoy. This means people in the future could gain the same nutrition from eating lesser amounts of food. For example, rice can be genetically modified to produce high levels of Vitamin A. This can help reduce global vitamin deficiencies.

2. Toxin reduction

Potato that prevents bruising and produces lesser acrylamide on frying.

3. Stress resistance:

One of the main advantages of GM technology is that crops can be engineered to withstand weather extremes. This means that there will be good quality and sufficient yields even under poor or severe weather conditions. Herbicide resistance, pest resistance, resistance to cold. Plants capable of withstanding stressors like draught, frost, high soil salinity.

E.g., DroughGard maize: draught resistant maize, introduced in the US.

Fig: - DroughGard maize

4. Useful by-products

- Plants engineered to produce useful by-products such as drugs, biofuel (algae), bioplastics

Biodiversity

5. Bioremediation:

Bioremediation is a process used to treat contaminated media, including water, soil and subsurface material, by altering environmental conditions to stimulate growth of microorganisms that degrade the target pollutants. GM plants for bioremediation of contaminated soils containing Hg, Se, PCBs, TNT, RDX etc.

e.g., switchgrass and bentgrass

Other advantages:

If we are using GM foods, there is several other advantages also there. Like.

- Cheaper and faster to grow crops.
- GMO crops are bred to grow efficiently. This means that farmers can produce the same amount of food using less land, less water, and fewer pesticides than conventional crops. Because they can save on resources, food producers can also charge lower prices for GMO foods.
- **Easier to transport:** Because GMOs have a prolonged shelf life, it is easier to transport them greater distances. GMO food gives us the opportunity to limit food waste, especially in the developing world, so that hunger can be reduced and potentially eliminated. No more malnutrition or lack of availability of food.
- **Endless possibilities:** anything alive can be genetically modified.

Gene Flow:

In the short term, the spread of transgenic herbicide resistance via gene flow can lead to logistical and/or economic problems for farmers. In the long run, transgenes that confer resistance to pests and environmental stress and/or lead to greater seed production are most likely to favour weeds or have a negative impact on non-target species. A number of transgenic traits have the potential to contribute to sustainability in agricultural systems. The benefits and risks associated with the use of transgenic crops need to be studied carefully in a comprehensive manner and systematically analysed. There is an urgent need to make this exercise a top priority.

Environmental risks of genetically modified organism (GMO):

1. Unexpected gene flow
2. Horizontal Gene Transfer
3. Competition with natural species
4. Increased selection pressure on target and non-target organisms
5. Ecosystem impacts

1. Unexpected gene flow:

Interbreeding between genetically modified organism (GMO) and wild type weeds and/or related species, can result in uncontrollable or **irreversible escape of genes** into neighboring wild plants by pollen.

E.g.: Hybrid rice crossbreeding with a weedy relative, confers on the latter, the competitive advantages of higher photosynthetic rates, more shoots, flowers and seeds.

2. Horizontal Gene Transfer:

The transfer of **foreign genes** to other organisms such as bacteria/virus that can cause harm to environment.

E.g.: Transfer of an antibiotic resistance gene to a pathogen can be terrible to humans/animals.

3. Competition with natural species:

Genetically modified organism (GMO) has favorable traits built-in, such as higher yields or resistance to environmental stress, presenting them with a natural advantage over native organisms, allowing them to become invasive, spread into new habitats unchecked and cause ecological damage.

4. Increased selection pressure on target and non-target organisms:

Evolution of resistant pests and weeds, termed **superbugs**, in response to herbicide-resistant crops. Constant spraying of herbicide on such crops would result in **acquired resistance** by surrounding weeds, resulting in a higher dose of the same, or a different type.

5. Ecosystem impacts:

- Genetic modification produces genetically modified animals, plants and organisms. If they are introduced into the environment, they can affect biodiversity. For example, existing species can be overrun by more dominant new species.
- Effect of a single species may extend beyond a single ecosystem, carrying with it risks of ecosystem damage and destruction.

In summary,

Advantages of GMO's:

- Enhance desired traits
- Pest resistance
- Improve nutritional content
- Less time than controlled breeding
- Improve accuracy
- Herbicide tolerance
- Cold tolerance

- Medical advantage e.g., Edible vaccines
- Virtual end of world hunger. E.g., No malnutrition
- Cheaper or faster to grow and don't have to be rich in plant
- Endless possibilities and anything alive can be genetically modified
- Reduce production cost to reduced chemical and mechanical need in planting, maintenance and harvest.

Disadvantages of GMO's:

- Harm to organisms
- Does not taste natural
- Spread of superweeds
- Spread of superbugs
- New trade, tariff and quota issues
- May cause health problems ϖ Larger companies have more power
- Possible greed to GMO manufacturers
- Unforeseen allergen risks
- Allergies may become more intense
- New allergies may arise
- Widening corporate size gaps between food producing giants and smaller ones.

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Environmental hazard: definition; Types, causes and solutions, biological hazards (COVID-19)

Environmental hazard

An environmental hazard is a substance, state or event which has the potential to threaten the surrounding natural environment or adversely affect people's health, including pollution and natural disasters such as storms and earthquakes.

It can include any single or combination of toxic chemical, biological, or physical agents in the environment, resulting from human activities or natural processes, that may impact the health of exposed subjects, including pollutants such as heavy metals, pesticides, biological contaminants, toxic waste, industrial and home chemicals.

Hazards can be categorized in three types:

- Chemical
- Biological
- Nuclear

This section deals with biological hazards, its causes, ways of encountering them and preventive measures that we can undertake for avoid or minimize the hazards. With this regard, we need to identify the hazard and assess the environment for the presence of hazards. This step is called environmental hazard identification.

Environmental hazard identification is the first step in risk assessment, which is the process of assessing the likelihood, or risk, of adverse effects resulting from a given hazard.

Risk

In simplest of terms, risk is the possibility of something bad happening. Risk is the uncertainty about the occurrence of a certain event such as injury, disease, death, economic loss, or damage. It is usually expressed as a mathematical statement about the likelihood of the occurrence of the event, or in other words, it is expressed in terms of mathematical probabilities.

Biological hazards

Biological hazards, also known as biohazards, refer to biological substances that pose a threat to the health of living organisms, primarily that of humans. This can include medical waste or samples of a microorganism, viruses, or toxins (from a biological source) that can affect human health.

Biological health hazards include bacteria, viruses, parasites and moulds or fungi. They can pose a threat to human health when they are inhaled, eaten or come in contact with skin. They can cause illness such as food poisoning, tetanus, respiratory infections or parasite infection.

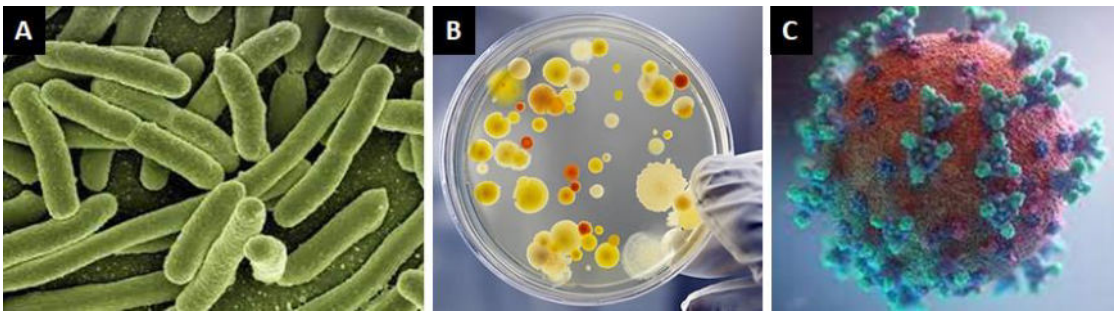
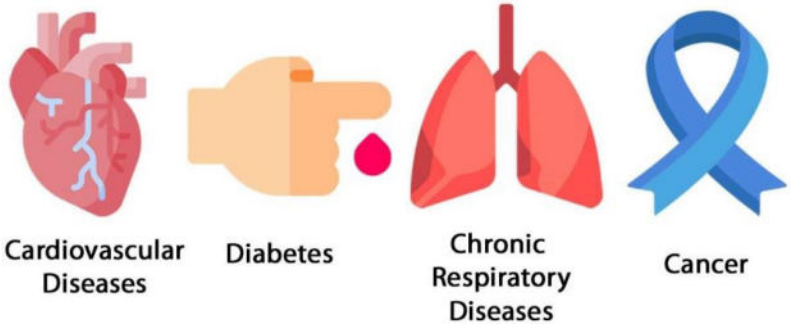


Image showing A) Bacteria, B) Mold/yeast, and C) Viruses

The main source of biological hazards is due to diseases caused by various factors. These diseases can be classified into transmissible and non-transmissible diseases.

Non-transmissible diseases (NCD)

A non-communicable disease (NCD) is a disease that is not transmissible directly from one person to another. NCDs include Parkinson's disease, autoimmune diseases, strokes, most heart diseases, most cancers, diabetes, chronic kidney disease, osteoarthritis, osteoporosis, Alzheimer's disease, cataracts, and others. NCDs may be chronic or acute. Most are non-infectious, although there are some non-communicable infectious diseases, such as parasitic diseases in which the parasite's life cycle does not include direct host-to-host transmission. NCDs are the leading cause of death globally. In 2012, they caused 68% of all deaths (38 million) up from 60% in 2000.



Transmissible/Communicable diseases

Communicable diseases, also known as infectious diseases or transmissible diseases, are illnesses that result from the infection, presence and growth of pathogenic (capable of causing disease) biologic agents in an individual human or other animal host. These diseases spread from one person to another through a variety of ways that include: contact with blood and bodily fluids; breathing in an airborne virus; or by being bitten by an insect. Some examples of the reportable communicable diseases include Hepatitis A, B & C, influenza, measles, and salmonella, tuberculosis, COVID-19, Ebola and several others.

Certain communicable diseases can spread at different rates and to varying geographical locations, resulting in either an endemic, epidemic or a pandemic disease.

Endemic disease

An endemic disease is consistently present but limited to a particular region. This makes the disease spread and rates predictable. Malaria, for example, is considered endemic in certain countries and regions.

Epidemic disease

An epidemic is the rapid spread of disease to a large number of patients among a given population within an area in a short period of time. Yellow fever, smallpox, measles, and polio are prime examples of epidemics. An epidemic disease doesn't necessarily have to be contagious.

Pandemic disease

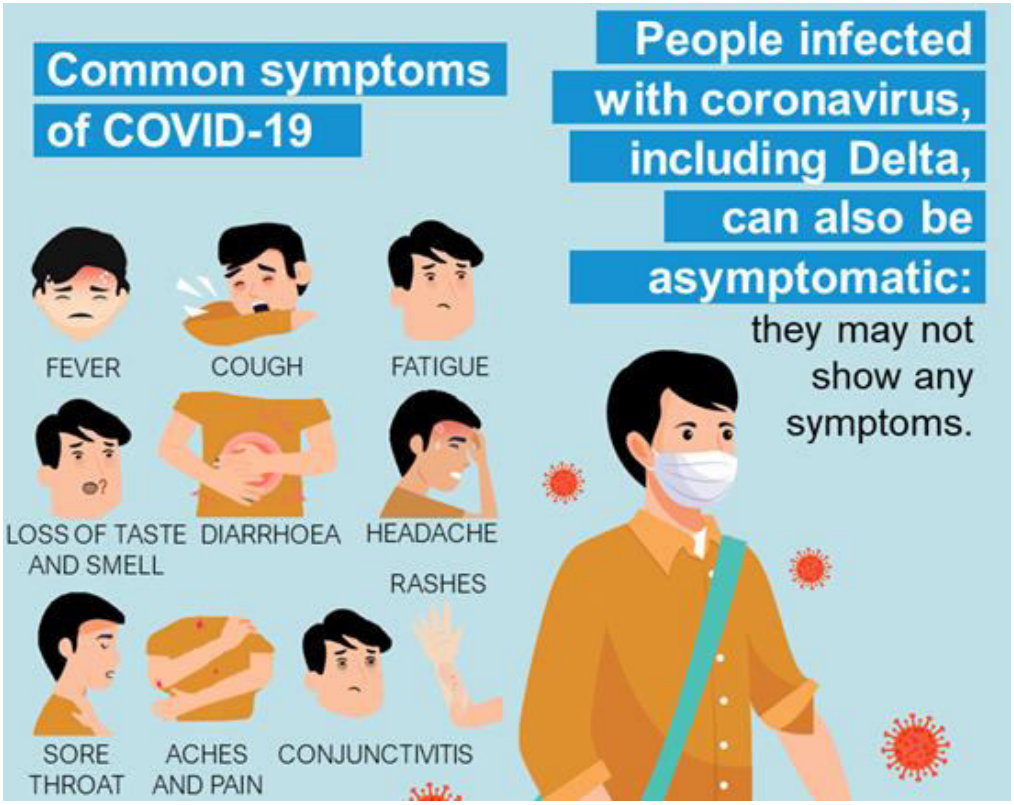
A pandemic is an epidemic of an infectious disease that has spread across a large region, for instance multiple continents or worldwide, affecting a substantial number of individuals. Recent pandemics include tuberculosis, Russian flu, Spanish flu, Asian flu, cholera, Hong Kong flu, HIV/AIDS, and COVID-19.

COVID-19

Coronavirus disease (COVID-19) is an infectious disease caused by the SARS-CoV-2 virus. The first known case was identified in Wuhan, China, in December 2019. The disease quickly spread worldwide, resulting in the COVID-19 pandemic.

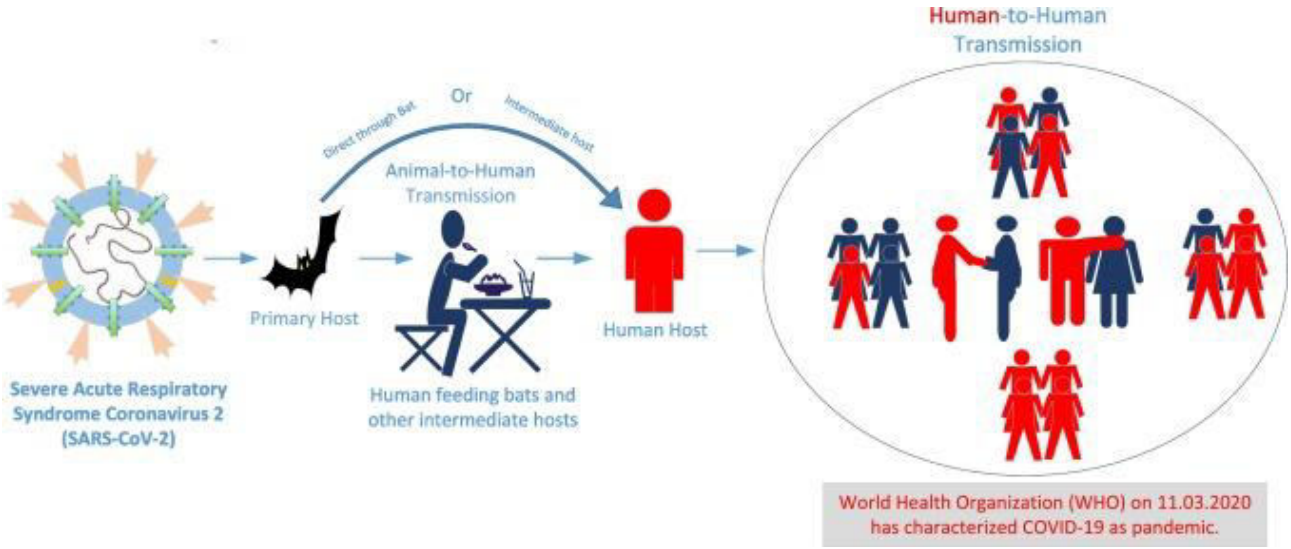
Symptoms

Symptoms of COVID-19 are variable, but often include fever, cough, headache, fatigue, breathing difficulties, loss of smell, and loss of taste. Symptoms may begin one to fourteen days after exposure to the virus. At least a third of people who are infected do not develop noticeable symptoms. Of those people who develop symptoms noticeable enough to be classed as patients, most (81%) develop mild to moderate symptoms (up to mild pneumonia), while 14% develop severe symptoms (dyspnea, hypoxia, or more than 50% lung involvement on imaging), and 5% develop critical symptoms (respiratory failure, shock, or multiorgan dysfunction). Older people are at a higher risk of developing severe symptoms. Some people continue to experience a range of effects (long COVID) for months after recovery, and damage to organs has been observed.



Transmission

COVID-19 is mainly transmitted when people breathe in air contaminated by droplets/aerosols and small airborne particles containing the virus. Infectious particles range in size from aerosols that remain suspended in the air for long periods of time to larger droplets that remain airborne briefly or fall to the ground. Infected people exhale those particles as they breathe, talk, cough, sneeze, or sing. Transmission is more likely the more physically close people are. However, infection can occur over longer distances, particularly indoors.



SARS-CoV-2 Variants

As of December 2021, there are five dominant variants of SARS-CoV-2 spreading among global populations:

- Alpha variant (B.1.1.7, formerly called the UK variant)
- Beta variant (B.1.351, formerly called the South Africa variant)
- Gamma variant (P.1, formerly called the Brazil variant)
- Delta variant (B.1.617.2, formerly called the India variant)
- Omicron variant (B.1.1.529)

Treatment

Most people who become sick with COVID-19 will only have mild illness and can get better at home. Symptoms might last a few days. People who have the virus might feel better in about a week. Several treatment options are available to people with coronavirus (COVID-19) who are at the highest risk of becoming seriously ill. The treatments available are:

- Nirmatrelvir And Ritonavir (Paxlovid)
- Sotrovimab (Xevudy)
- Remdesivir (Veklury)
- Molnupiravir (Lagevrio)

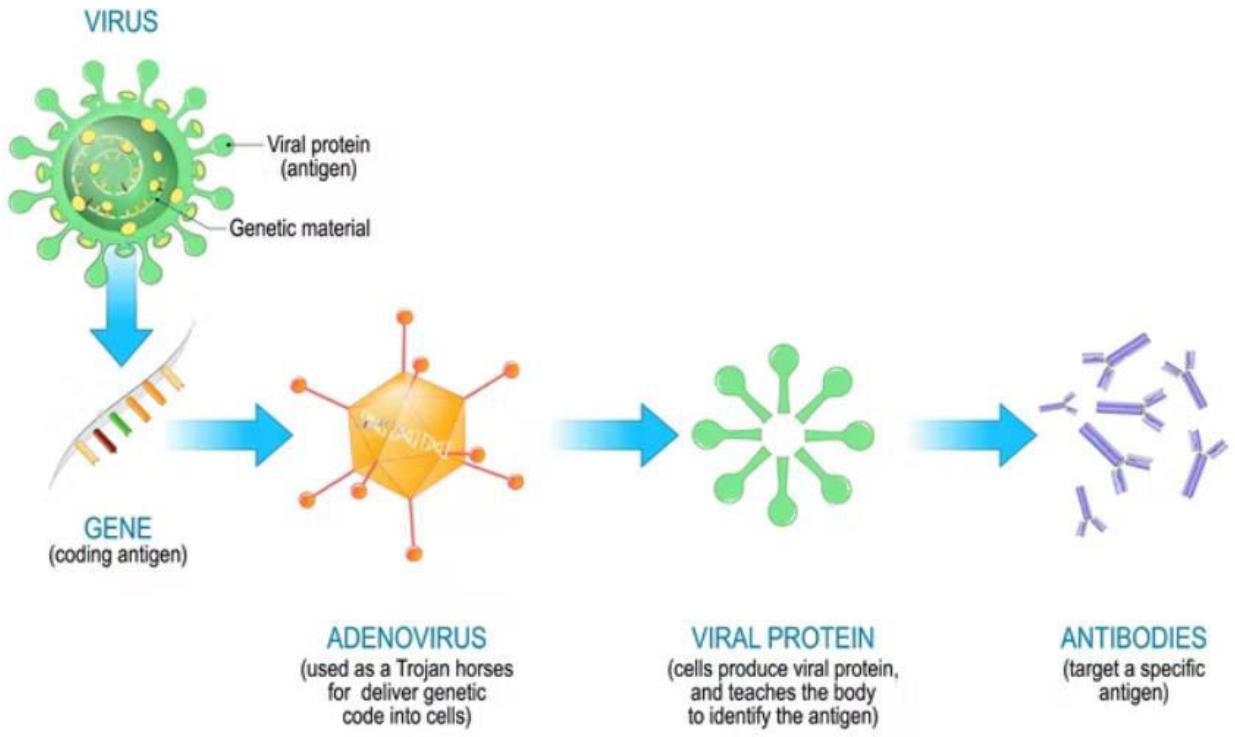
Vaccines for COVID-19

A COVID-19 vaccine is a vaccine intended to provide acquired immunity against severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the virus that causes coronavirus disease 2019 (COVID-19). Mass vaccination programmes have been established by WHO, and nine vaccines have been approved for emergency or full use by at least one stringent regulatory authority recognized by the World Health Organization (WHO): Pfizer–BioNTech, Oxford–AstraZeneca, Sinopharm BIBP, Moderna, Janssen, CoronaVac, Covaxin, Novavax, and Convidecia. Each of these vaccines causes the immune system to create antibodies for fight COVID-19 using a harmless version of a spike-like structure on the surface of the COVID-19 virus. These vaccines act by different mechanisms, a few of which are explained below. The different types of vaccines include:

- Viral vector vaccines
- mRNA vaccines
- Whole virus vaccines
- Protein sub-unit vaccines

Viral vector vaccine

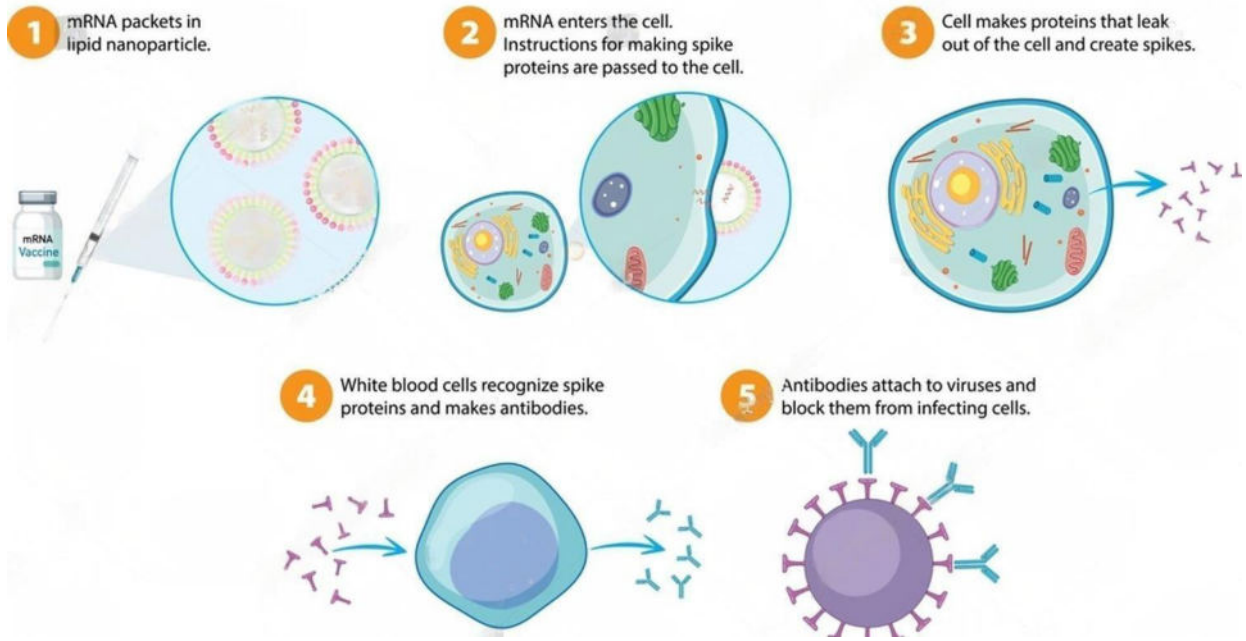
In this type of vaccine, genetic material from the COVID-19 virus is placed in a modified version of a different virus (viral vector). When the viral vector gets into your cells, it delivers genetic material from the COVID-19 virus that gives your cells instructions to make copies of the S protein. Once your cells display the S proteins on their surfaces, your immune system responds by creating antibodies and defensive white blood cells. If you later become infected with the COVID-19 virus, the antibodies will fight the virus. The Janssen/Johnson & Johnson COVID-19 vaccine is a vector vaccine. AstraZeneca and Covaxin vaccines work on this principle.



Schematic representation for the mechanism of action of the viral vector vaccine of COVID-19

mRNA vaccines

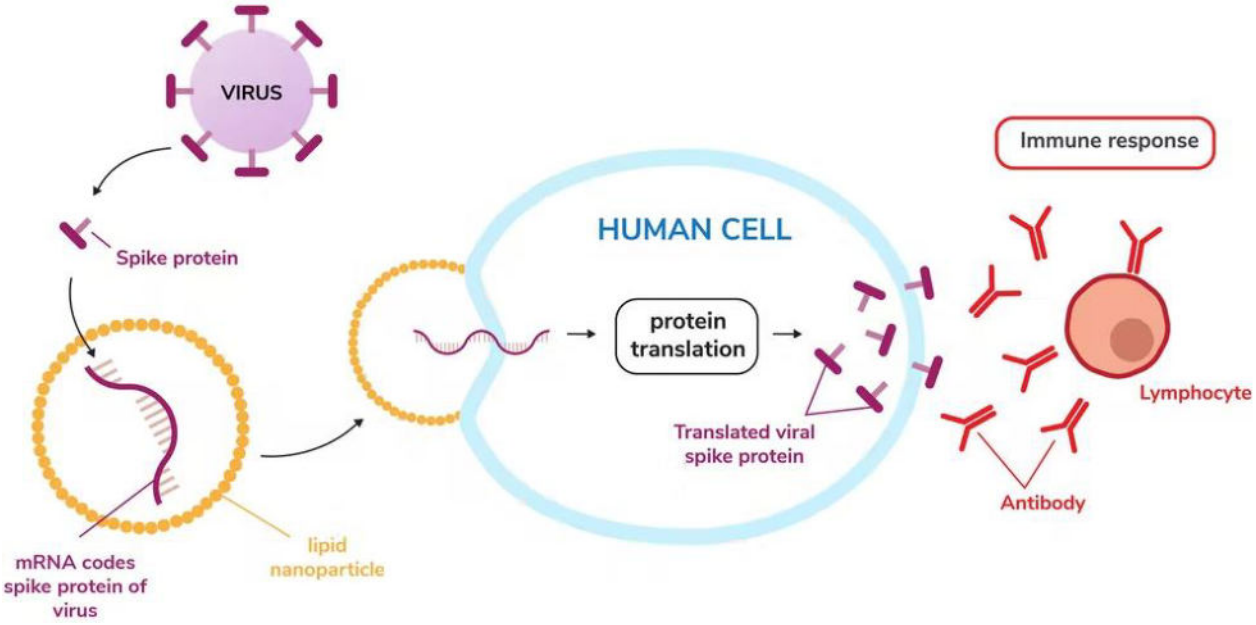
This type of vaccine uses genetically engineered mRNA to give your cells instructions for how to make the S protein found on the surface of the COVID-19 virus. After vaccination, your muscle cells begin making the S protein pieces and displaying them on cell surfaces. This causes your body to create antibodies. If you later become infected with the COVID-19 virus, these antibodies will fight the virus. Both the Pfizer-BioNTech and the Moderna COVID-19 vaccines use mRNA.



Schematic representation for the mechanism of action of mRNA vaccine of COVID-19

Whole virus vaccines

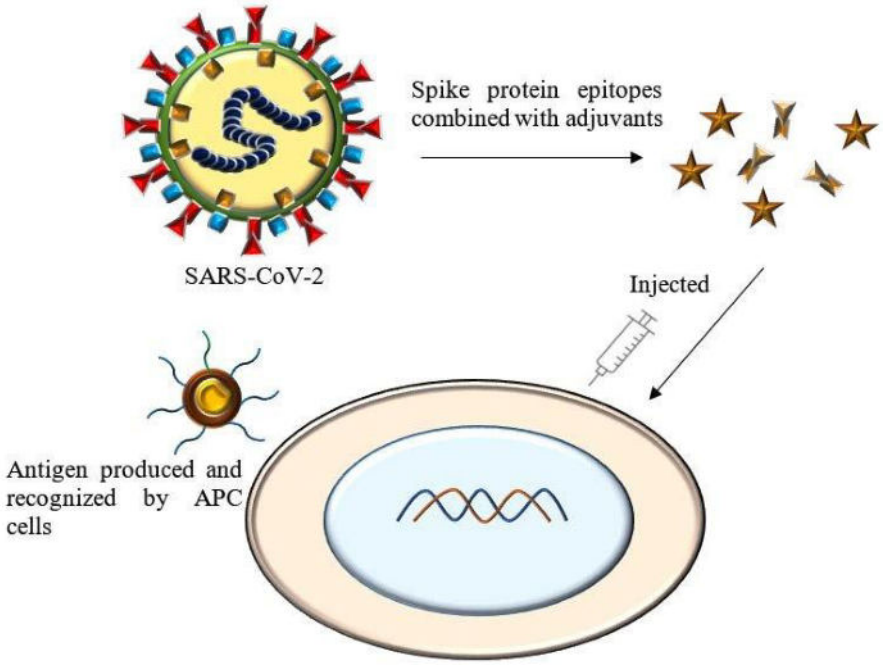
Whole virus vaccines use a weakened (attenuated) or deactivated form of the pathogen that causes a disease to trigger protective immunity to it. the advantages of an inactivated whole virus vaccine include the fact its technology is well established, it is suitable for people with compromised immune systems, and it's relatively simple to manufacture.



Schematic representation for the mechanism of action of the whole virus vaccine of COVID-19

Protein subunit vaccine

Subunit vaccines include only the parts of a virus that best stimulate your immune system. This type of COVID-19 vaccine contains harmless S proteins. Once your immune system recognizes the S proteins, it creates antibodies and defensive white blood cells. If you later become infected with the COVID-19 virus, the antibodies will fight the virus. Novavax is working on a protein subunit COVID-19 vaccine. Covishield is one such vaccine prepared according to this method.



Schematic representation for the mechanism of action of the protein subunit vaccine of COVID-19

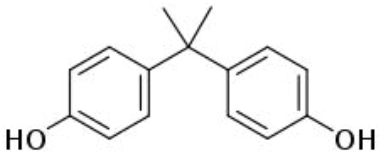
Chemical Hazards: Bisphenol-A, Mercury

Chemical hazard

A chemical hazard is any non-biological substance that has the potential to cause harm to life or health. It can include any single or combination of toxic chemical, biological, or physical agents in the environment, resulting from human activities or natural processes, that may impact the health of exposed subjects. This can include pollutants such as heavy metals, pesticides, biological contaminants, toxic waste, industrial and home chemicals. Chemical hazards and toxic substances pose a wide range of health hazards (such as irritation, sensitization, and carcinogenicity) and physical hazards (such as flammability, corrosion, and explosibility).

In this section, we will look at bisphenol A and problems associated with its poisoning in the human body. We will also look at contamination due to heavy metals, specifically mercury.

Bisphenol A



Bisphenol A (BPA) is a chemical compound primarily used in the manufacturing of various plastics. It is a colourless solid which is soluble in most common organic solvents but has very poor solubility in water. BPA's largest single application is as a co-monomer in the production of polycarbonates, which accounts for 65-70% of all BPA production. The manufacturing of epoxy resins and vinyl ester resins account for 25-30% of BPA use.

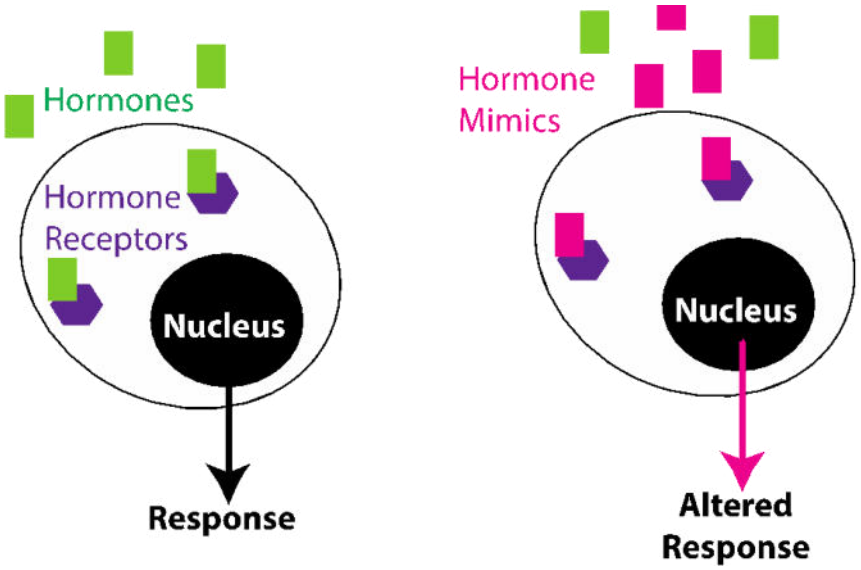
Products containing Bisphenol A

BPA is found in polycarbonate plastics and epoxy resins. Polycarbonate plastics are often used in containers that store food and beverages, such as water bottles. Epoxy resins are used to coat the inside of metal products, such as food cans, bottle tops and water supply lines. Common products that may contain BPA include:

- Items packaged in plastic containers
- Baby bottles
- Canned foods
- Toiletries
- Menstrual products
- Thermal printer receipts
- CDs and DVDs
- Household electronics
- Eyeglass lenses
- Sports equipment
- Dental filling sealants

Mechanism of action of BPA in the human body

BPA binds to both nuclear estrogen receptors (ERs), ERα and ERβ, activating them. It can mimic as well as antagonize estrogen, indicating that it is a selective estrogen receptor modulator (SERM) or partial agonist. It also acts as an antagonist of the androgen receptor (AR) at high concentrations.

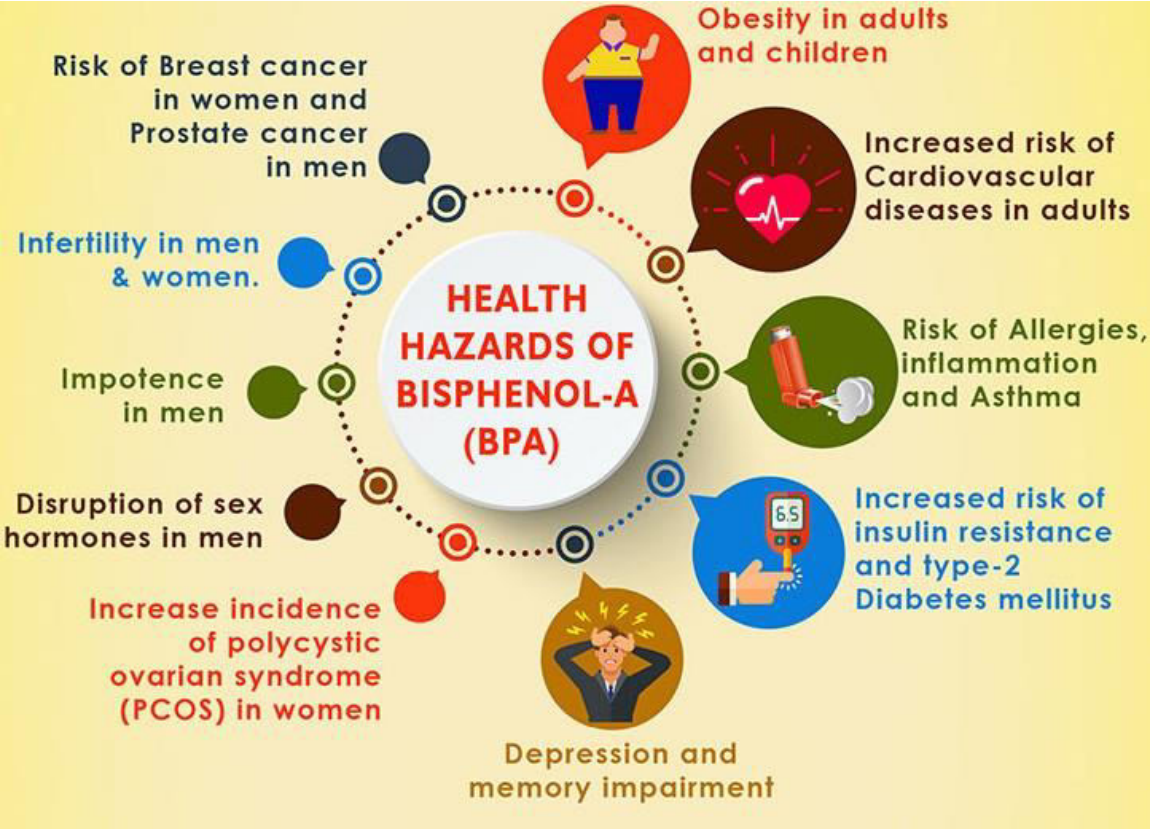


Schematic representation of the mechanism of action of BPA in the human body

Health problems associated with BPA

BPA has been linked to causing reproductive, immunity, and neurological problems, as well as an increased likelihood of Alzheimer's, childhood asthma, metabolic disease, type 2 diabetes, and cardiovascular disease.

- Several neurological health issues have been observed during pregnancy and development, like reduced lung capacity, wheezing and asthma after birth, leading to ban in the use of BPA in baby bottles.
- Studies have linked BPA and obesity; BPA exposure modifies insulin sensitivity and insulin release without affecting weight.
- Other endocrine-related disorders include infertility, polycystic ovarian syndrome (PCOS) and precocious puberty.
- BPA also disrupts thyroid function, binding to thyroid hormone receptor, and studies have linked BPA with increased TSH (Thyroid stimulating hormone).
- BPA exposure can lead to prostate cancer in men.



Summary of some health problems associated with BPA poisoning in the human body

Sources of BPA contamination

BPA can get in our body through eating or drinking foods heated in plastics; eating or drinking foods stored in metal cans (canned foods) or plastics (take-out containers); and touching cash register receipts. The major points of entry of bisphenol A into our body are summarized below.

- Major human exposure to BPA is diet, via ingestion of contaminated food and water.
- Plastics leach BPA when cleaned with harsh detergents, or when they contain acidic or high-temperature liquids.
- BPA-based resin coatings in older water pipes can leach BPA.
- Several uses of BPA in digital media, electrical and electronic equipment, sports safety equipment, electrical laminates in printed circuit boards, composites, paints and adhesives can also lead to exposure.
- Bioaccumulation in water bodies, aquatic plants and organisms can result in toxicity.
- BPA is also found in high concentrations in thermal and carbonless copy paper, used for printing receipts, airline tickets etc., and can be absorbed into body through skin.

Environmental effects of BPA

Even though BPA has a short half-life (4.5 days in soil and water, < 1 day in air), its ubiquity makes it an important pollutant. It has a low rate of evaporation from water and soil, which creates problems despite its biodegradability. It interferes with nitrogen fixation at the roots of certain leguminous plants. BPA affects growth, reproduction and development in aquatic organisms, especially fish, with endocrine-related effects observed in fish and other aquatic

invertebrates, amphibians and reptiles. It also impacts reproduction in terrestrial animals and insects, impairing development and inducing genetic aberrations.

Steps to limit BPA contamination

Heavy metal poisoning

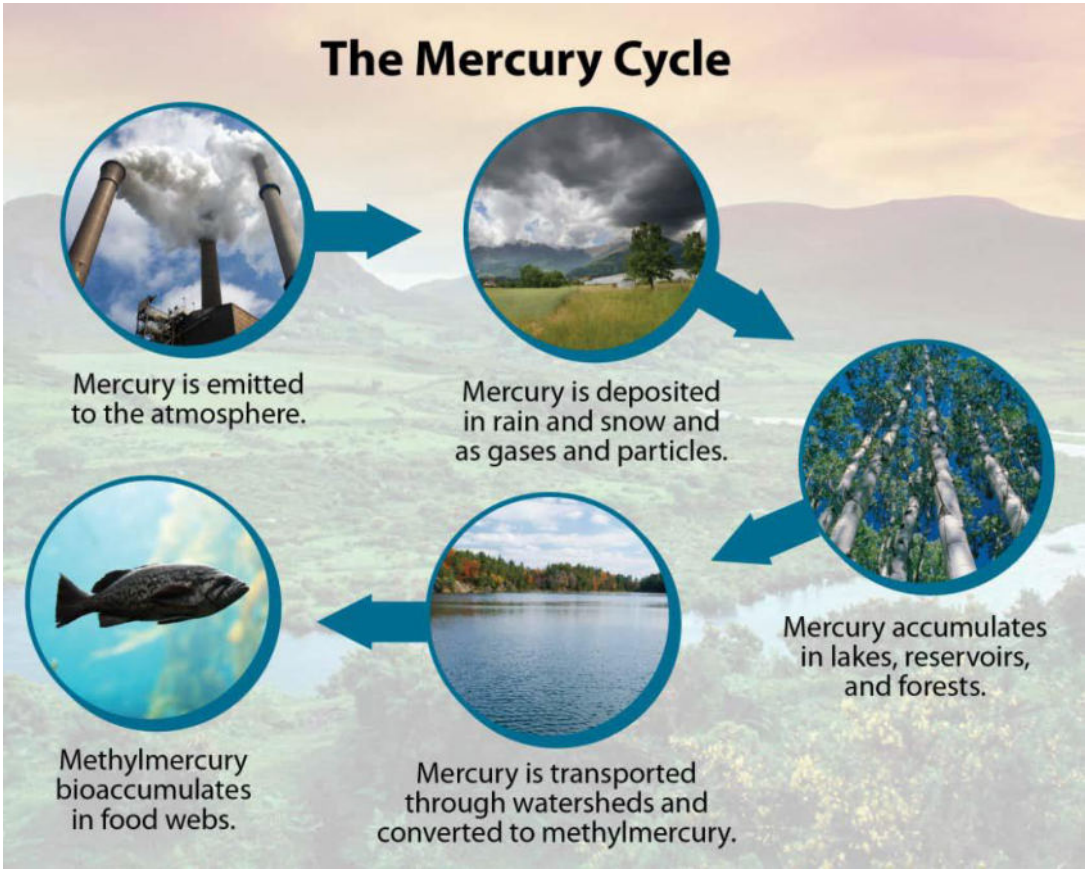
Heavy metal poisoning refers to when excessive exposure to a heavy metal affects the normal function of the body. Examples of heavy metals that can cause toxicity include lead, mercury, arsenic, cadmium, and chromium. Exposure may occur through the diet, from medications, from the environment, or in the course of work or play. Heavy metals can enter the body through the skin, or by inhalation or ingestion. Toxicity can result from sudden, severe exposure, or from chronic exposure over time.

Mercury

Mercury is a heavy metal belonging to the transition element series in the periodic table. It exists in nature in three forms: elemental, organic and inorganic, each with its own profile of toxicity. It is a liquid at room temperature; it has high vapour pressure and is released into the environment as mercury vapour. Its most commonly occurring oxidation states are +1 +2. Methylmercury is the most frequently encountered organic compound found in the environment, formed as a result of methylation of inorganic mercuric forms of mercury by microorganisms found in soil and water.

Mercury in the Environment

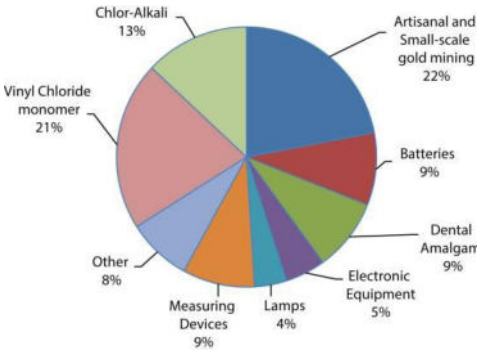
Mercury is a widespread environmental toxicant and pollutant, inducing severe alterations in the body and a wide range of adverse health effects. It is ubiquitous in the environment, therefore, making it difficult for plants, animals and humans alike to avoid exposure.



Schematic representation of the different forms of mercury in the environment. *[Source: https://webcam.srs.fs.fed.us/impacts/mercury/index.shtml]*

Uses of Mercury

- Electrical industry (switches, thermostats, batteries)
- Dental fillings
- Industrial processes (production of caustic soda)
- Nuclear reactors
- Anti-fungal agents for wood processing
- Solvent for reactive and precious metals



Sources of Mercury Poisoning

- Major sources of exposure to mercury are through accidents, environmental pollution, food contamination, dental care, preventive medical practices, industrial and agricultural operations such as non-ferrous metal production, cement production etc.
- Major sources of chronic low level mercury exposure are through dental amalgams (50% elemental mercury) and fish consumption.
- Mercury exposure can also occur by inhaling contaminated air, and improper use/disposal of mercury-containing objects after spills or disposal of fluorescent lamps.
- Human activities that can result in Mercury release into environment: burning of coal (half of atm. mercury) and gold mining.

- Mercury enters water either through Earth's crust or through industrial pollution, which are methylated by algae and bacteria in the water, which then bioaccumulates in fish, and eventually into humans.
- Two most highly absorbed species: Hg(0) and methyl mercury.

Mechanism of Mercury in the Human Body

- Elemental mercury vapour is highly lipophilic and effectively absorbed through lungs and tissues lining the mouth.
- After mercury enters the blood, it rapidly passes through cell membranes, including both the blood-brain-barrier (BBB) and placental barrier (PB).
- Within the cell, it is oxidized to its highly reactive +2 state.
- Methyl mercury, from fish, is readily absorbed in the gastrointestinal tract because of its lipid solubility, and can cross the BBB and PB.
- Once absorbed, mercury has a very low excretion rate, accumulating in kidneys, neurological tissues and liver, resulting in gastrointestinal toxicity, neuro and nephrotoxicity.

Adverse Health Effects of Mercury

- Brain is the target organ for mercury, but it can also impair any organ leading to malfunctioning of nerves, kidney and muscles.
- Mechanism: mercury binds to free thiol groups (cysteine residues).
- Symptoms depend on the type, dose and duration of exposure, including peripheral neuropathy, skin discolouration (pink), swelling and desquamation (shedding or peeling of skin).
- Mercury is neurotoxic, responsible for microtubule destruction, mitochondrial damage, lipid peroxidation etc.
- High-levels of exposure to mercury: Minamata disease.
- Symptoms: acrodynia (pink disease) skin becomes pink and peels, kidney problems, decreased intelligence.

Treatment and Prevention

- Mercury poisoning can be reduced by eliminating/reducing exposure to mercury and related compounds.
- Powdered sulfur may be applied in case of a spill, resulting in a solid compound that can be easily disposed off of.

Treatment

- First step is decontamination, disposal of clothes, washing skin with soap and water, flushing eyes with saline as needed.
- Chelation therapy with DMSA and other sulfur-based compounds are effective for inorganic mercury poisoning.
- DMSA can be used against severe mercury poisoning.

Nuclear Hazards

Nuclear hazards

Nuclear hazards are caused by radioactive substances that pose a risk to human health/environment. These radioactive substances can be either naturally occurring or man-made.

Natural Sources of Radiation

Cosmic radiation from outer space, quantity depends on altitude and latitude (higher at higher altitudes and latitudes). Terrestrial radiation: Emissions from radioactive elements from the Earth's crust, e.g., radon-222, soil rocks, air, water and food containing one or more radioactive materials. Internal radiation: All people contain radioactive potassium-40, carbon-14, lead-210 and other isotopes inside their bodies from birth.

Anthropogenic Sources of Radiation

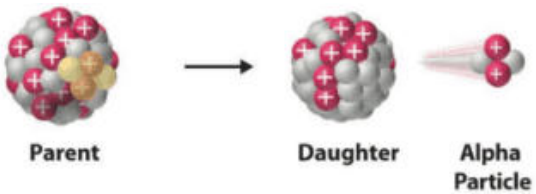
Some of the anthropogenic sources of radiation include:

1. Radiation emitted during the mining and processing of radioactive ores.
2. Radioactive materials in nuclear power plants and reactors, both raw materials and nuclear waste.
3. Radioactive fallouts during nuclear weapons testing, both on the surface, and in the oceans can also release a large amount of radiation. So too can leaks/accidents in nuclear power plants.
4. Radioactive isotopes in medical technology (x-ray machines, radioisotopes used in medicine) also release radiation.

Types of Ionizing Radiations Emitted

When a radioactive nucleus undergoes decay, it breaks up into several smaller atoms, also called daughter isotopes, along with various types of ionizing radiations, which can be divided into three types.

Alpha particles: are released when a radioactive nucleus breaks up into daughter isotopes and positively charged helium atoms, also called alpha radiations. These are inherently positively charged. They have low penetrating power, and can be easily blocked by a sheet of paper or cardboard. They move relatively slowly, and are attracted by negative charges.

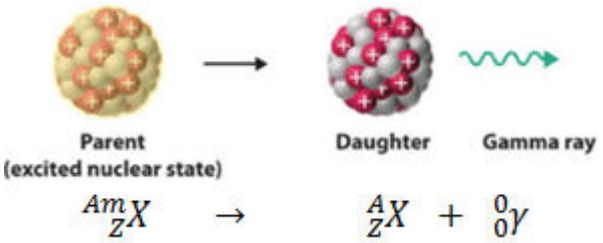


$$^{A}_{Z}X \rightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}He$$

$$^{A}_{Z}X \longrightarrow {}^{A}_{Z+1}X' + {}^{0}_{-1}\beta$$

Beta particles: on the other hand, are produced when a parent isotope undergoes decay into daughter isotopes, along with the release of electrons, also called beta radiations. These are usually high-speed electrons with high penetrating power, requiring a thin aluminium plate to stop. Being electrons, they are negatively charged, and are deflected by positive charges.

Gamma rays: are photons that move at the speed of light. They are electromagnetic waves and can be blocked only a thick lead or concrete block. They are not affected by electric charges, either positive or negative, and are neutral in nature.



Effects of Radioactive Poisoning

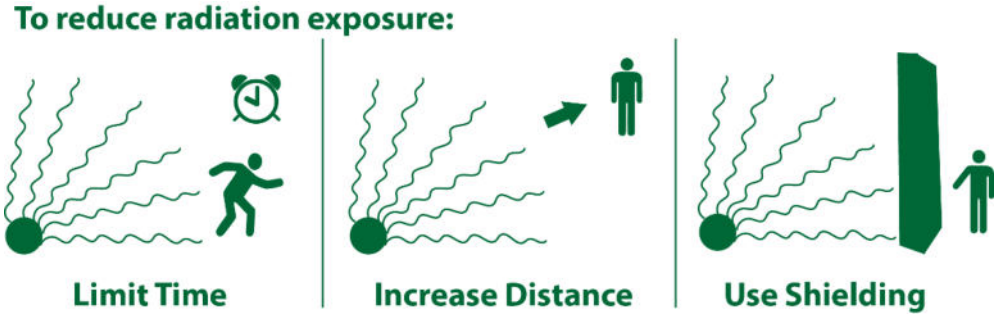
Radioactive emissions can penetrate biological tissues. For this reason, radiation is used to destroy cancerous tumours. But high levels of radiation > 100 rem can cause cell division blockage, prevents the normal replacement of blood, skin and other tissues, resulting in radiation sickness, and finally death.

- Very high doses of radiation may totally destroy cells, causing immediate death
- Lower doses may damage DNA, causing malignant tumours, cancers such as leukaemia. It also weakens the immune system, causing mental retardation and cataracts.
- DNA mutations affect genes and chromosomes, and are often carried over to offspring, up to several generations
- Acute exposure: burns and radiation sickness, burns, miscarriages, eye cataract, cancers of bone, thyroid, skin, lungs etc.

Protection from Radioactive Pollution

In case of a leak, there are only three ways in which we can protect ourselves from radioactive pollution.

- **Exposure time:** the lesser the amount of time that you are exposed for, the lower the dose of radiation that you will receive.
- **Distance:** the farther away that you are from the source of radiation, the less intense its effects will be.
- **Shielding:** shielding yourself behind a thick concrete or lead door can stop most of the harmful ionizing radiation, since they are very good at withstanding penetration.



Case Study: Chernobyl Disaster

The Chernobyl disaster is considered the worst nuclear disaster in history both in terms of cost and casualties. It occurred on 26 April 1986 at the Chernobyl Nuclear Power Plant, near the city of Pripyat in the north of the Ukrainian SSR in the Soviet Union. It is one of only two nuclear energy accidents rated at seven—the maximum severity—on the International Nuclear Event Scale, the other being the 2011 Fukushima nuclear disaster in Japan. The accident was caused by the malfunctioning of one of the steam turbines destabilizing the reactor. But this risk was not made

evident immediately. So, operators continued the testing. Instead of shutting down, an uncontrolled chain reaction began, resulting in a core melt down. Explosions ruptured the core, destroyed the building, resulting in an open-air reactor core fire, which released considerable radioactive contamination that was airborne, and spread for over 9 days, precipitating into other parts of the USSR and Western Europe, before ending on 4th May 1986. The reactor explosion killed two engineers immediately. Overall, 237 suffered from acute radiation sickness, of whom 31 died within the first three months. The most lethal radionuclides that spread from Chernobyl were iodine-131, caesium-134, caesium-137 and strontium-90. The initial emergency response, together with later decontamination of the environment, involved more than 500,000 personnel and cost an estimated 18 billion Soviet rubbles—roughly US$68 billion in 2019, adjusted for inflation.

The Chernobyl nuclear power plant in May 1986, a few weeks after the disaster

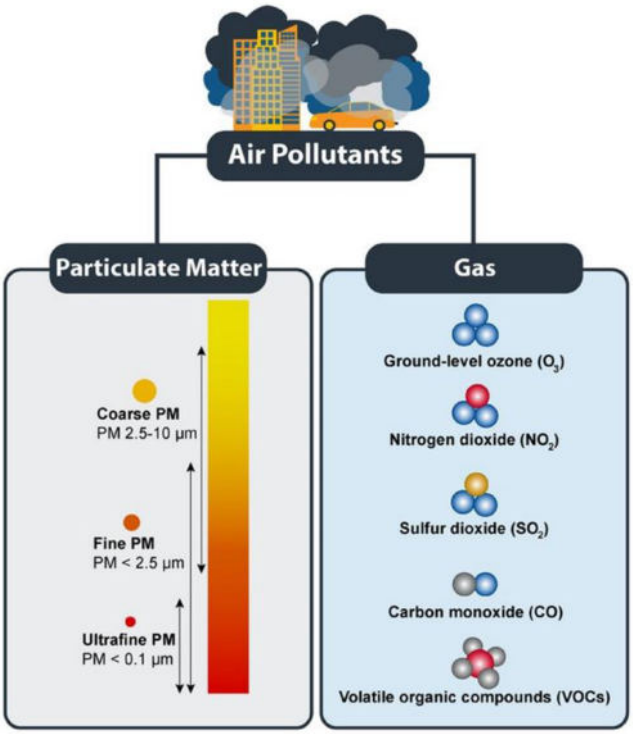
Air Pollution

Air Pollution

Air pollution is contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere. Household combustion devices, motor vehicles, industrial facilities and forest fires are common sources of air pollution. Pollutants of major public health concern include particulate matter, carbon monoxide, ozone, nitrogen dioxide and sulfur dioxide. Outdoor and indoor air pollution cause respiratory and other diseases and are important sources of morbidity and mortality.

Sources of Air Pollution

The sources of air pollution can be broadly classified into natural and anthropogenic. The natural sources include volcano, forest fire and pollens, organic compounds from plants, sea salt, suspended soils and dusts, etc. The anthropogenic sources include everything involving human activities such as:



Reprinted from Asian Pac J Allergy Immunol DOI 10.12932/AP-100619-0579

Anthropogenic sources of air pollution:

1) Burning of fossil fuels and motor vehicle exhausts:

These can include gases emitted by the burning of fossil fuels and vehicle exhausts. This means that road traffic is one of the biggest sources of air pollution. Vehicles emit nitrogen oxides, carbon dioxide, carbon monoxide and particulate matter. Trains pollute a lot less than cars. But they also cause pollution, since they utilize a large amount of electricity produced by power stations, which produces large quantities of nitrogen oxides, carbon dioxides, sulfur dioxides and particulate matter. These pollutants may be categorised as primary or secondary pollutants.

2) Agriculture:

Animals like cows and sheep release a massive amount of methane through belching and breaking wind. Methane is a colourless gas which is produced in their stomachs when bacteria break down the food that they eat. Across the whole world, livestock is the biggest source of methane. Methane is the second most important greenhouse gas which can cause climate change.

3) Waste disposal:

Waste disposal from landfills is the largest producer of methane emitted after agriculture and livestock rearing.

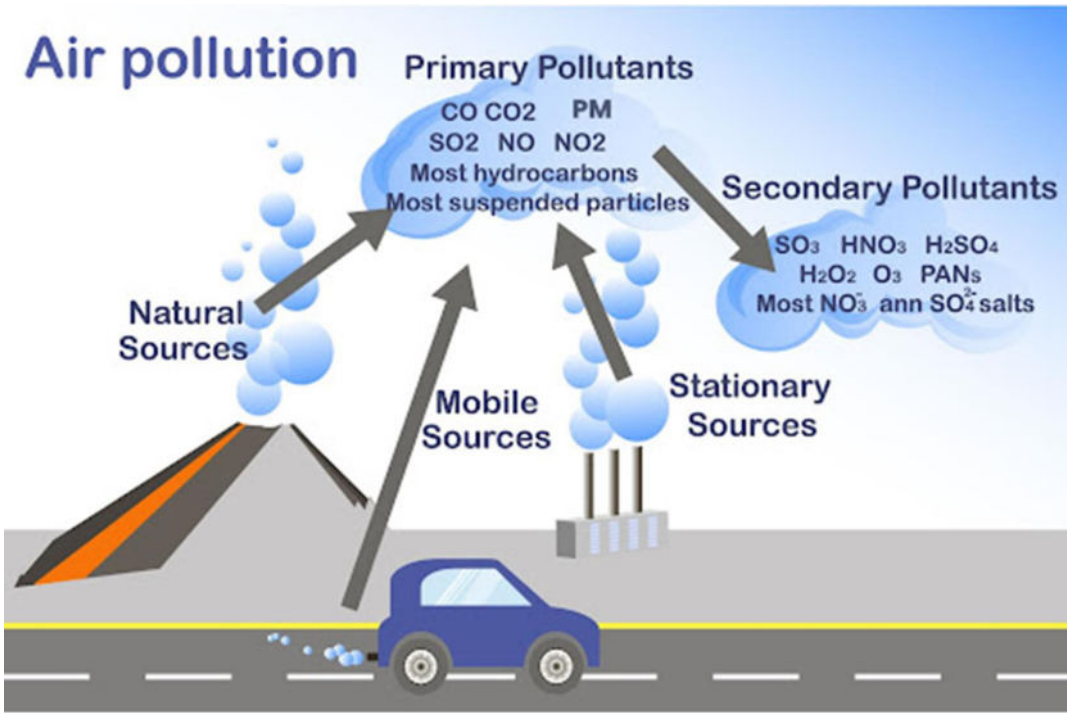
Primary Pollutants

Primary pollutants are directly emitted to the atmosphere, Air pollutants may have a natural, anthropogenic or mixed origin, depending on their sources or the sources of their precursors. Key primary air pollutants include particulate matter (PM), black carbon (BC), sulphur oxides (SO_2), nitrogen oxides (NO_X) (including nitrogen monoxide and nitrogen dioxide, NO_2), ammonia (NH_3), carbon monoxide (CO), methane (CH_4), non-methane volatile organic compounds (NMVOCs), including benzene, and certain metals and polycyclic aromatic hydrocarbons, including benzo[a]pyrenes (BaP).

Secondary Pollutants

Secondary pollutants are formed in the atmosphere from precursor gases through chemical reactions and microphysical processes. Key secondary air pollutants are PM, ozone (O_3), NO_2 and several oxidised volatile organic compounds (VOCs). Key precursor gases for secondary PM are sulphur dioxide (SO_2), NO_X, NH_3 and VOCs. These pollutants and their precursor gases can be of both natural and anthropogenic origin including:

- Burning of fossil fuels in electricity generation, transport, industry and households
- Industrial processes and solvent use, for example in the chemical and mining industries;
- Agriculture
- Waste treatment
- Natural sources, including volcanic eruptions, windblown dust, sea-salt spray and emissions of volatile organic compounds from plants



Primary and Secondary Air Pollutants

Reprinted from: https://www.clarity.io/blog/how-measuring-different-types-of-air-pollutants-creates-a-more-holistic-picture-of-air-pollution

Types of Air Pollutants

The following pollutants form the major category of air pollutants.

Carbon monoxide (CO):

Carbon monoxide (CO) is a colorless, odorless, and highly toxic gas that forms during the incomplete combustion of carbon-containing materials. Major sources are motor vehicle exhaust, burning of forests and grasslands, smokestacks of fossil fuel–burning power plants and industries, tobacco smoke, and open fires and inefficient stoves used for cooking. Carbon monoxide can combine with hemoglobin in red blood cells, which prevents the normal binding of oxygen with hemoglobin molecules. This in turn reduces the ability of blood to transport oxygen to body cells and tissues. Long-term exposure can trigger heart attacks and aggravate lung diseases such as asthma and emphysema. At high levels, CO can cause headache, nausea, drowsiness, confusion, collapse, coma, and death.

Carbon dioxide:

Carbon dioxide (CO_2) is a colorless, odorless gas. About 93% of the CO_2 in the atmosphere is the result of the natural carbon cycle. The rest comes from human activities, mostly the burning of fossil fuels and the clearing of CO2-absorbing forests and grasslands. CO2 is being added to the atmosphere faster than it is removed by the natural carbon cycle. This can contribute to human health problems such as heat exhaustion and to the reduction of food supplies in some areas, while causing water shortages, prolonged drought, or excessive flooding in other areas.

Nitrogen oxides:

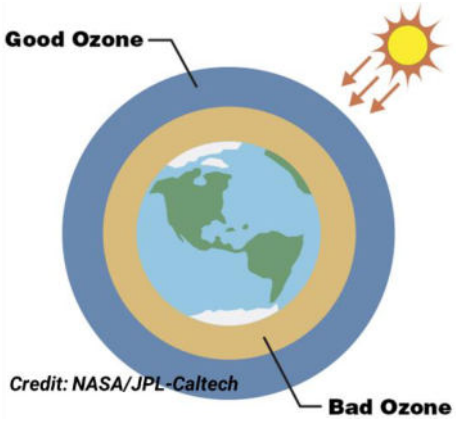
Nitrogen oxides are emitted during fuel combustion from industrial facilities and the road transport sector. NO_X is a group of gases comprising nitrogen monoxide (NO) and nitrogen dioxide (NO_2). NO makes up the majority of NO_X emissions. NO_X contributes to the formation of ozone and particulate matter.

Sulfur dioxide:

Sulphur dioxide is formed and emitted by combustion of fossil fuels (mainly coal and oil) primarily for electricity generation. High concentrations of SO_2 are associated with multiple health and environmental effects. The highest concentrations of SO_2 have been recorded in the vicinity of large industrial facilities. SO_2 emissions are an important environmental issue because they are a major precursor to ambient $PM_{2.5}$

Ground-level ozone:

Ground level ozone is created when sunlight reacts with, volatile organic compounds (VOCs) and nitrous oxides (NOx). When particles in the air combine with ozone, they create smog. Smog is a type of air pollution that looks like smoky fog and makes it difficult to see. These can be transported long distances by wind.



Photochemical smog:

Photochemical smog also results from interactions between different air pollutants. This smog has a brown haze and can be painful to the eyes, accounting for most of the smog we see today. Photochemical smog forms from interactions between particulates, nitrogen oxides, ozone, and other air pollutants, though primarily from VOCs and NOx since ozone comprises a large portion of this smog.

Beijing on a clear day after a rain (left) and on a smoggy day (right)
Credit: Bobak via Wikimedia Commons

Suspended Particulate Matter (SPM):

Particulate matter is a mixture of aerosol particles (solid and liquid) covering a wide range of sizes and chemical compositions. PM is either directly emitted as primary particles or it forms in the atmosphere from emissions of certain precursor pollutants such as SO_2, NOx, NH_3. SPM is emitted from many anthropogenic sources, including both combustion and non-combustion sources. Natural emissions of PM also occur, including from sea salt and windblown Saharan dust.

Volatile Organic Compounds (VOCs)

Volatile organic compounds (VOCs) are emitted as gases from certain solids or liquids. VOCs include a variety of chemicals, some of which may have short- and long-term adverse health effects.

Management of Air Pollution

Air pollution management aims at the elimination or reduction to acceptable levels, of airborne gaseous pollutants, suspended particulate matter and physical and, to a certain extent, biological agents whose presence in the atmosphere can cause adverse effects on human health, deleterious effects on animal or plant life, damage to materials of economic value to society and damage to the environment

Health Effects of Air Pollution

Our body has a number of natural defence mechanisms to help protect us against air pollution. But prolonged or acute exposure to air pollutants, including tobacco smoke can overload or break down these natural defenses.

- Years of smoking or breathing polluted air can lead to other lung ailments such as chronic bronchitis and emphysema, which leads to acute shortness of breath and usually to death.
- Inhalation of small, fine and ultra-fine particles added to the atmosphere by coal-burning power plants causes asthma attacks and other respiratory disorders.

Steps to Reduce Air Pollution

The best air quality management methods stress that the air pollutant emissions should be kept to a minimum. Some of the methods that can be used to reduce or minimize air pollution are:

- Enforcement of the use of catalytic converters in vehicles or of emission standards in incinerators
- Shut-down of factories or reduction of traffic during unfavourable weather conditions
- Strict laws for emission of pollutants, which emphasize prevention of emission
- Stricter laws need to be enforced on coal-burning power plants and industrial facilities so that the harmful emissions of sulfur dioxides and nitrogen oxides can be controlled
- Use of air pollution control devices such as chemical scrubbers in emission towers that can capture most of the harmful chemicals that might be emitted in industries. E.g., SO_2 can be removed by use of a lime scrubber
- Control devices such as inertial separators for particular matter and wet collectors
- Safe disposal methods to reduce the effects of the harmful agents
- Tax each unit of pollutant produced

We, as individuals can take a few steps to reduce consumption of energy and air pollution. They are summarized as follows.

1. Walk, bike or use public transportation to reduce air pollution
2. Minimize pollution from cars by prevention of idling
3. Save energy and make sure you use energy efficiently
4. Recycle and reuse
5. Consume less and choose sustainable products
6. Avoid/minimize plastic bags
7. Reduction of forest fires and smoking
8. Use of fans instead of Air conditioners
9. Use filters for chimneys
10. Avoid usage of crackers
11. Avoid using of products with chemicals
12. Implement Afforestation

Water Pollution

Water Pollution

Water pollution is the contamination of water sources by substances which make the water unusable for drinking, cooking, cleaning, swimming, and other activities. Pollutants include chemicals, trash, bacteria, and parasites. All forms of pollution eventually make their way to water. Water bodies include lakes, rivers, oceans, aquifers, reservoirs and groundwater. Water pollution results when contaminants are introduced into these water bodies. Water pollution can be attributed to one of four sources: sewage discharges, industrial activities, agricultural activities, and urban runoff including stormwater.

Sources of Water Pollution

Sources of water pollution are either point sources or non-point sources.

1) Point Sources

Point sources have one identifiable cause, such as a storm drain, a wastewater treatment plant or an oil spill. Because point sources are located at specific places, they are fairly easy to identify, monitor, and regulate.

Point Source of water pollution

2) Non-point Sources

Nonpoint sources are broad and diffuse areas, rather than points, from which pollutants enter bodies of surface water or air. Examples include runoff of chemicals and sediments from cropland, livestock feedlots, logged forests, urban streets, parking lots, lawns, and golf courses.

Nonpoint sediment pollution eroded from farmland flows into streams

Types of Water Pollution

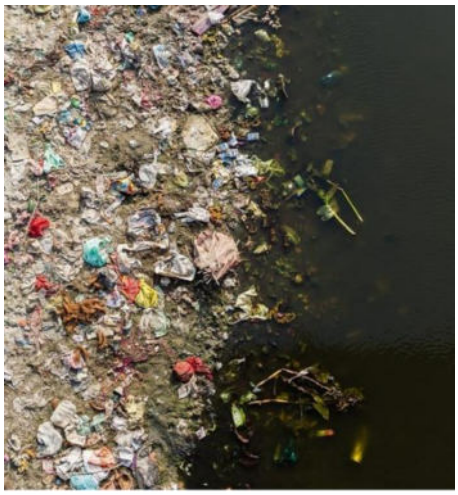
1) Ground-water Pollution

Groundwater gets polluted when contaminants—from pesticides and fertilizers to waste leached from landfills and septic systems—make their way into an aquifer, rendering it unsafe for human use. Ridding groundwater of contaminants can be difficult to impossible, as well as costly. Once polluted, an aquifer may be unusable for decades, or even thousands of years. Groundwater can also spread contamination far from the original polluting source as it seeps into streams, lakes, and oceans. Common sources of ground water pollution include septic tanks, industries like textile, chemical and tanneries, deep well injections, mining, etc.

2) Surface-water Pollution

Covering about 70 percent of the earth, surface water constitutes our oceans, lakes, rivers, streams, etc. Major sources of surface water pollution are:

1. Sewage: emptying drains and sewers
2. Industrial effluents: industrial waste containing toxic chemicals, acids, alkalis, salts and radioactive waste
3. Synthetic detergents: in washing and cleaning
4. Agrochemicals: fertilizers, insecticides and pesticides
5. Oil: spillage into sea during drilling and shipment
6. Waste heat: from industrial discharges increases water temperature and affects the distribution and survival of sensitive species



Surface water Pollution

Types of Contaminants

Water pollutants can be classified as organic pollutants, inorganic pollutants, pathogens, suspended solids, nutrients and agriculture pollutants, thermal, radioactive, and other pollutants. Organic and inorganic pollutants are mainly discharged from industrial effluents and sewage into the water bodies.

1) Organic Contaminants

The following are the types of organic contaminants that are responsible for water pollution

- Detergents
- Food processing waste: fats, grease, oxygen demanding substances
- Insecticides and herbicides: organohalides
- Petroleum hydrocarbons: fuels, lubricants and fuel combustion products
- Volatile organic compounds: industrial solvents
- Chlorinated solvents (PCBs, trichloroethylene)
- Drug pollution
- Personal hygiene and cosmetic products

2) Nitrogen and Phosphorus Compounds

Addition of compounds containing nitrogen and phosphorus helps in the growth of algae and other plants that consume DO after death. Foul smelling gases are produced under anaerobic conditions. Excess growth or decomposition of plant material changes CO2 concentrations, thereby affecting water pH. These changes in DO, oxygen and temperature change the physicochemical properties of water.

3) Inorganic Compounds

The following inorganic contaminants are responsible for water pollution. They are

- Acidity caused by industrial discharge (SO_2)
- Ammonia from food processing waste

- Chemical waste
- Fertilizers containing nutrients (nitrates and phosphates)
- Heavy metals from moto vehicles and acid mine drainage
- Silt/sediment

4) Pathogens

Wastewater sewage contain several pathogenic and non-pathogenic microorganisms and viruses that can cause water-borne diseases such as cholera, dysentery, typhoid, jaundice etc. Coliform bacteria do not cause an actual disease, but is used as a bacterial indicator of water pollution. High levels of pathogens may result from on-site sanitation systems (septic tanks, pit latrines) or inadequately treated sewage discharges. Combined sewers in certain cities discharge untreated sewage during rain storms that can result in contamination. Pathogen discharge can also be caused by poorly managed livestock operations.

5) Macroscopic Pollution

They are large, visible items polluting water, also called floatables or marine debris found in open seas, including

- Trash/garbage: discarded by people, or washed by rainfall into storm drains and eventually reaching surface waters
- Nurdles: small ubiquitous waterborne plastic pellets
- Shipwrecks: large, derelict ships

6) Thermal Pollution

Thermal pollution, sometimes called "thermal enrichment", is the degradation of water quality by any process that changes ambient water temperature. A common cause of thermal pollution is the use of water as a coolant by power plants and industrial manufacturers. Thermal pollution can also be caused by the release of very cold water from the base of reservoirs into warmer rivers. Fish and other organisms adapted to particular temperature range can be killed by an abrupt change in water temperature (either a rapid increase or decrease) known as "thermal shock".

7) Radioactive Substances

Radioactive waste is any pollution that emits radiation beyond what is naturally released by the environment. It's generated by uranium mining, nuclear power plants, and the production and testing of military weapons, as well as by universities and hospitals that use radioactive materials for research and medicine. Radioactive waste can persist in the environment for thousands of years, making disposal a major challenge.

Table 20-1 Major Water Pollutants and Their Sources

Type/*Effects*	Examples	Major Sources
Infectious agents (pathogens) *Cause diseases*	Bacteria, viruses, protozoa, parasites	Human and animal wastes
Oxygen-demanding wastes *Deplete dissolved oxygen needed by aquatic species*	Biodegradable animal wastes and plant debris	Sewage, animal feedlots, food-processing facilities, paper mills
Plant nutrients *Cause excessive growth of algae and other species*	Nitrates (NO_3^-) and phosphates (PO_4^{3-})	Sewage, animal wastes, inorganic fertilizers
Organic chemicals *Add toxins to aquatic systems*	Oil, gasoline, plastics, pesticides, fertilizers, cleaning solvents	Industry, farms, households, mining sites, runoff from streets and parking lots
Inorganic chemicals *Add toxins to aquatic systems*	Acids, bases, salts, metal compounds	Industry, households, mining sites, runoff from streets and parking lots
Sediments *Disrupt photosynthesis, food webs, other processes*	Soil, silt	Land erosion from farms and construction and mining sites
Heavy metals *Cause cancer, disrupt immune and endocrine systems*	Lead, mercury, arsenic	Unlined landfills, household chemicals, mining refuse, industrial discharges
Thermal *Make some species vulnerable to disease*	Heat	Electric power and industrial plants

Effects of Water Pollution

- **Increase of oxygen demand:** Demand of O_2 increases with addition of biodegradable organic matter, expressed as biological oxygen demand (BOD)
- **Diseases:** In humans, drinking or consuming polluted water in any way has many disastrous effects on our health. It causes typhoid, cholera, hepatitis and various other diseases.
- **Destruction of Ecosystems:** Ecosystems are extremely dynamic and respond to even small changes in the environment. Water pollution can cause an entire ecosystem to collapse if left unchecked.
- **Biomagnification:** Non-biodegradable waste biomagnifies, causing toxic effects at various levels of the food chain. Several chemicals such as DDT are not water soluble, and tend to accumulate in body lipids, building up at successive levels of the food chain.
- **Eutrophication:** Chemicals in a water body, encourage the growth of algae. These algae form a layer on top of the pond or lake. Bacteria feed on these algae and this decreases the amount of oxygen in the water body, severely affecting the aquatic life there.
- **Effects the food chain:** Disruption in food chains happens when toxins and pollutants in the water are consumed by aquatic animals (fish, shellfish etc) which are then consumed by humans.

Control of Water Pollution

The best way to protect streams from pollution is to prevent it at the source. The following are some of the methods that can be implemented to control water pollution.

- Judicious use of pesticides and fertilizers
- Use of nitrogen-fixing plants
- Prevent manure run-off into surface water, instead divert them into basins for settlement that can be used later as fertilizer
- Separate drainage of sewage and rain water to prevent overflow and contamination
- Planting trees would reduce pollution by preventing runoff

- Treatment of wastewater is essential to prevent pollution from point sources
- Parameters considered for water quality: BOD, chemical oxygen demand (COD), nitrates, phosphates, oil and grease, toxic metals
- Waste water should be treated properly by primary and secondary methods to reduce BOD, COD levels up to permissible levels for discharge

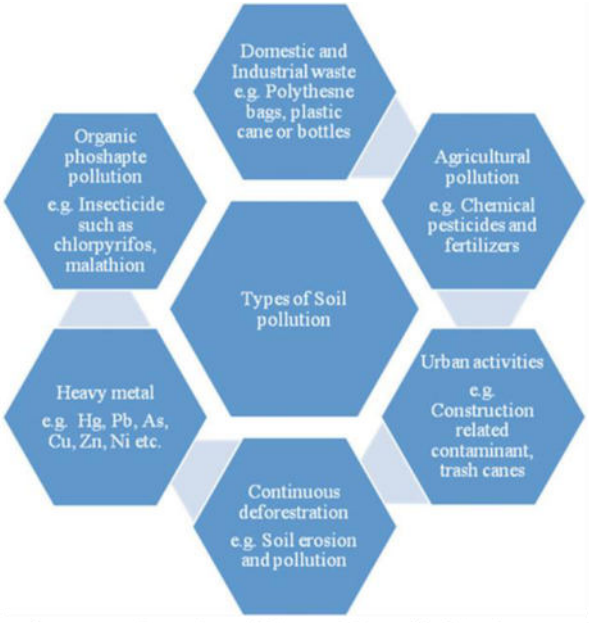
Soil Pollution

Soil Pollution

Soil contamination, soil pollution, or land pollution as a part of land degradation is caused by the presence of xenobiotic (human-made) chemicals or other alteration in the natural soil environment. It is typically caused by industrial activity, agricultural chemicals or improper disposal of waste. Contamination is correlated with the degree of industrialization and intensity of chemical substance. The concern over soil contamination stems primarily from health risks, from direct contact with the contaminated soil, vapour from the contaminants, or from secondary contamination of water supplies within and underlying the soil.

Types of Soil Pollutants

All soils, whether polluted or unpolluted, contain a variety of compounds (contaminants) which are naturally present. Such contaminants include metals, inorganic ions and salts (e.g. phosphates, carbonates, sulfates, nitrates), and many organic compounds (such as lipids, proteins, DNA, fatty acids, hydrocarbons, PAHs, alcohols, etc.). These compounds are mainly formed through soil microbial activity and the decomposition of organisms (e.g., plants and animals). Additionally, various compounds get into the soil from the atmosphere, for instance with precipitation water, as well as by wind activity or other types of soil disturbances, and from surface water bodies and shallow groundwater flowing through the soil. When the amounts of soil contaminants exceed natural levels (what is naturally present in various soils), pollution is generated. This can occur through anthropogenic (man-made) causes as well as natural causes.

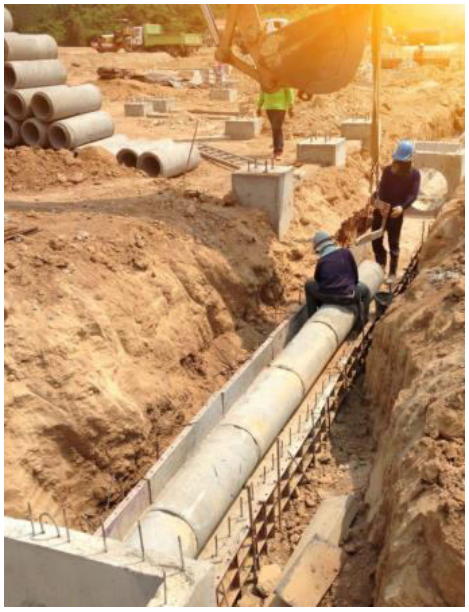


Types of soil pollutants. Reprinted from *Microbial Rejuvenation of Polluted Environment*, Vol I, Chapter: 8; DOI: 10.1007/978-981-15-7447-4_8

Anthropogenic Soil Pollutants

Anthropogenic (man-made) soil pollution originates in several types of processes, some deliberate (industrial) and others, accidental. Human-caused soil pollution can work in conjunction with natural processes to increase the toxic contamination levels in the soil.

- Accidental spills and leaks during storage, transport or use of chemicals (e.g., leaks and spills of gasoline and diesel at gas stations)
- Foundry activities and manufacturing processes that involve furnaces or other processes resulting in the possible dispersion of contaminants in the environment;
- Mining activities involving the crushing and processing of raw materials, for instance, heavy metals, emitting toxic substances;
- Construction activities
- Agricultural activities involving the diffusion of herbicides, pesticides and/or insecticides and fertilizers;
- Transportation activities, releasing toxic vehicle emissions
- Chemical waste dumping, whether accidental or deliberate – such as illegal dumping;
- The storage of waste in landfills, as the waste products may leak into groundwater or generate polluted vapours
- Cracked paint chips falling from building walls, especially lead-based paint.



Construction sites are the most important triggers of soil pollution in urban areas, due to their almost ubiquitous nature. Almost any chemical substance handled at construction sites may pollute the soil. However, the higher risk comes from those chemicals that can travel more easily through the air as fine particulate matter. The chemicals that travel as particulate matter are more resistant to degradation and bioaccumulate in living organisms, such as PAHs.

Additionally, construction dust may easily spread around through the air and is especially dangerous because of its lower particle size (less than 10 microns). Such construction dust can trigger respiratory illnesses such as asthma and bronchitis, and even cancer. Moreover, the sites that involve the demolition of older buildings can release asbestos, a toxic mineral that can act as a poison in soil. Asbestos particles can be redistributed by the wind.

Natural Pollutants

Apart from the rare cases when a natural accumulation of chemicals leads to soil pollution, natural processes may also have an influence on the human released toxic chemicals into the soil, decreasing or increasing the pollutant toxicity and the level of contamination of the soil. This is possible due to the complex soil environment, involving the presence of other chemicals and natural conditions which may interact with the released pollutants.

The following are some of the natural processes leading to soil pollution:

- There may be a natural accumulation of compounds in soil due to imbalances between atmospheric deposition and leaking away with precipitation water (e.g., concentration and accumulation of perchlorate in soils in arid environments).
- Natural production in soil may also occur under certain environmental conditions (e.g., natural formation of perchlorate in soil in the presence of a chlorine source, metallic object and using the energy generated by a thunderstorm).
- Sewer lines may leak from into the subsurface (e.g., adding chlorine could generate trihalomethanes such as chloroform).

Effects of Soil Pollution

Soil pollution is devastating to the environment and has consequences for all forms of life that encounter it. The toxic substances that are deposited on the earth's surface harm our health and well-being and affect food, water and air quality directly and indirectly. The most important effects of soil pollution are indicated below:

1. Effect on Health of Humans

Considering how soil is the reason we are able to sustain ourselves, its contamination has major consequences on our health. Crops and plants grown on polluted soil absorb much of the pollution, which is then passed on to us. This could result in the sudden surge of certain illnesses. Long term exposure to such soil can affect the genetic make-up of the body, causing congenital illnesses and chronic health problems that cannot be cured easily. In fact, it can sicken the livestock to a considerable extent and cause food poisoning over a long period of time. The soil pollution can even lead to widespread famines if the plants are unable to grow in it.

There are three main routes where soil can directly enter the body: inhalation, eating, or through skin contact.

Inhalation

This route mostly affects people, like workers, who are continually working with soil or those who reside nearby such areas. These types of environments have fine dust particles floating around, which can be inhaled and eventually absorbed by the body.

Eating

Adults consume soil through accidental ingestion. An example of this is when the ingested food, like vegetables, still has some soil attached to it. However, in some parts of the world, the soil is deliberately consumed due to cultural reasons. On the other hand, children, especially those under the age of three, are at high risk for soil contamination exposure as they tend to eat soil while playing outdoors. In addition, their biological makeup is more likely to absorb more of the toxic chemicals than that of an adult.

Skin Contact

Also known as “dermal absorption” or “cutaneous absorption,” this route is most applicable to volatile organic compounds. However, some heavy metals do cause skin contact problems.

2. Effect on Growth of Plants

The ecological balance of any system gets affected due to the widespread contamination of the soil. Most plants are unable to adapt when the chemistry of the soil changes so radically within a short period of time. Fungi and bacteria found in the soil that bind it together, begin to decline,

which creates an additional problem of soil erosion. The fertility of the soil thus slowly diminishes, making the land unsuitable for agriculture and for any local vegetation to survive. Soil pollution causes large tracts of land to become hazardous to health.

3. Decreased Soil Fertility

The toxic chemicals present in the soil can decrease soil fertility, which in turn affects its yield. The contaminated soil is then used to produce fruits and vegetables, which lacks quality nutrients and may contain some poisonous substance that can cause serious health problems to the people consuming them.

4. Toxic Dust

The emission of toxic and foul gases that emanates from landfills pollutes the environment, causing serious health problems to people. Another side effect is the unpleasant smell causes that causes inconvenience to people living in the vicinity.

5. Changes in Soil Structure

Soil pollution can lead to the death of several soil organisms (e.g., earthworms) in the soil that can alter the soil structure. In addition, it could also force animals to migrate to other places in search of food.

6. Poisoning of the Underground Water Table

Soil pollution can also result in contamination of the underground water table. This water, being present beneath soil layers, the toxins can easily percolate slowly and steadily into the water table. Since this is the water that is available for consumption and usage through wells and tube wells, it causes a lot of ill effects on our health. Diseases like arsenic poisoning, food poisoning and others are caused due to the prolonged consumption of this toxic underground water. These diseases could also prove to be quite fatal.

Possible Solutions to Soil Pollution

With a global population that is projected to exceed 9 billion by 2050, our current and future food security hinges on our ability to increase yields and food quality using the soils that we already have available today. Soil pollution negatively impacts us all, and has been identified as one of the main threats to soil functions worldwide. We need to be aware of the causes of soil pollution so that we can create and implement solutions. Soil protection and conservation starts with us. Making sustainable food choices, properly recycling dangerous materials like batteries, composting at home to reduce the amount of waste that enters landfills or managing antibiotic waste more responsibly, are just a few examples of how we can be part of the solution. On a larger scale, we need to promote sustainable agricultural practices in our communities. Soil pollution is a complex problem that ought to be solved. It is essential that we all realize how important soil is for us. The earlier we realize, the better we will be able to solve this problem. It is a complex problem, and thus, it requires everyone, from an individual to the government, to work in complete unison. Listed below are a few things that could help in reducing soil pollution.

1. Reduced Use of Chemical Fertilizers

Chemical fertilizers do more harm than good. While proper amounts could enhance the fertility of the soil, excess of it actually poisons the soil. The excess of chemical fertilizers could pollute the soil in several ways. It could mess with the pH levels of the soil. It could also destroy the good microorganisms in the soil. Not only that, but the runoffs from such soils also cause water pollution as well. Thus, using chemical fertilizers is like a double-edged sword.

2. Promotion of Reforestation and Afforestation

One of the major causes of soil pollution is soil erosion due to deforestation. It is natural that with the ever-growing population, the humankind needs more and more space to expand their civilization. Often it is achieved at the cost of the health of the soil. To prevent this from happening, reforestation of a deforested area should be promoted. Also, afforestation should be promoted in the barren lands. The roots of the plants bind the soil particles together and even capture good microorganisms in the soil. It also ensures the maintenance of the underground water table.

3. Recycle and Reuse Products

These steps not only reduce waste generation but also ensure that soil pollution is reduced. At present, plastic forms a significant portion of the generated wastes. More often than not, these wastes are buried in landfills. In these landfills, these plastics and other materials decompose slowly and release toxic materials into the soil. These toxic substances are very harmful to the health of the soil and are a major source of soil pollution. By reusing and recycling things, we can ensure that lesser wastes are dumped in these landfills, and this, in turn, would reduce soil pollution.

4. Get the Locals Involved

In order to ensure that a problem like soil pollution is solved, it is essential that every individual must get involved. It is with their involvement that things can work out better. Awareness programs could be designed so that people understand soil pollution better. If people are aware, they will help even subconsciously.

5. Promote Use of Natural Manure

Natural manure is one of the best sources of nutrients for the soil. It is harmless and completely organic. It adds essential nutrients to the soil and restores the health of the soil. It has no harmful by-products that could harm the soil or the environment in any way.

Soil Waste Management

Soil Waste Management

Solid waste management refers to the process of collecting and treating solid wastes. It also offers solutions for recycling items that do not belong to garbage or trash. As long as people have been living in settlements and residential areas, garbage or solid waste has been an issue. Waste management is all about how solid waste can be changed and used as a valuable resource.

Solid waste refers to any unwanted or discarded material we produce that is not a liquid or a gas. Solid waste can be divided into two types.

1. **Industrial solid waste**: produced by mines, farms, and industries that supply people with goods and services.
2. **Municipal solid waste (MSW)**: often called garbage or trash, which consists of the combined solid waste produced by homes and workplaces. Examples include paper and cardboard, food wastes, cans, bottles, yard wastes, plastics, metals, glass and e-waste.
3. **Hazardous/toxic waste**: which threatens human health or the environment because it is poisonous, dangerously chemically reactive, corrosive, or flammable. Examples include industrial solvents, hospital medical waste, car batteries (containing lead and acids), household pesticide products, dry-cell batteries (containing mercury and cadmium), and incinerator ash.

Solid waste polluting a river

Waste Management

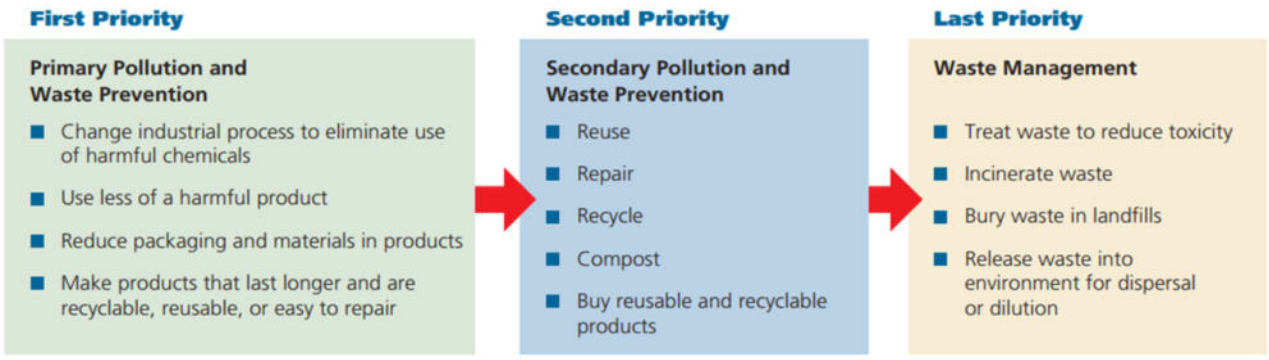
Solid waste can be dealt with in two ways, the first being waste management, while the second approach is waste reduction.

- **Waste Management** refers to controlling waste in ways so as to reduce their environmental harm without any serious efforts to reduce the amount of waste produced.
- **Waste Reduction** refers to the approach by which lesser amounts of waste and pollution is produced. So, there is greater emphasis on the reuse, recycling and composting of resources.

But there is no single solution to the solid waste problem. Most analysts call for using integrated waste management, which include a variety of coordinated strategies for both waste disposal and waste reduction.

Integrated Solid Waste Management

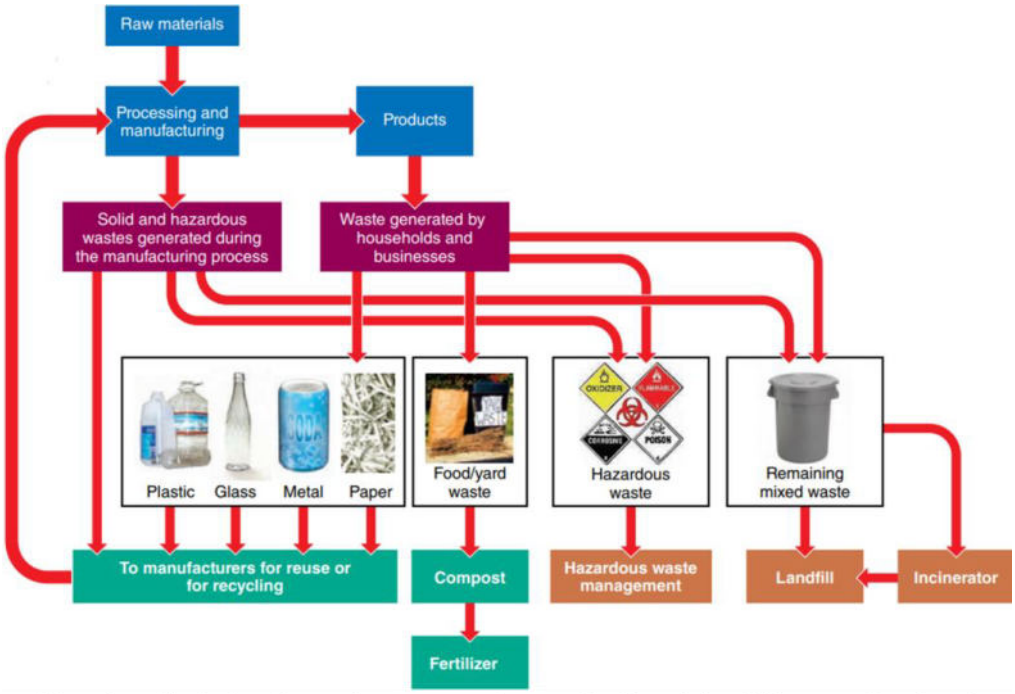
Integrated waste management has three main priorities for waste reduction and elimination.



Priorities to deal with waste according to Integrated Solid Waste Management. Reprinted from Fig 21-7, Living in the Environment, Tyler and Spoolman

It has three main priorities, which are summarized as follows:

1. The first priority is *control of pollution and waste prevention*. This involves changing industrial processes to eliminate the use of harmful chemicals. Swapping a more harmful product with a safer alternative; or, making products that last longer, and can be recycled, reused or are easy to repair.
2. The second priority is *control of secondary pollution and waste prevention*. This focuses mainly on the three Rs, i.e., reduce, reuse and recycle.
3. The third priority is *waste management*. This is adopted in cases where waste cannot be avoided, charting out safe methods to eliminate and dispose of hazardous waste, so that it does not cause further environmental pollution. This flow chart helps you understand the entire process of IWM. It lists out ways to deal with the different kinds of waste. E.g., plastic, glass, metal and paper can be reused or recycled, whereas, food waste or garden waste can be converted into compost. On the other hand, hazardous waste such as harmful chemicals and metals are dealt with in a different manner. They are either disposed off into sanitary landfills, so that it is burnt up in an incinerator.



Flowchart depicting the various approaches to dealing with solid waste. Reprinted from Fig 21-6, Living in the Environment, Tyler and Spoolman

Waste Disposal

Waste disposal refers to methods adopted in order to safely dispose off with waste in order to avoid further pollution and damage to the environment. Waste disposal can be done by either burning or burying solid waste. They can be classified into the following methods. Landfills: either open dumps or sanitary landfills, biocomposting, incineration

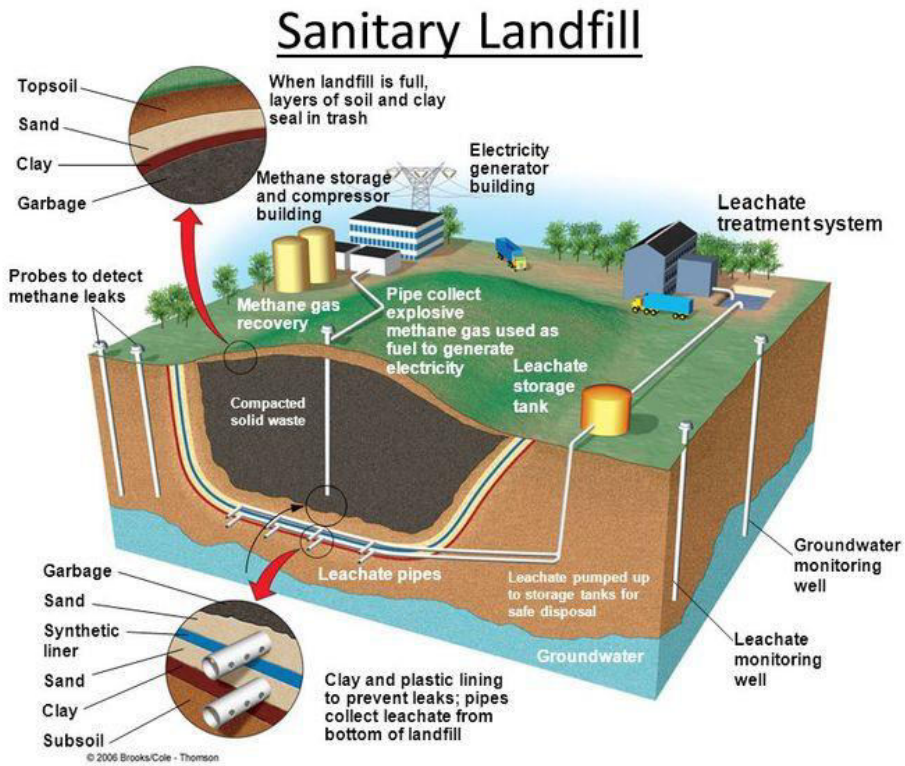
Open dumps

Open dumps are essentially fields or holes in the ground where garbage is deposited and sometimes burned. They are rare in more-developed countries, but are widely used near major cities in many less-developed countries, lacking a proper waste disposal system.

Sanitary landfills

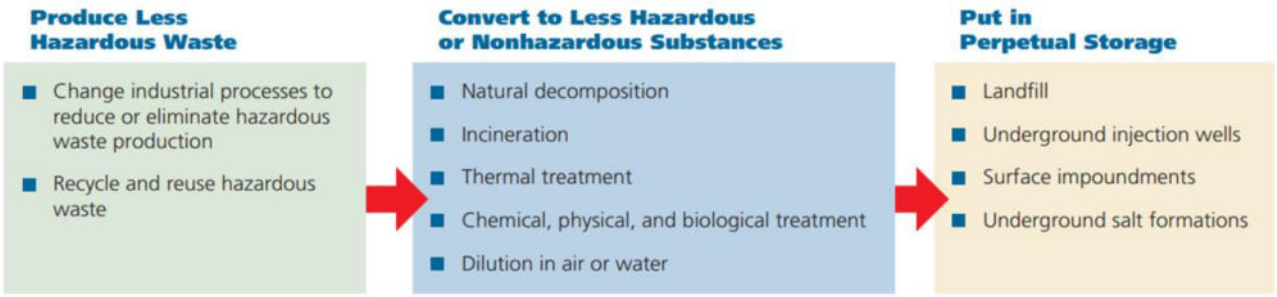
Sanitary landfills are a method of waste disposal in which solid wastes are spread out in thin layers, compacted and covered daily with a fresh layer of clay or plastic foam, which keeps the material dry and reduces leakage of contaminated water from the landfill. This covering also reduces the risk of fire, decreases odour and reduces accessibility to vermin. The bottom and sides are also lined with strong double liners and containment systems that collect liquid leaching (leachate) from them. Some are equipped with systems for collecting and burning methane, which is produced when wastes decompose in the absence of oxygen.

Sanitary landfills have their set of advantages and disadvantages. They are commonly used because they have low operating costs and can handle large amounts of waste. The filled land can also be used for other purposes. Certain disadvantages associated with sanitary landfills are: they can release greenhouse gases such as methane and carbon dioxide. They can contaminate the groundwater.



Disposal of hazardous waste

IWM suggests three priority levels in dealing with hazardous waste, namely, produce less; convert as much of it as possible to less hazardous substances; and put the rest in long-term, safe storage. The top priority should be pollution prevention and waste reduction. With this approach, industries try to find substitutes for toxic or hazardous materials, reuse or recycle the hazardous materials within industrial processes, or use them as raw materials for making other products.



Priorities to deal with hazardous waste according to Integrated Solid Waste Management. Reprinted from Fig 21-17, Living in the Environment, Tyler and Spoolman

Let us look at some of the methods to detoxify or dispose hazardous waste briefly. Some of the detoxification methods include: Physical methods, Chemical methods, Nanomagnets, Biological methods, Incineration and the Plasma arc torch method.

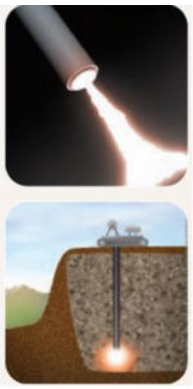
1. Physical methods for detoxifying hazardous wastes include using charcoal or resins to filter out harmful solids, distilling liquid wastes to separate out harmful chemicals, and precipitating, or allowing natural processes to separate, such chemicals from solution.

2. Chemical methods are used to convert hazardous chemicals to harmless or less harmful chemicals through chemical reactions. For example, cyclodextrin (a type of sugar made from cornstarch) is used to remove toxic materials such as solvents and pesticides from contaminated soil and groundwater. Cyclodextrin acts like a sponge picking up chemicals from the soil.

3. Nanomagnets are magnetic nanoparticles coated with certain compounds that can remove various pollutants from water. E.g., magnetic nanoparticles coated with chitosan, derived from the exoskeletons of shrimps and crabs, are used to remove oil and other organic pollutants from contaminated water. Magnetic fields are used to remove the pollutant-coated nanomagnets. The pollutants can then be separated out and disposed of or recycled, and the magnetic nanoparticles can be reused.

4. Biological methods are used for treatment of hazardous waste. Some of the methods used are bioremediation and phytoremediation, bioremediation utilizes Bacteria and enzymes help destroy toxic/hazardous substances, or convert them to harmless compounds. Phytoremediation involves using natural or genetically engineered plants to absorb, filter, and remove contaminants from polluted soil and water.

5. Plasma arc torch breaks them down at very high temperatures. Plasma

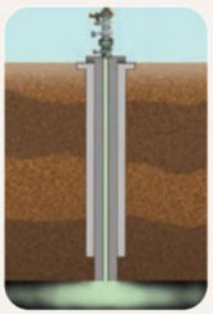


Plasma-Arc Torch Method

can decompose liquid or solid hazardous waste to gas consisting mostly of carbon monoxide (CO) and hydrogen (H_2) and a molten, glassy, solid material can be used to encapsulate toxic metals and keep them from leaching into groundwater. This method is not widely used due to its high cost.

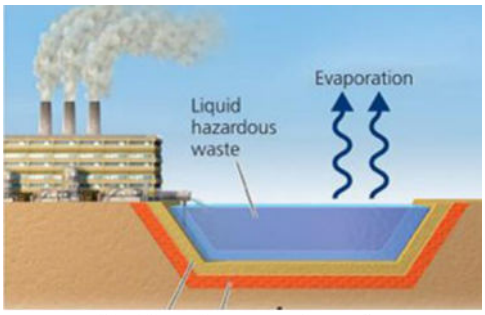
Storage of hazardous waste

Storage of hazardous waste such as burial or long-term storage should be considered as the third and final resort, after the first two priorities have been exhausted. The most commonly used disposal methods are deep-well disposal and surface impoundments.



Deep-well disposal

1. In **deep-well disposal**, liquid hazardous wastes are pumped under pressure through a pipe into dry, porous rock formations far beneath aquifers that are tapped for drinking and irrigation water. However, this fairly cheap, out-of-sight and out-of-mind approach presents some problems. There are a limited number of such sites and limited space within them. Sometimes the wastes can leak into groundwater from the well shaft or migrate into groundwater in unexpected ways.



Surface Impoundments

2. **Surface impoundments** are lined ponds, pits, or lagoons in which liquid hazardous wastes are stored as the water evaporates, the waste settles and becomes more concentrated. But using no liner, using leaking single liners, and failing to use double liners can allow such wastes to percolate into the groundwater, and because these impoundments are not covered, volatile harmful chemicals can evaporate into the air.
3. **Secure hazardous waste landfills:** are used for waste that cannot be destroyed, detoxified or safely buried. In such cases, they are put into metal drums or containers that are buried in salt mines or bedrock caverns, where they can be inspected on a regular basis, and retrieved, if necessary.

Steps to reduce waste as an individual

- Follow the three Rs, i.e., reduce, reuse and recycle.
- Try to avoid packaging material whenever possible when you buy a particular item.
- Rent, borrow or barter goods and services when you can buy second-hand, and donate or sell unused items.
- Buy things that are reusable, recyclable or compostable, and be sure to reuse, recycle and compost them.
- Avoid disposables and throwaway paper and plastic cups, eating utensils and other disposable items when reusable versions are available.
- Use email or text-messaging in place of conventional paper email. Read newspapers and magazines online and read e-books.
- Buy products in bulk or concentrated form whenever possible.

Steps from the government to improve recycling and waste reduction

- Increase in subsidies and tax breaks for reuse and recycling materials (positive incentive).

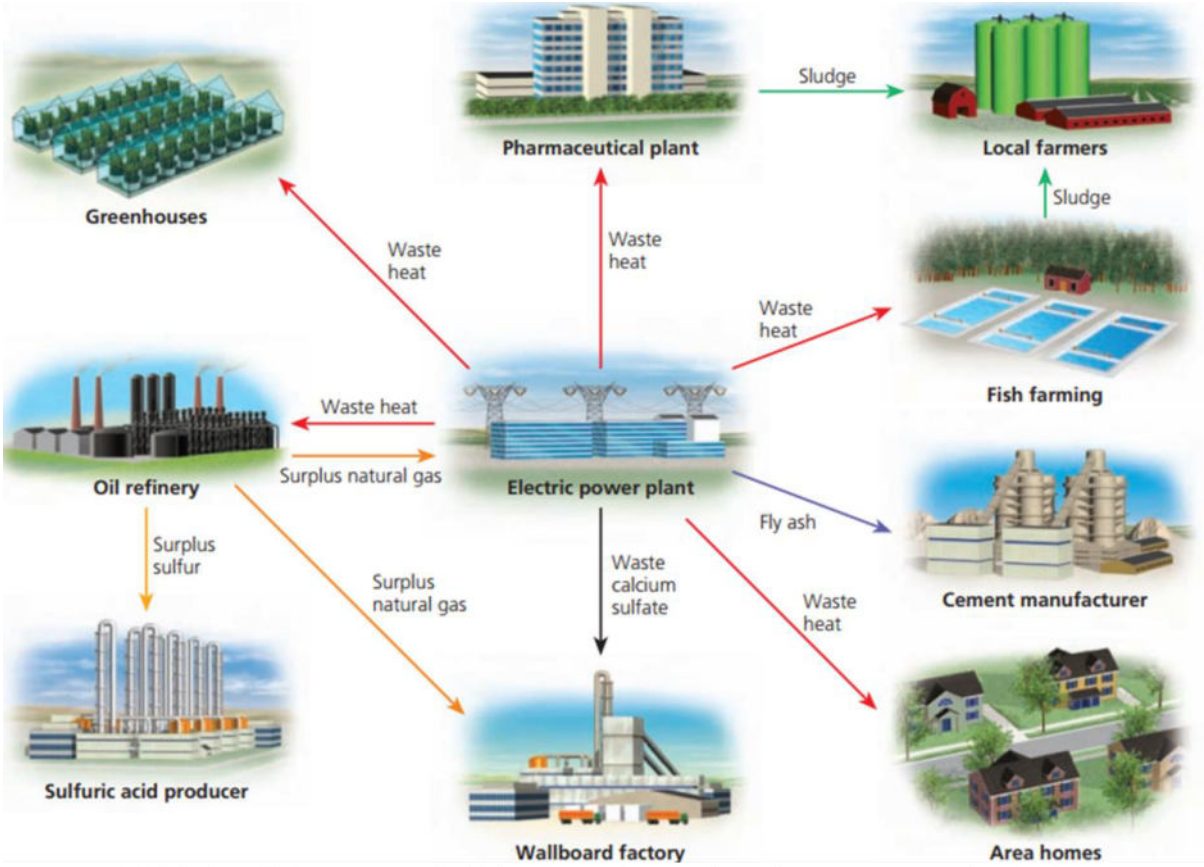
- Decrease subsidies and tax breaks for producing items from virgin resources (negative incentive).
- Fee-per-bag waste collection systems.
- Encourage purchases of recycled products.
- Pass laws requiring companies to take back and recycle/reuse packaging and electronic waste discarded by consumers.

Case study: Industrial Ecosystems: Biomimicry

Biomimicry is the science and art of discovering and using natural principles to help solve human problems. For example, scientists have studied termite mounds to learn how to cool buildings naturally. One way for industries to mimic nature is to reuse or recycle most of the minerals and chemicals they use, instead of burying or burning them or shipping them somewhere. Another way for industries to mimic nature would be to interact through resource exchange webs in which the wastes of one manufacturer become the raw materials for another–similar to food webs in natural ecosystems.

Industrial ecosystem: Kalundborg, Denmark

In Kalundborg, an electric power plant and nearby industries, farms, and homes are collaborating to save money and to reduce their outputs of waste and pollution, within what is called an eco-industrial park, or industrial ecosystem. They exchange waste outputs and convert them into resources. This cuts pollution and waste and reduces the flow of non-renewable mineral and energy resources through the local economy.



This industrial ecosystem in Kalundborg, Denmark, reduces waste production by mimicking a natural ecosystem's food web. Reprinted from Fig 21-26, Living in the Environment, Tyler and Spoolman

Biomimicry also encourages companies to come up with new, environmentally beneficial, and less resource-intensive chemicals, processes, and products that they can sell worldwide. In addition, these companies convey a better image to consumers based on actual results rather than public relations campaigns. Biomimicry involves two major steps.

- The first is to observe certain changes in nature and to study how natural systems have responded to such changing conditions over many millions of years.
- The second step is to try to copy or adapt these responses within human systems in order to help us deal with various environmental challenges. In the case of solid and hazardous wastes, the food web serves as a natural model for responding to the growing problem of these wastes.

Introduction; Solar energy-thermal and photovoltaic

What is energy?
What is the need for energy resources?

The term energy is derived from the Greek word en-ergon meaning that in-work
To perform any work in this world we require energy.
Let's take an example
To cook our food, we need energy.
To travel from one place to another place we need energy.
To keep vegetables and fruits afresh inside the refrigerator we need energy
To heat our house, we need energy
To cool down our rooms we need energy
To work with our mobile phones and laptop we need energy.

We are using some source of energy for a variety of applications.
If you take the history humans started using firewood and plant materials for cooking their foods.
Humans used animals for transportation such as a horse for riding
During the last century breakthroughs have happened. That is Benjamin Franklin discovered the electricity.
Followed by him Michael Faraday invented the electric dynamo the machine which converts mechanical energy into electricity in the year 1831
Thomas Alva Edison invented the light bulb which will glow when electricity passes
Nikola Tesla discovered the AC current motor which would convert electrical energy into mechanical energy.
We can't even imagine life without fuel or electricity, right?
The energy consumption of a country is usually considered as a sign of its development.

Let's discuss about
Types of Energy Resources
Energy resources are broadly classified into renewable or non-renewable energy resources.
Non-renewable energy resources are exhaustible and cannot be renewed. It can be available only for a limited period of time. Once they are consumed soon, they will run out.
On the other hand, Renewable energy resources are inexhaustible and they can be renewed. They are replaced as fast as they are used.
Can you say some renewable and non-renewable energy resources?

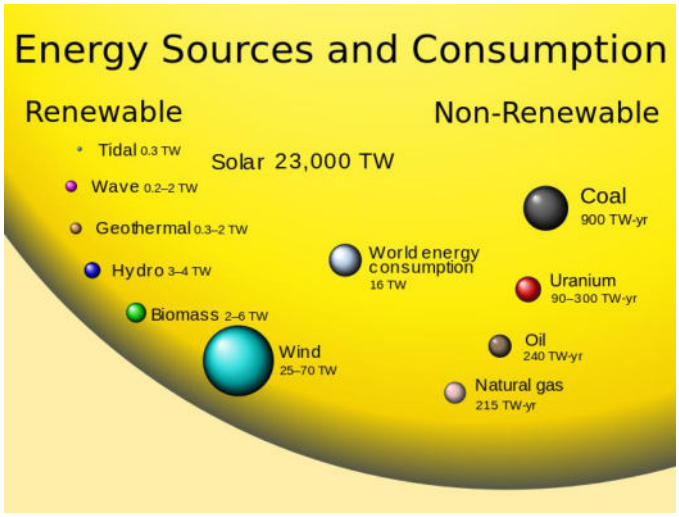


Photo courtesy **https://commons.wikimedia.org/**

Non-renewable Energy Resources are Fossil fuels such as oil petroleum diesel coal and natural gas.
The drawback with fossil fuels is if fossil fuels are burned to generate energy, they may release pollutants or carbon dioxide or other greenhouse gases into the atmosphere which will lead to global temperatures rising. It is called global warming.

Next Renewable Energy Resources
Examples of renewable energy resources are solar energy geothermal energy wind energy biomass hydroelectric power and tidal energy.
These energy resources are inexhaustible and can be renewed or replaced faster than we can use them.
Important Things to Consider about Energy Resources
Whether renewable or non-renewable energy resources two important things must be considered.
The first one is successfully making a useful form of energy from the energy resource. For example, how to harvest electricity from the sun.
Another one is Net Energy Net energy is the amount of high-quality energy produced from an energy resource minus the amount of energy required to develop it.

Let's discuss this by taking one example
if we get much less energy as output by burning fuel than the input energy to produce it. Then That particular fuel is probably not a practical energy resource. For example, nuclear power.
In order to produce nuclear energy, we need to spend a lot of energy on mining and extraction of uranium isotopes and enrichment of uranium fuels and fuel rod fabrications. Further after electricity is generated from uranium, we need to spend a lot of money on the storage of used fuel rods safely. Thus, net energy will be low

On the other hand, for another fuel net energy is high but if it creates large amounts of pollution that particular fuel also may not be the best choice for an energy resource. For example, a coal-based thermal power plant produces a lot of energy. Net energy will be higher than the nuclear energy. However, if you consider the amount of CO2 release or

greenhouse gas emission is very high in coal-based power plants. Thus, even though net energy is high in coal-based thermal energy this is not an eco-friendly energy resource.

In this module we are going to learn more about renewable energy recourses
First, we can start with SOLAR ENERGY.
Sun is an abundant source of energy, and it is inexhaustible.
Solar energy actually supports all life on earth
Thus, directly or indirectly the sun is the source of all the energy available on earth.
Solar energy applications can be classified into two categories one is direct solar energy and another one is indirect solar energy.

Photo courtesy **https://commons.wikimedia.org/**

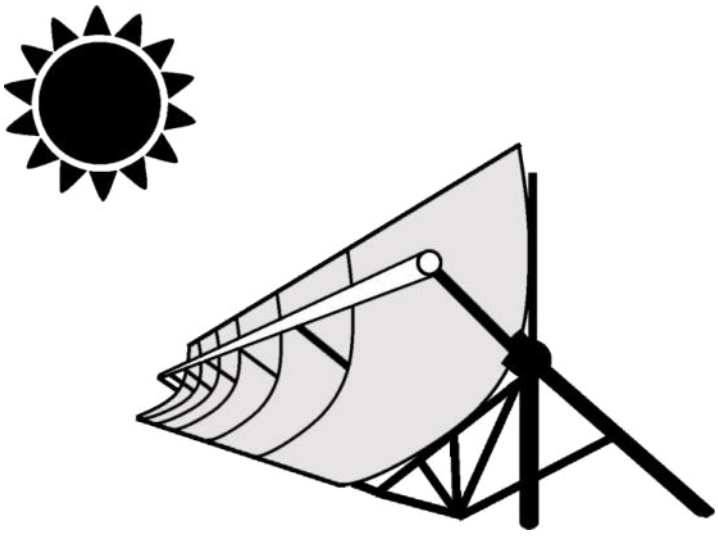
Plants need sunlight to grow.
Animals and humans were dependent on plants for their food and for oxygen.
Once plants and animals die, they will reach underground. After millions of years later these dead plants and animals turn into fossil fuels such as coal and oil. Hence coal and oil are regarded as indirect solar energy.
Solar energy causes pressure differences in the atmosphere and this causes the movement of air that is wind. So, wind energy is actually a byproduct of solar energy.
Let's take the water cycle Water evaporates because of heat condenses to form clouds and precipitates back to earth in the form of rain and snow. This water can be stored in dams to produce hydroelectricity. Hence hydroelectricity is an indirect form of solar energy.

Now we came to an important discussion that is Direct solar energy usage
Direct solar energy can be obtained using two methods. The first one is Thermal example is Solar radiation can be absorbed in solar collectors to provide hot water.
The second one is Photovoltaic. For example, solar energy can be converted directly into electricity using photovoltaic panels which are normally mounted on roofs.

Let me explain Direct solar energy applications
Solar energy is abundant found everywhere and has no political barrier everlasting and available for free of cost
Solar energy is one of the cleanest and most easily accessible sources of energy.

Direct solar energy can be harvested in various ways; there are three ways to harness solar energy
First one is passive solar energy system
Second one is active solar energy system
Third one is photovoltaic.

First, we can discuss about how we can utilize Solar thermal heat for various applications
It is not a new concept
Solar thermal heat was used to evaporate seawater to produce salt
Solar thermal heat was used to dry our food
Solar thermal heat was used to dry our clothes
These are a few examples of passive solar energy applications.



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The best example of a passive solar energy system is a solar cooker which is a device that uses sunlight to cook food.
Solar cookers work without any large complex systems of lenses or mirrors
We all know that when sunshine falls on a dark surface or black colored surface it absorbs solar energy, and it heats up.
The solar cooker uses the same principle.
Inside a solar cooker a glass-covered chamber is painted black, and the entire unit will be insulated. When we keep the solar cooker in sunlight it absorbs solar energy and heats up the surrounding air. This warm air circulates throughout the box and cannot escape. Because of this sometimes the inside temperature would reach more than 100 ^{o}C which is sufficient to cook our food.

Photo courtesy flickr.com

However Solar cooker takes longer times to cook food. This is the best example of a passive solar energy system
In most parts of India where solar radiation is relatively abundant; thus, we can use solar box cooker to prepare food more sustainable way
In India we have the largest solar steam cooking system. More importantly it is still working from the 90s in Brahmakumaris Ashram at Mount Abu in Rajasthan.
They have 84 shining parabolic concentrators on the roofs; each one looking like a huge dish made of reflecting concave mirrors. The sunlight from the concentrators heats up the receiver and converts water into steam. This system can cook for more than 38000 people.

The next example of Passive use of solar energy is daylighting
Today many buildings are designed to take advantage of natural solar energy for daylighting.
Daylighting is simply the use of natural sunlight to light up a building's interior.
The south side of a building mostly receives the highest sunlight Therefore buildings are designed south facing for passive solar daylighting. Usually, the building is designed with large south-facing windows. This kind of design will allow the entry of maximum sunlight into the building's interior.
Passive solar systems are maintenance-free. There are no operating costs. We can substantially reduce the electric bills.
There is no need for devices such as external pumps fans or electricity.
The only major problem is passive solar heating or passive solar lighting systems depend on the climate.
In a cloudy and dark climate, it will not operate.

Photo courtesy flickr.com

The second method of solar energy application is Active solar energy utilization
Active solar energy utilization means capturing and storing of solar energy for future use.
In active solar heating systems solar energy will be used to heat up fluid or air and then the fluid is moved with the help of external pumps to the storage system and then the captured heat will be transferred directly for later use.
Usually, active solar heating and solar cooling systems require solar collectors which are usually mounted on roofs.
Such systems also require pumps and motors to move the heated fluids to the storage system in order to deliver the captured heat.
Solar water heaters are the best example of active solar energy utilization. Typical solar water heaters consist of two parts one is solar collector and the second one is storage tank.

First, we can discuss about Solar Collectors.
A typical water heater is composed of solar flat plate collectors.
Solar radiation is absorbed by the collector and converts the incident solar radiation into thermal energy by absorbing heat. The heat gathered is transferred to the storage unit.
The solar collectors are usually placed on the roof of the building facing south and at an inclination of 30-60 degrees with respect to the horizontal plane.
Solar collectors are classified into two categories. The first one is Non concentrating collectors and the second one is Concentrating collectors.

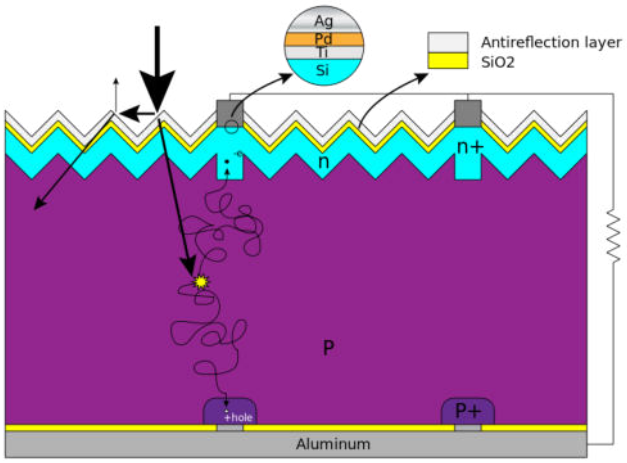
Let me explain what Non concentrating collectors is
Non concentrating collectors means the area that intercepts the sunlight is the same as the area absorbing the solar energy
Flat-plate collectors are the most common example of non-concentrating collectors which are used widely for water heating.
These collectors are simply metal boxes that have a transparent glass cover on top of a dark or black-colored absorber plate
The rest of the faces of the box are insulated to prevent heat losses. These boxes consist of copper pipes running in parallel. The fluid typically water flows through these copper pipes.
Solar radiation passes through the transparent glass material and absorbs the radiation from the sun. The circulating water inside copper pipes heats up and transfers the heat to water in a storage vessel.
This can be used for domestic purposes as a water heater or heating the water in the swimming pools in warm climates.
Next, I will explain about Concentrating Collectors
In Concentrating collectors, the area intercepting solar radiation is greater than the absorber area.
Solar Furnace and Solar thermal power plants use concentrating solar collector systems.
A solar furnace is an optical system that uses concentrated solar power to produce high temperatures. The solar furnace technique is based on reflecting solar radiation from Parabolic mirrors or heliostats and concentrating it onto a focal point.
The largest solar furnace was installed at Mont-Louis in France. it has been operational since 1970.
Nearly 20000 mirrors were used to concentrate sunlight to create more than 3500 °C
Temperature at the focal point of this solar furnace

Photo courtesy flickr.com

Next example for active solar energy utilization is Solar energy to produce electricity
Solar energy is used to generate electricity.
Solar collectors in sunny deserts can produce high-temperature heat which drives a heat engine nothing but a steam turbine which is connected to an electrical power generator for producing electricity.
The advanced computer-connected solar collectors usually move by tracking the sun to maintain a high degree of concentration on a central heat collection unit and transform solar energy received from the sun into high-temperature heat energy which can be used to convert heat energy into electricity.

Next, we can see Solar energy for cooling applications
The principle behind the solar cooling or solar refrigeration is like conventional refrigeration. But the difference is Solar thermal energy is used instead of electrical power to operate a heat engine.
The heat engine compresses a special vapor into a liquid refrigerant.
The re-evaporation of this liquid refrigerant absorbs the heat out of the surroundings and in turn cools its surroundings.

Final topic I want to discuss is Solar cells or photovoltaic technology
Modern solar power systems use photovoltaic cells to collect solar energy.
“Photo” means “produced by light” and “voltaic” is “electricity produced by a chemical reaction.”
Simply the process of converting photons into electricity.
A single PV device is commonly called as a solar cell.
The photovoltaic cell contains a semiconductor most commonly silicon with a small number of impurities such as boron or phosphorus. Recently PV cells are made up of cadmium telluride or copper indium gallium diselenide. Arsenic and antimony have also been used in solar cells. New photovoltaic technologies are coming up such as solar cells made up of organic materials or quantum dots or made up of hybrid organic-inorganic materials perov-skites materials such as calcium titanate.
A typical solar cell contains a very thin semiconductor and is often less than the thickness of human hairs.



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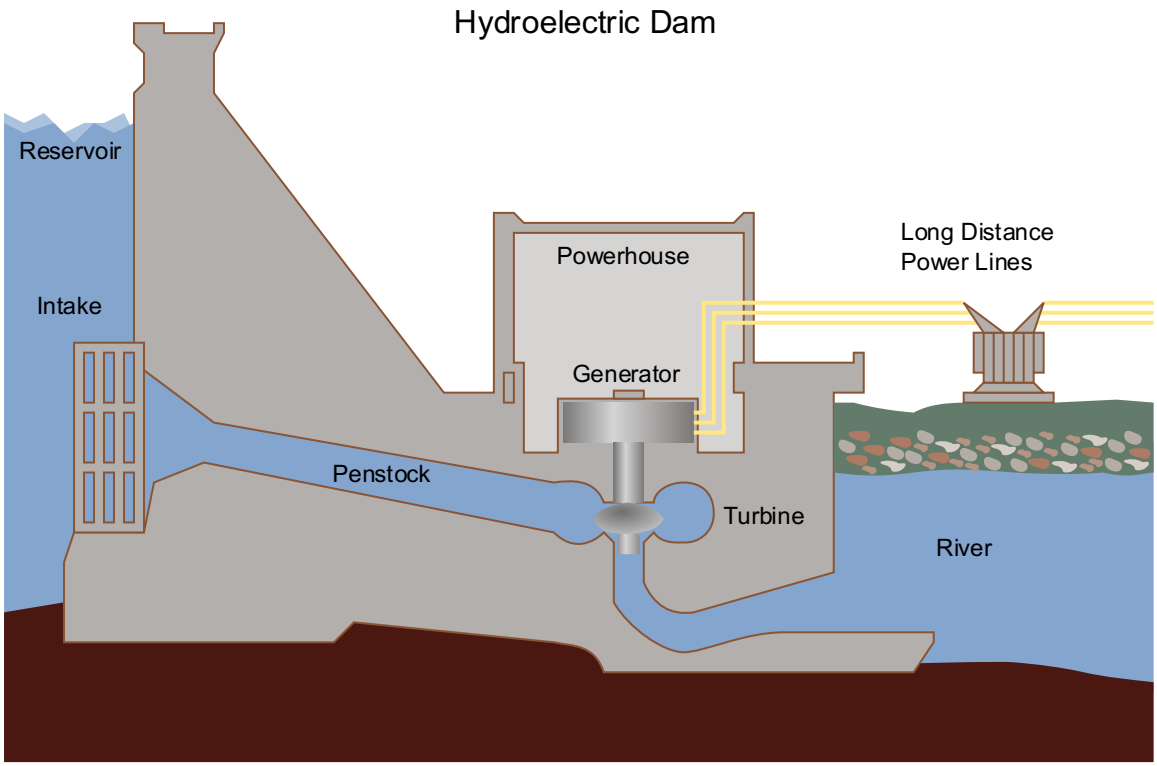
Each cell is connected by a circuit and designed into modules or panels. Several panels can be connected to form arrays. One or more arrays are then connected to the electrical grid.
When sunlight falls on the silicon layer it causes electrons to eject. And these ejected electrons move quickly into the circuit and generate electricity.
Commercial or domestic PV panels produce an average current from 10 watts to 300 watts in a direct current.
PV panels require an inverter to change the DC electricity into AC current in order to be compatible with electrical devices and the electric grid.
PV panels can **also** be used to create large-scale power plants. Bhadla Solar Park is the world's largest solar park which is located in Rajasthan India.
It is spread over a total area of 14000 acres and generates 2250 Mega Watts of electricity

PV cells can be used to power space satellites
Solar cells can be used. to provide electricity to remote villages street lighting applications.
in the desalination of salt water and water pumping and so on.
PV cells are used Powering remote telecommunication devices and railway signals.
Also powering of smaller items such as calculators and watches.

Hydroelectric and wind energy

We are going to learn about two important renewable energy resources.
One is Hydroelectric power and another one is wind energy
First we begin with Hydroelectric Power
Hydro-energy or hydropower is known as one of the traditional renewable energy resources.
Harvesting energy from flowing water or falling water into electricity is known as Hydroelectric energy.
Globally hydroelectricity accounts for more than 18% of all electricity produced and Hydroelectricity is the fourth largest energy resource across the whole world.
Hydro-energy is known as a traditional renewable energy resource. The principle behind the hydroelectric power generation is relatively very simple and has been existing for a significant span of time.
It has been in use for many centuries. Hydro energy was mentioned even in the Greek poems of the 4th century.
If you travel to European countries you can still see large waterwheels. The Romans were the first to utilize the waterwheel. They have used these waterwheels mostly for grinding grains.
On September 30 1882 the world's first hydroelectric power plant began operation on the Fox River in Wisconsin. This is the first example of converting water energy into electricity.



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There are two methodologies in use that utilize water to produce electricity
One is electricity from a hydroelectric dam and another one is electricity from a pumped-storage plant.
Let's see how exactly is electricity generated from the dam?
The principle is simple:
The source of hydroelectric power is water; Thus hydroelectric power stations are usually constructed on a large river.
The dam has massive walls that blocks the flow of a stream or a river.
It allows accumulation of lot of water in the reservoir of the dam. At the bottom of the dam or large reservoir there is an intake from which the water delivers through a special channel called penstock. When an intake opens the nozzle system of penstock forces water to flow through a channel. The water rushes to the hydraulic turbine water get accelerated and then water hitting the turbines blades and causing it to spin. The turbine is connected by a shaft. Rotating turbine causes the shaft to rotate. The rotating shaft is connected to an electrical generator which converts the mechanical energy of the shaft into electrical energy. That is converting waters kinetic energy into mechanical energy subsequently into electricity.

Dams stores a lot of water at a higher level Gravity causes water to fall to rotate turbines that generate electricity. After passing through the turbine the water returned to the river and continued its journey.

Opening underwater gates directly controls the amount of water flowing through the special channel determining the amount of electricity generation from the dams.

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The second methodology to harvest hydropower is through Pumped-storage plants. A pumped-storage plant is very similar to a dam-based hydroelectric power stations but the main difference is that the pumped-storage plant uses two reservoirs at different elevations one will be considerably higher than the other. The surplus electrical energy available during low-demand periods or in off-peak periods will be utilized to pump the water from a lower reservoir to an upper reservoir. When the power consumption is low for example the middle of the night the dam uses this surplus electrical energy to pump the water from lower reservoir to the upper reservoir. When high electrical demand occurs the stored water is released. The released water will rotate the turbines and generate electricity. These kinds of systems increase revenue and overcome shortage of electricity and reduces the electricity bills.


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Also Hydroelectric energy can be harvested even on a small scale with the natural flow of run-of-river; the running water drives one or more turbines and generating electricity

However like every source of energy there are several advantages and disadvantages with hydroelectric energy. Let's discuss the benefits and drawbacks of hydroelectric energy.

Advantages of hydroelectric energy
Hydroelectric energy is renewable.
The cost of hydroelectricity is relatively low.
It is cheaper than thermal or nuclear power.
The efficiency of hydropower systems is very high >80% while thermal power plants have low efficiency as low as 40%.
The average cost of electricity from hydropower power station is very less.
The electricity production of a dam is dependent on how much water stored in the reservoirs that's why the output electricity can be determined based on the need.
Meaning that we can adjust water flow and hence we can control the output electricity. For example when power consumption is low water flow can be adjusted consecutively we can control the output electricity.
Hydropower plants are flexible and they can produce electricity at a constant rate.
Besides hydropower does not consume water.
Hydropower is the most reliable efficient and economical.
Once constructed a hydropower power stations will be operational for at least 40–50 years.
Even though construction of large dams is very expensive the produced energy from hydroelectric dam is virtually free.
The water reserved in the dam can be used for irrigation or for leisure purposes such as recreation and fishing.
Also hydroelectric dams release a negligible amount of greenhouse gases.
Furthermore it creates no pollution and it is a relatively cheap and clean source of energy.

Hydropower also has some disadvantages
Dams are very expensive to build
Hydroelectric dams alter the landscape dramatically

Building of dams disturbs and depletes the natural habitats of fisheries and river ecosystems plants and animals.
Large dams have forced people to relocate making people homeless especially tribals.
Building a large dam will of course causes flood. If flooding happens a large area gets submerged. This causing problems for people and the animals who live there.
Another drawback is finding suitable locations to construct the dams is challenging.
The construction of a dam blocks the natural flow of water such as rivers. It can result in serious disputes between neighbouring countries and also neighbouring states.

Let's discuss about second renewable energy I have mentioned.
That is Wind energy

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Wind energy is actually a by-product of solar energy.
Wind energy is one of the most promising fast-growing renewable energy of the future.
Let's discuss Where does wind come from?
Solar energy causes differences in temperature density and pressure in the atmosphere and this causes the movement of air. That's why wind energy is considered as indirect solar energy.
As early as 4000 - 3500 BC Ancient Egyptians used wind energy to sail their ships.
As the water wheel the wind wheel has been used by humans for a long time for grinding grains and pumping water for irrigation and doing other types of work. Windmills even started appearing around 8th and 9th centuries in the middle east and Western Asia. Then slowly arrived in India China and Europe.

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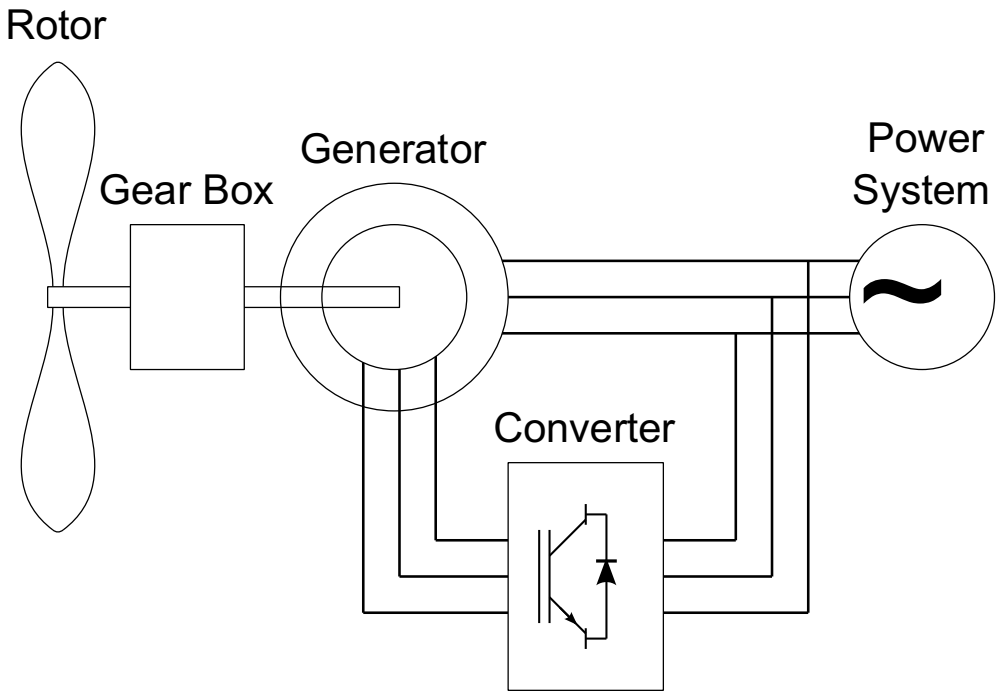
Modern windmills have evolved through several cycles of incredible innovation. Recently because of huge demand for energy created an interest in developing alternative energy especially on wind energy to generate electricity.
A wind turbine is a device that converts kinetic energy from the wind into electrical power. Wind turbines are fixed on a tower enables turbines to capture most of the wind energy. As the wind passes through the turbines it moves the blades which spin the shaft. The shaft is attached to a generator that produces electricity. Thus wind turbines convert the kinetic energy of the wind into mechanical energy. This mechanical energy can be converted into electricity by means of a generator.



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There are two types of wind turbines:
First one is horizontal-axis turbines and second one is vertical axis turbines.
In the horizontal-axis turbines the axis of rotation is horizontal. It is most widely used turbines. And It is more efficient than the vertical-axis windmills.

Photo courtesy **flickr.com**

Whereas in the vertical-axis design the axis of rotation is vertical. The blades will also be connected vertically.

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A group of wind turbines in the same location used to produce electricity they are called as wind farms.
Wind farms have advantages it makes easier to feed the produced electricity into the power grid.


Photo courtesy : Public Domain Pictures

In recent years there is significant breakthroughs are happening in turbine technologies because of that the amount of energy produced by windmills has increased exponentially making wind power as an economically suitable energy source.
Wind power generation capacity in India has dominating in recent years.
In India the states of Tamil Nadu and Gujarat is the largest producer of wind energy according to the National Institute of Wind Energy (NIWE) reports.
India is the fifth-largest producer of wind power in the world.
Apart from India many countries also involved in the development of wind energy for example USA (California) Great Britain Greece Spain Netherlands and Denmark

Wind energy have many advantages compared to fossil fuels such as coal-based thermal energy.
Wind energy is a renewable and inexhaustible source of energy.
It is non-polluting it is low cost energy
It is a safe and clean source of energy and pollution-free energy resource
Wind energy is regarded as a potential energy source for solving todays energy problems.
Most importantly windmills do not produce any greenhouse gas emissions

Lest see the disadvantages of wind energy:
The main disadvantage of wind energy is it is unreliable energy resource. The degree wind availability and the speed of the wind are often uncertain.
Also high speed and large volumes of air is required to produce wind energy.
Wind does not blow at a constant rate and wind is not always consistent sometimes it does not blow at all. As a result the wind energy must be harvested as and when it is available
The rotor noise produced by windmills causes noise pollution which is another disadvantage of wind energy
The windiest locations are often in remote locations thus it is location specific.

Just like with any other energy plant people oppose it because of aesthetic reasons that is due to visual pollution.
Winds mills have a costly setup
Sometimes windmills interferences to radio and TV signals
Furthermore the available evidence suggests that wind farms are harmful to birds birds often crash into the wind turbines. Many birds and bats die because of wind turbines.

Ocean thermal energy; Geothermal energy

We are going to learn about two more important renewable energy resources.
One is Ocean Thermal Energy and another one is Geothermal energy
First, we begin with Ocean Thermal Energy
The Ocean Thermal Energy is abundantly available, and it is free
Surface ocean currents can occur as long as the sun shines.
Recent estimates suggest that ocean thermal energy itself would be sufficient to satisfy the worlds electricity demand.
This is one of the non-conventional energy resources.
The ocean covers more than 70 percent of the surface of our planet.
In the oceans the temperature of water might vary by location. The latitude and the depth of the ocean or variations in solar radiation availability and also the physical properties of water determine the temperature variations of ocean water. As the solar radiation falls on the surface water Suns heat energy will be transferred to the water. Therefore, the surface water continually becomes much warmer than the deep waters. Sunlight does not penetrate as deeply; thus, the deeper parts of the ocean are relatively cool. This causes a temperature difference between the surface water and the deep water of the sea. This temperature difference can be exploited to produce electricity. This process is known as Ocean Thermal Energy Conversion (OTEC).

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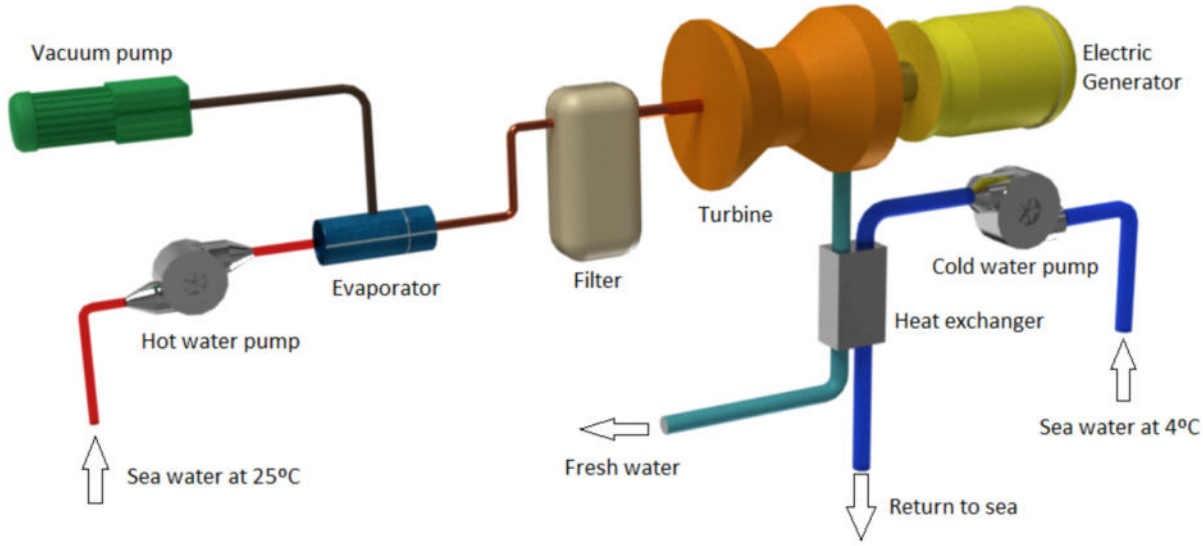
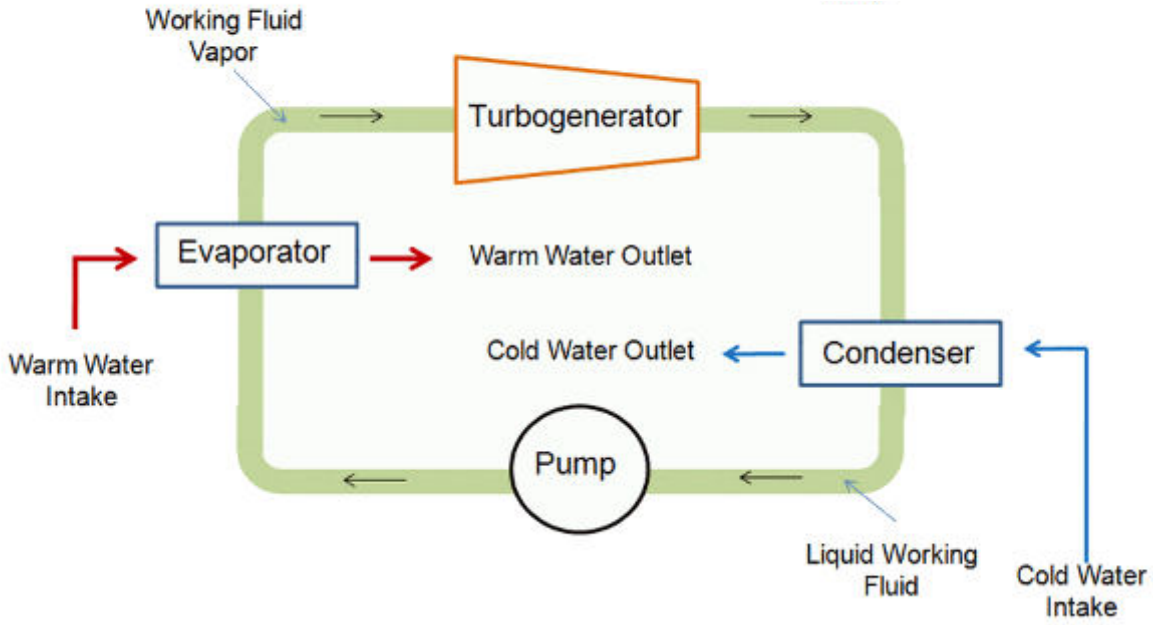
One of the main requirements for ocean thermal energy conversion OTEC is the temperature difference between the upper layer water and the deep sea water should be at least >20 ºC. Mostly the temperature difference is maximum in the tropics nearly 20 to 25 oC because the tropics receive a lot of sunlight throughout the year which warms the surface of the oceans hence increasing the temperature difference or temperature gradient.
The efficiency of the system depends on the temperature difference. Greater the temperature difference the greater the efficiency.

Let's discuss how to harvest the electricity from Ocean Thermal Energy Conversion (OTEC) technologies.
There are two different methodologies to harvest electricity.
The first one is closed-cycle ocean thermal energy and the second one is open-cycle thermal energy.
We can discuss about what is closed-cycle ocean thermal energy
The warm seawater would be pumped from surface warm seawater and then it will be sent to the heat exchanger. Heat exchanger is a device which has a low boiling working fluid. Mostly ammonia whose boiling point is -33 °C and propane whose boiling point is -42 °C or 1112-Tetrafluoroethane also called as R-134a whose boiling point is -26.3 °C. Usually these fluids will be used as a refrigerant. Inside the heat exchanger heat will be absorbed from the warm water and the fluid will get vaporized. These vapors will rotate the turbine and thus the generator will generate electricity. During this process cold water from the deep sea also will be pumped to cool down the vapors. Coldwater is used to cool the vapors again into liquid. Now the fluid vapor will be converted into liquid. The same liquid is recycled back to the heat exchanger. That's why this process is known as closed-cycle ocean thermal energy conversion.



Let's discuss the second method that is open-cycle thermal energy to harvest electricity from ocean thermal energy. In this open cycle methodology, the warm seawater is first pumped into a low-pressure container. Because of the reduction in the pressure the boiling point of the water will drop. This causes the water to boil quickly and expand into vapor. This vapor or

steam passes to the turbine and rotates the low-pressure turbine which is connected directly to an electrical generator. Finally, the generator will generate electricity.
There is an advantage with this second methodology that is in the open cycle system steam will be converted back to the water during the cooling process. Finally, we are getting pure desalinated water from the plants in the form of steam. Since the steam is free of impurities this desalinated water can be used for various applications including domestic agricultural and industrial purposes.



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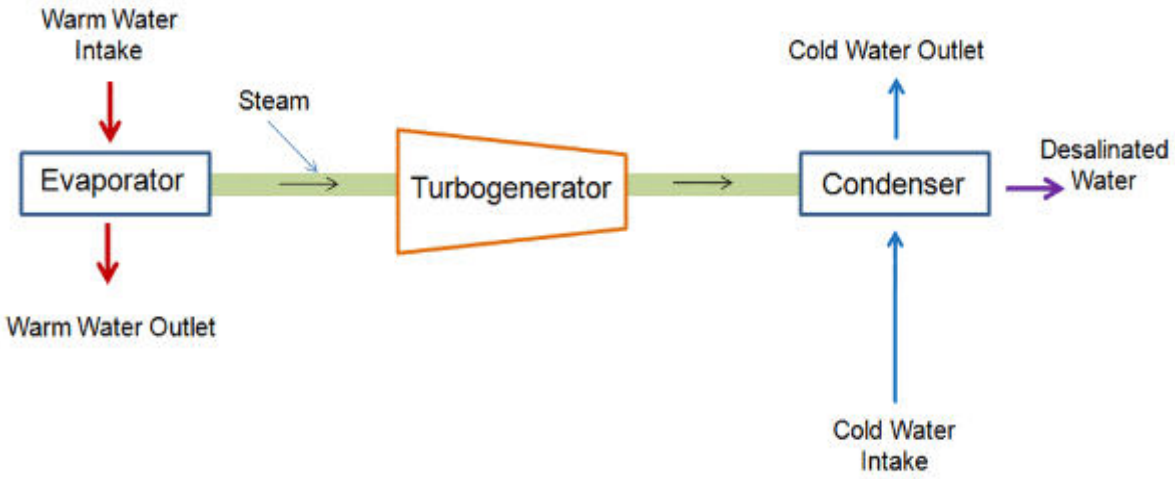

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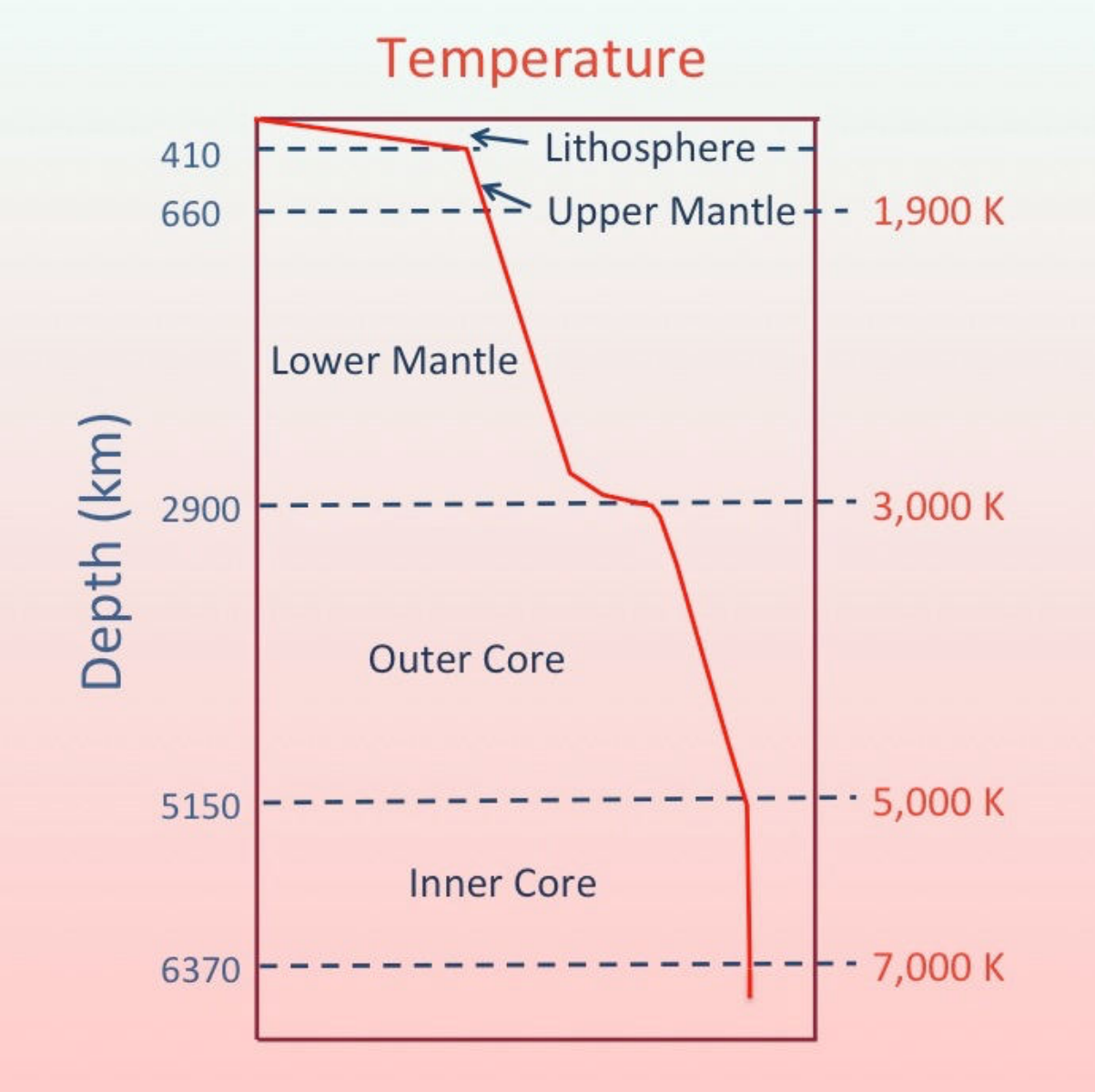
Let's discuss the advantages and disadvantages of Ocean Thermal Energy.
Global demand for energy is increasing rapidly with each passing day.

We need to look for non-conventional or alternative energy resources
Ocean Thermal Energy is an excellent renewable Energy
Also, the oceans aren't going to dry up very soon.
The variance in temperatures in the oceans will almost always exist. Hence, we can generate electricity for a lifetime
Ocean Thermal Energy is renewable and clean energy. It does not cause pollution in the atmosphere or to the water bodies.
Ocean Thermal Energy is reliable. If you take wind or solar power, they are highly dependent on the weather conditions. But ocean thermal energy is reliable because as long as the sun is there the temperature variation will occur.
Ocean Thermal Energy is environmentally friendly: The ocean thermal energy plants are mainly constructed in the sea usually far away from human settlements.
Also, once the machinery and heat exchanger pipes are installed. They need no or low maintenance.
Many times, ocean thermal energy is harvested using floating-type OTEC plants that are primarily very small and hence cheaper.
Finally, the ocean thermal energy is independent of weather

Let's discuss the Disadvantages of Ocean Thermal Energy
The initial installation of the plant is an expensive process
Also pumping of either a warm seawater or deep cold water causes disruptions in aquatic and marine life.
With the available current technology, we can only achieve low efficiency nearly 1-3%.
It is location specific. Some countries lack coastal line areas and thus they cannot be able to utilize this technology.
In the case of floating type OTEC plants electricity must be transported from the ocean to land. It is expensive process.

Let's move to the second renewable energy resource that is Geothermal Energy
Geothermal energy is not an indirect form of solar energy. It is a completely new form of energy which is relied only on the heat produced under the earth mainly at the core of the earth.
Geothermal energy is the thermal energy which is stored deep inside the earth. The average increase in temperature with a depth of the earth is 1°C for every 35 to 40 meter depth.
In the earth's core the pressure and temperature are very high, and the temperature is as same as the sun which is due to the continuous nuclear fusion reactions taking place inside the earth core. Because of this some rocks melt. These molten rocks are called magma. Magma is found under the surface of the earth. Magma rises up from the earth's mantle causing upward movement. These molten rocks get trapped in particular regions which are referred to as hot spots. If the magma pushes through the cracks or holes present in the weak spots of the earth's crust it results. in a volcanic eruption.
Similarly, when the magma and underground water come in contact they form a hot spot from there steam is generated. Sometimes the steam from that region finds channels or openings at the surface. Such holes are known as hot springs or geysers. Geothermal energy is harvested mostly near hot springs or geysers or volcanic activity
Moreover, the molten magma contains water in the form of steam which is used to run turbines and hence electricity is produced.



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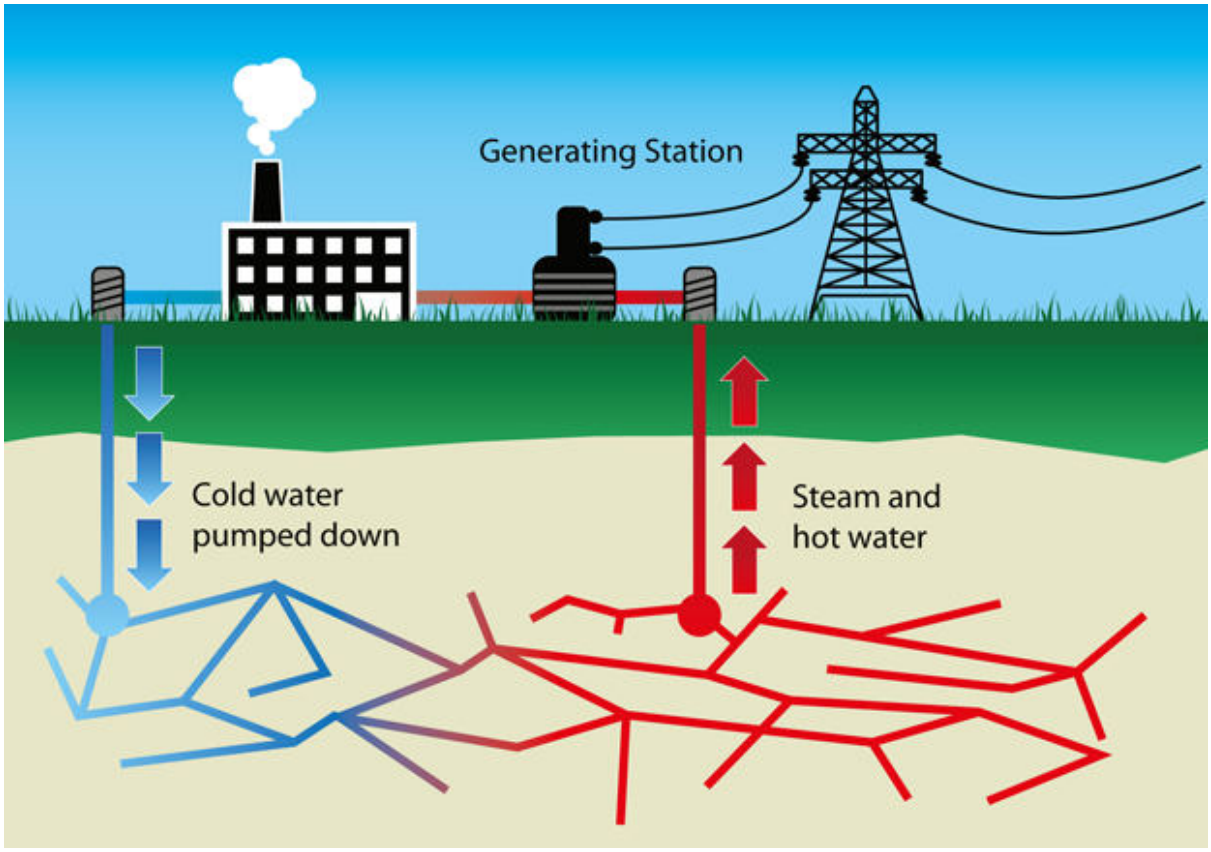
Let's see how to harvest geothermal energy.
A hydrothermal convection system can be used to harness geothermal energy. That means cooler water is sent into Earth's crust where it is heated up and then rises to the surface in the form of steam.
In this process wells are drilled 1 or 2 miles deep under the Earth and the pipes are inserted. through the holes.



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Coldwater is injected deep underground through an injection well. Then it is converted into hot water. Hot water flows up through a well from deep underground due to its high pressure. When the water reaches the surface, the pressure decreases which makes the water boil subsequently converted into steam.

Photo courtesy **https://commons.wikimedia.org/**

This steam is then used to turn the blades of a turbine which is connected to a generator. This electric generator converts mechanical energy into electricity.
Geothermal power plants use cooling towers to cool-off the steam and condense it back into the water.
The cooled water is reinjected back into the Earth and the cycle begins once again.

Photo courtesy **https://commons.wikimedia.org/**

Let's discuss the advantages and disadvantages of geothermal energy
There are plenty of hot springs and natural geysers across the world that emit geothermal energy.

Geothermal energy is an inexhaustible source of energy and is available 24 hours a day 365 days a year. It is free and abundant. The earth will continuously transmit heat from its core, and it is inexhaustible and limitless. It may be available for around 2-3 billion years easily.
Geothermal energy is a renewable resource: Because heat is continuously produced inside the earth due to nuclear fusion reactions. Hence the amount of heat generated by the Earth's core is unlimited.
Geothermal energy is environmentally friendly energy because it is non-polluting and self-replenishing. Also, it does not release hazardous greenhouse gases unlike fossil fuels.
Also, it does not generate any residue or any by-product.
Thus, it is safe for both environmental and human health.

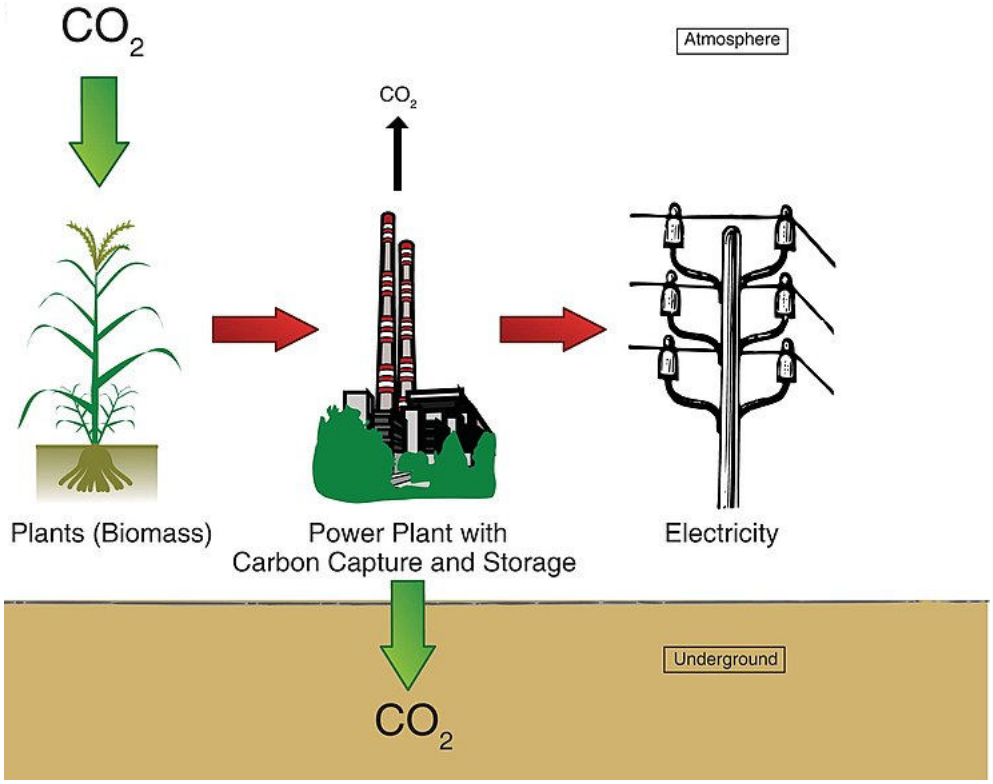
Let's talk about the disadvantages of geothermal energy
Geothermal energy is an expensive one. It requires a huge initial investment for the drilling and installation of a complex systems.
Geothermal energy is location specific and limited to particular regions. Geothermal plants need to be built in geologically active areas where some geysers or hot springs or volcanic activity are available. Unlike fossil fuels geothermal energy requires large transmission lines to transport the electricity produced from it.
Geothermal sites are present deep under the earth so the process of drilling may increase earthquake risk since; earths structure is altered during drilling or digging processes.
The drilling process results in the release of toxic gases such as sulfur dioxide and hydrogen sulfide into the environment which is harmful.

Energy from biomass

We are going to learn about biomass energy which is another important renewable energy resource.

Let's begin with what is biomass?

Biomass is natural and organic materials or wastes produced by plants or animals. Mostly biomass is derived from plants or plant-based materials which are referred as lignocellulosic biomass. Even animal-derived materials are used for biomass generation.



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Biomass can be used to generate three important products

First one is Biopower or bioenergy: Biomass can be converted into heat and electricity using various techniques.

Second one is Biofuels Biomass can be converted into biofuels such as bioethanol and biodiesel

Third one is biogas decomposition of biomass will give biogas which can be used to generate either heat or electricity.

Let's discuss above mentioned three important products one by one.

First biopower or bioenergy

How to harvest bioenergy such as heat or electricity from biomass?

Harvesting energy from biomass is not a new concept.

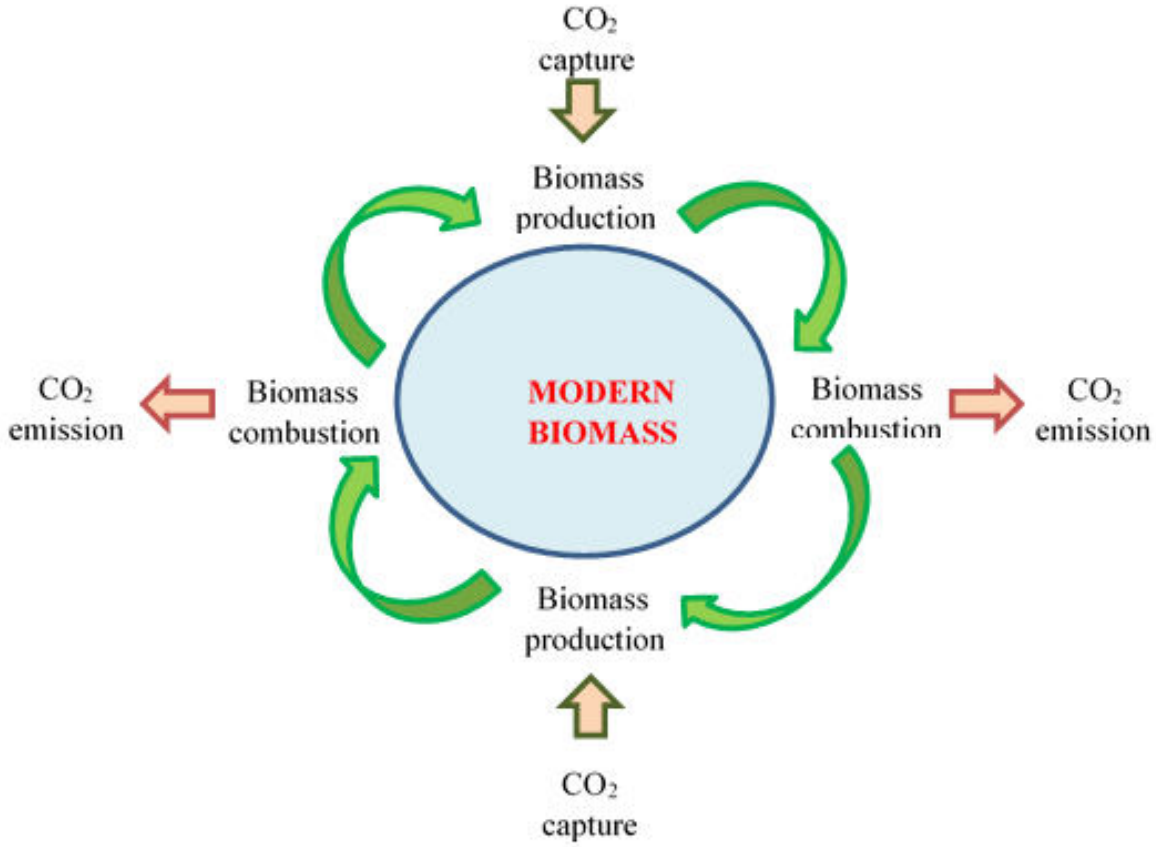
Biomass has been in use since the stone age and cavemen used wood material to burn to cook his food and keeping warm.

Strictly speaking biomass energy is indirect solar energy. Solar energy is trapped by green plants through photosynthesis and converted into biomass energy.

As I mentioned earlier biomass is composed of plant-derived materials such as starch and sugar-producing plants wood crop residues latex producing plants vegetable oilseed plants agricultural wastes forestry waste and various biomass wastes such as municipal wastes industrial solid wastes sewage waste agricultural wastes industrial effluents and cattle dung apart from this biomass residues such as wheat straw maize cubes rice straw groundnut wastes jute sticks and so on are source for energy.

Biomass can be converted into either heat or electricity by various processes.
They are combustion digestion pyrolysis fermentation and catalyzed reactions.

Let's discuss first process called **biomass combustion** means directly burning organic materials. For ages humans have utilized this technology to create fire and the heat generated can be efficiently used to generate electricity through steam. The plant or animal-derived natural products including wood crop residues cattle dung sewage wastes and agricultural wastes are the most commonly used materials which can be burned effectively to generate heat and this heat energy can convert water into steam. This steam hits the turbine blades causing turbine blades to rotate. The rotation of the turbine in turn energies a generator makes electricity.



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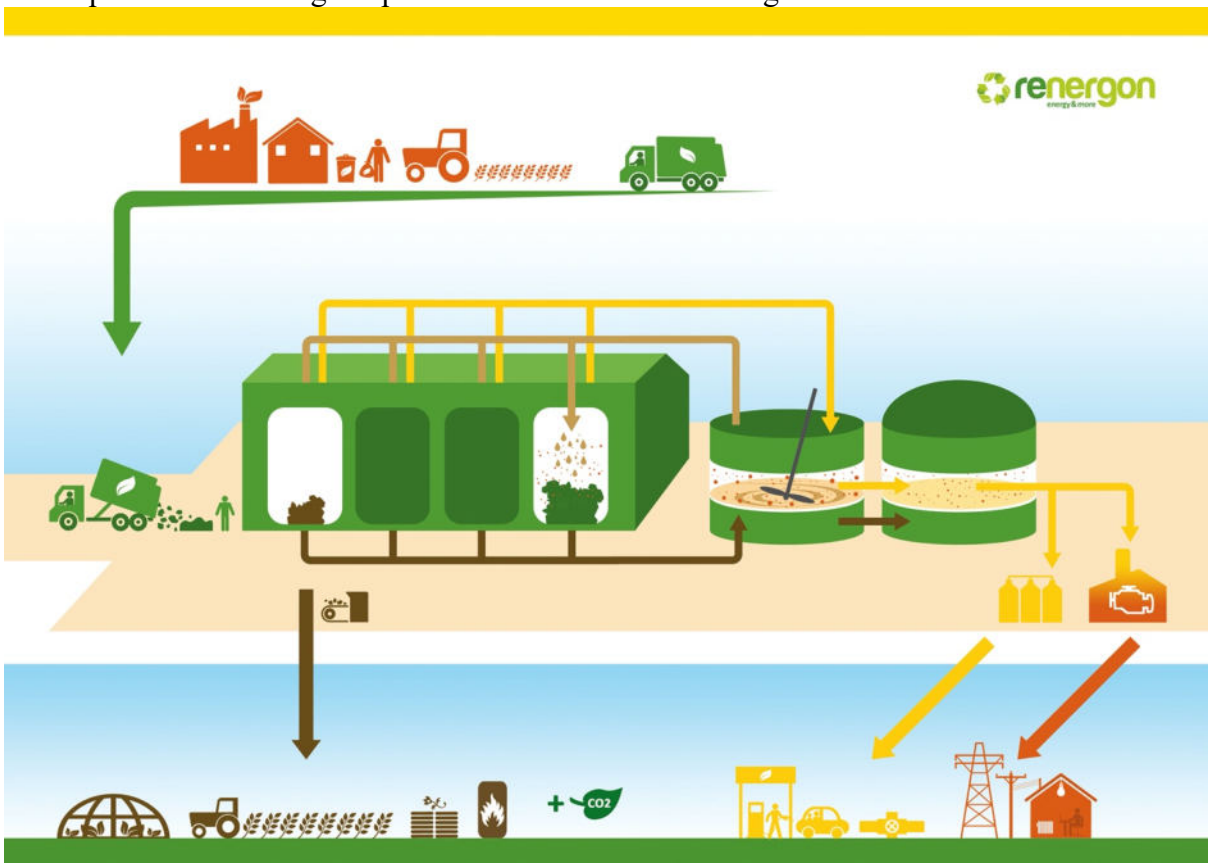
Second process is **Digestion**. Digestion is another technique that makes use of existing biodegradable waste materials. Most of the time the digestion process will be carried out in the absence of oxygen. That is known as anaerobic digestion. During the digestion process biomass will be broken down into gases like methane carbon monoxide etc. with the help of

microorganisms such as bacteria. Actually, microorganisms feed the biowastes and decompose them. During the process the above-mentioned gases will be released.



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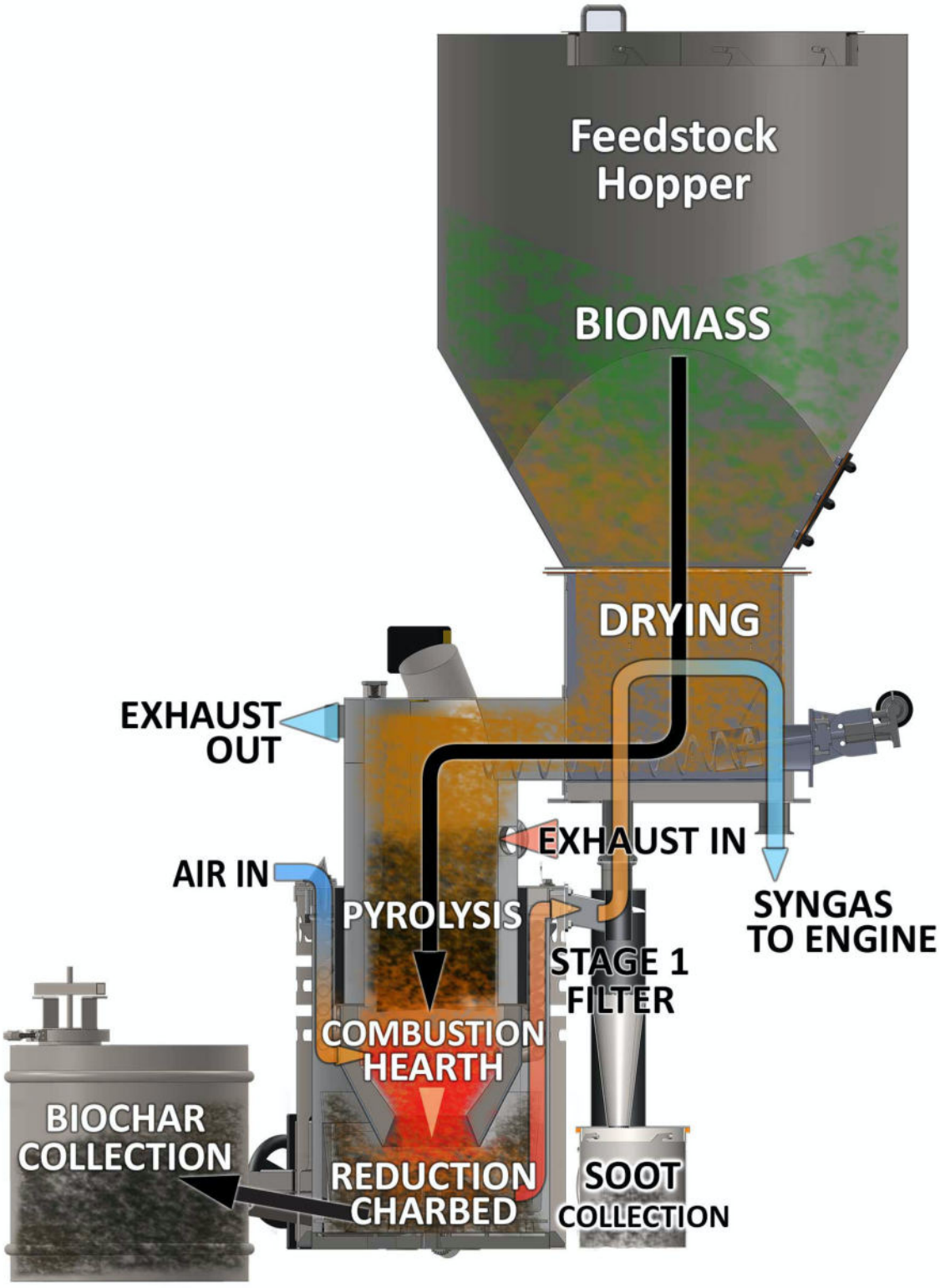
The third process is **pyrolysis** which means the thermochemical decomposition of natural biomass at elevated temperatures in the absence of oxygen or water. During the process biomass can be converted into mostly solid materials like charcoal. This process is irreversible. At the industry level these pyrolysis processes will be done under pressure and at temperatures greater than 800° F. Industrial pyrolysis can produce even liquid fuel. End product of the pyrolysis usually charcoal which have double the energy as that of original biomass and can be transportable and more efficient.



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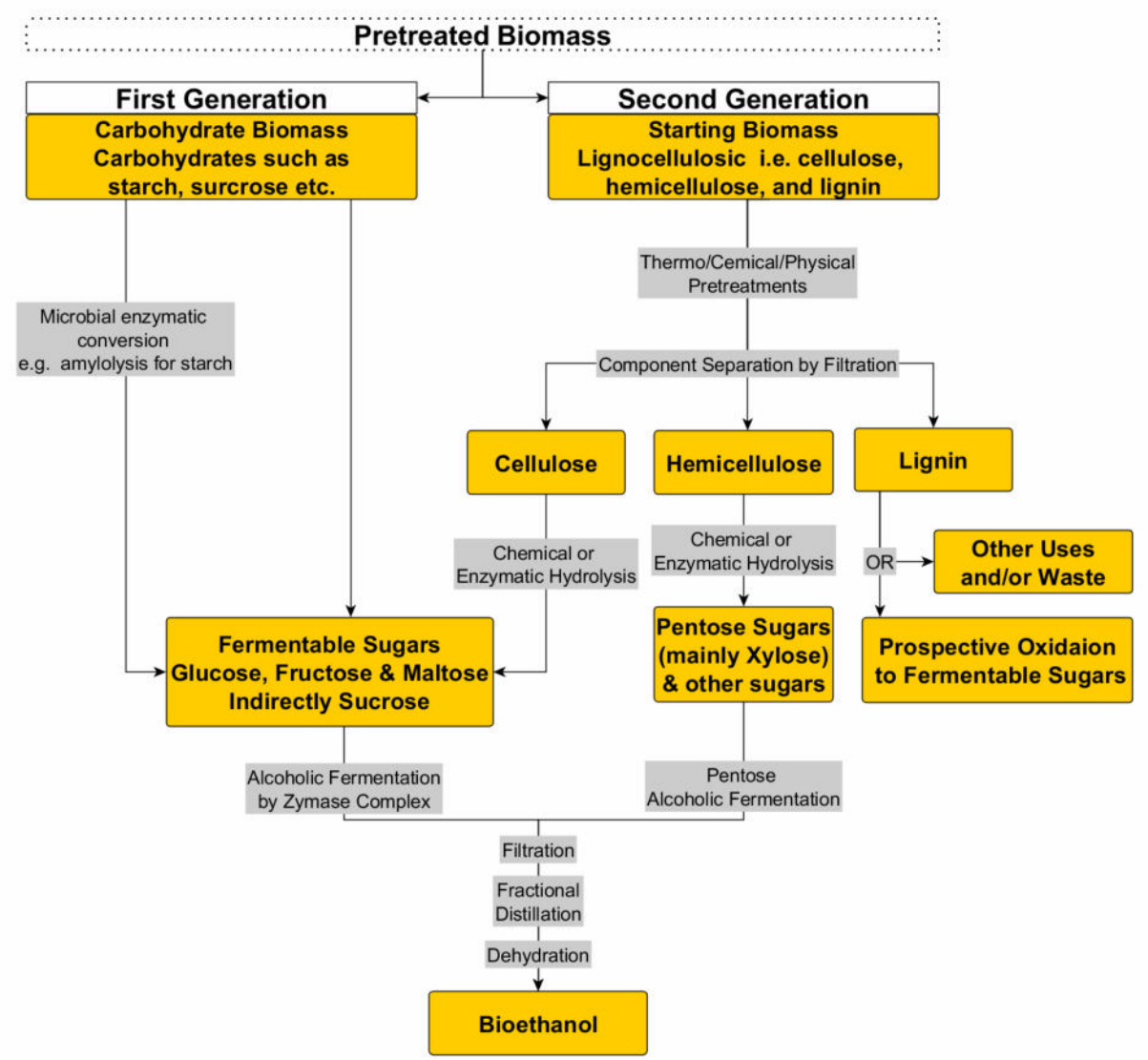
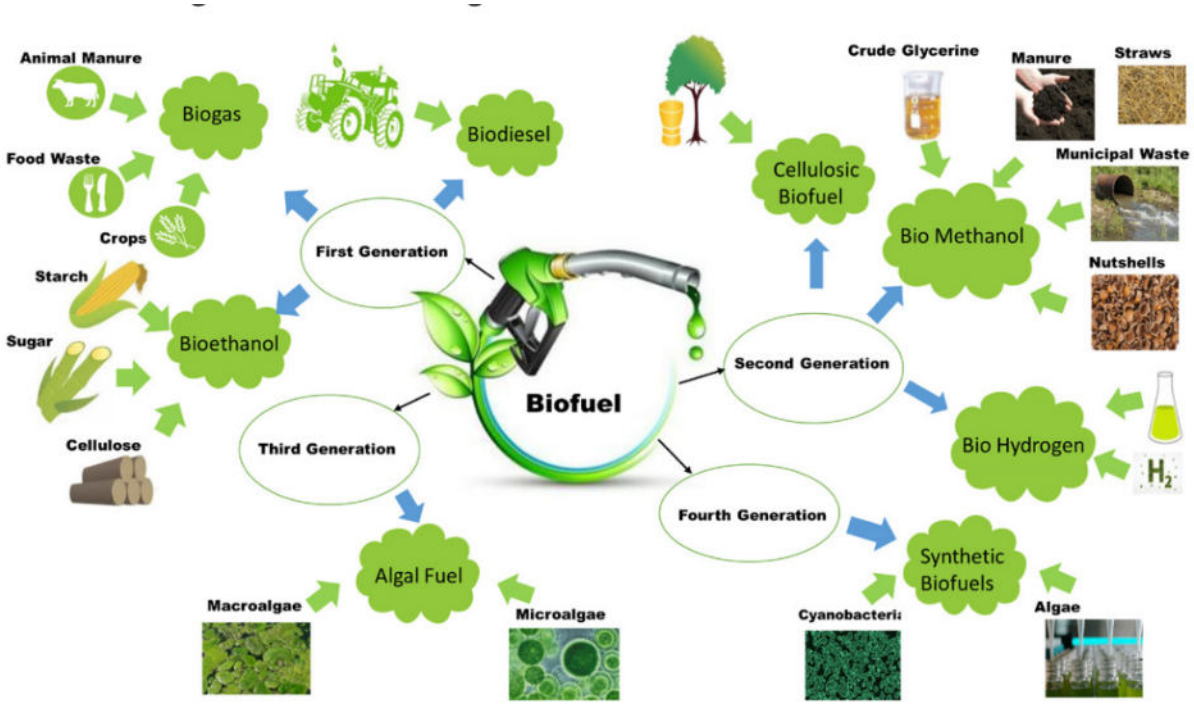
Next process is **Fermentation**: Fermentation is a complex biochemical process that converts sugar into alcohol or acids or other gases. The fermentation process occurs mostly in the presence of yeast and bacteria.
Mostly the thermal conversion or combustion process is the dominant mechanism to convert biomass into heat or electricity. The energy produced by burning biomass is predominantly

well suited for countries where the fuelwood grows more rapidly for example tropical countries.



Let's discuss another important biomass energy source that is **bioethanol**
Bioethanol can be produced by converting biomass into liquid fuels to meet transportation needs. Bioethanol can be created by using fermentation of organic materials.
Microorganisms such as bacteria and yeasts play an important role in fermenting starchy sugary biomass products like sugarcane corn sorghum and yielding products like biofuels and bioethanol.



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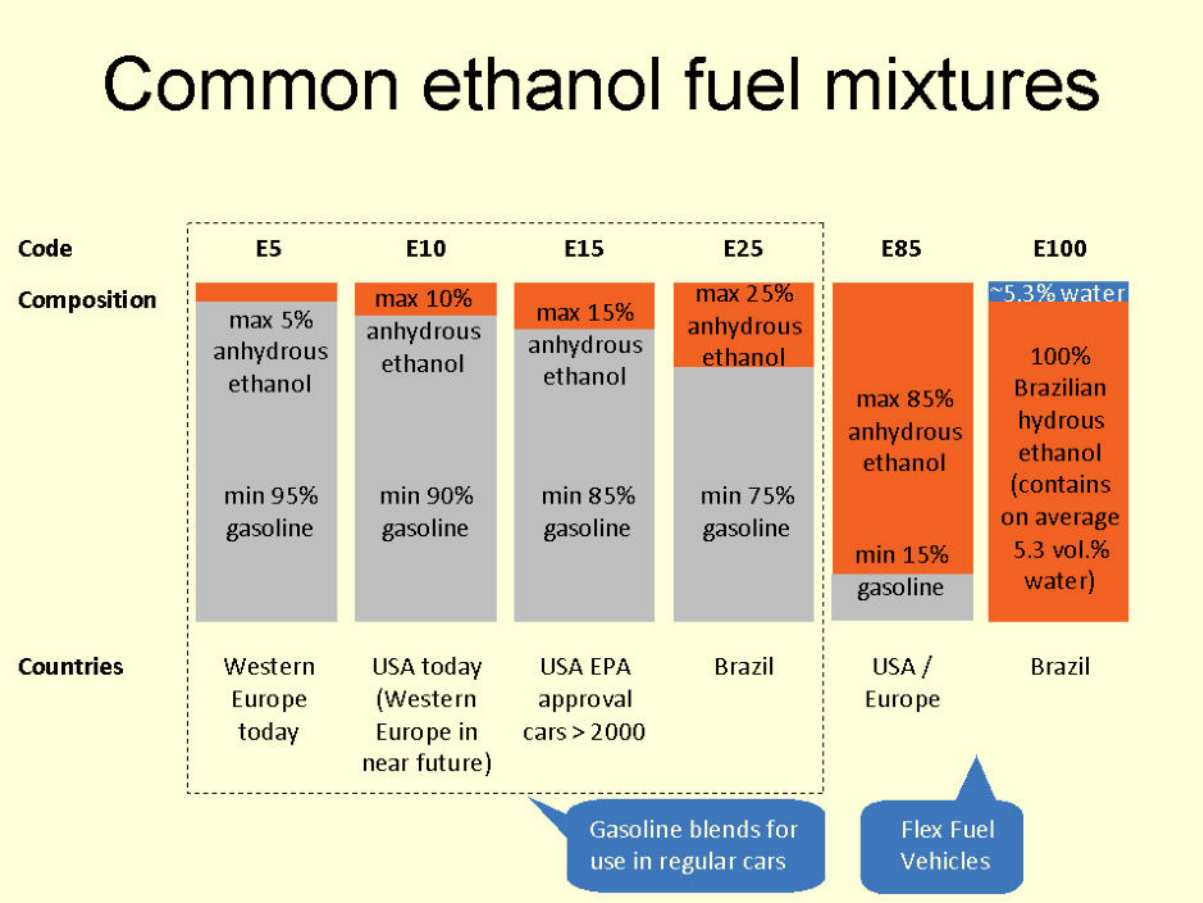
Bioethanol can be used as fuel in a variety of applications.
Bioethanol cannot be used alone in fuel cars. Instead, bioethanol can be blended with gasoline. The most widely used blends are E10 and E85. The E and number refer to the percentage of ethanol fuel by volume in the blend. For examples E10 is a blend of 10% ethanol and 90% gasoline. In the case of E85 85% ethanol and 15% gasoline.

Bioethanol is a clean fuel; even though its calorific value is lesser than gasoline bioethanol increases the octane number and decreases the amount of greenhouse gas emissions
Bioethanol production will offer economic benefits to farmers. Most of bioethanol used today comes from sugarcane and corn. Many bioethanol production plants are farmer-owned plants. It is indirectly supporting the industry's growth.
Bioethanol actually reduces the fuel economy by 2 to 3 percent.
Hence it is a desirable alternative fuel leading the future away from our gasoline addiction.



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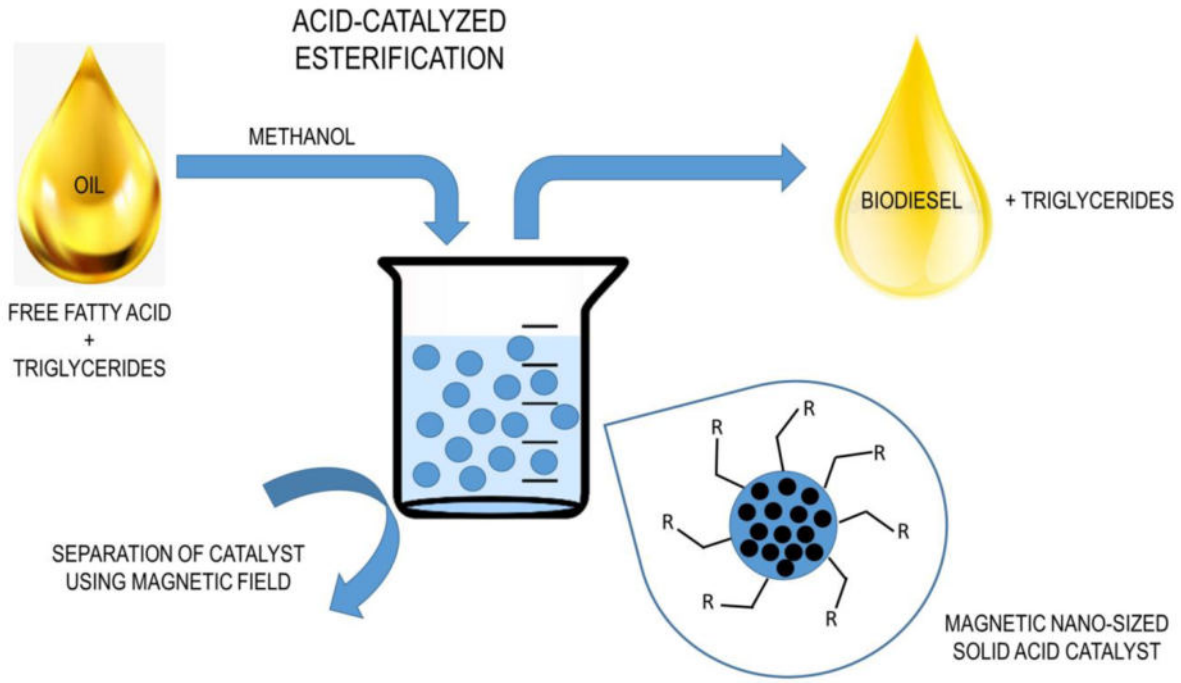
Next, we can discuss about **Biodiesel**.
Biodiesel is an alternative liquid fuel especially in the transportation sector. Biodiesel is a potentially low-carbon-containing renewable biodegradable fuel sharing similar chemical properties and physical properties to conventional petroleum diesel. Chemically these are long-chain fatty acid esters produced from sources like vegetable oil and animal fats and from an alcohol such as methanol or ethanol produced from plants and plant wastes using a catalyst. It shows great promise as fuel when used alone or when mixed with petroleum diesel.

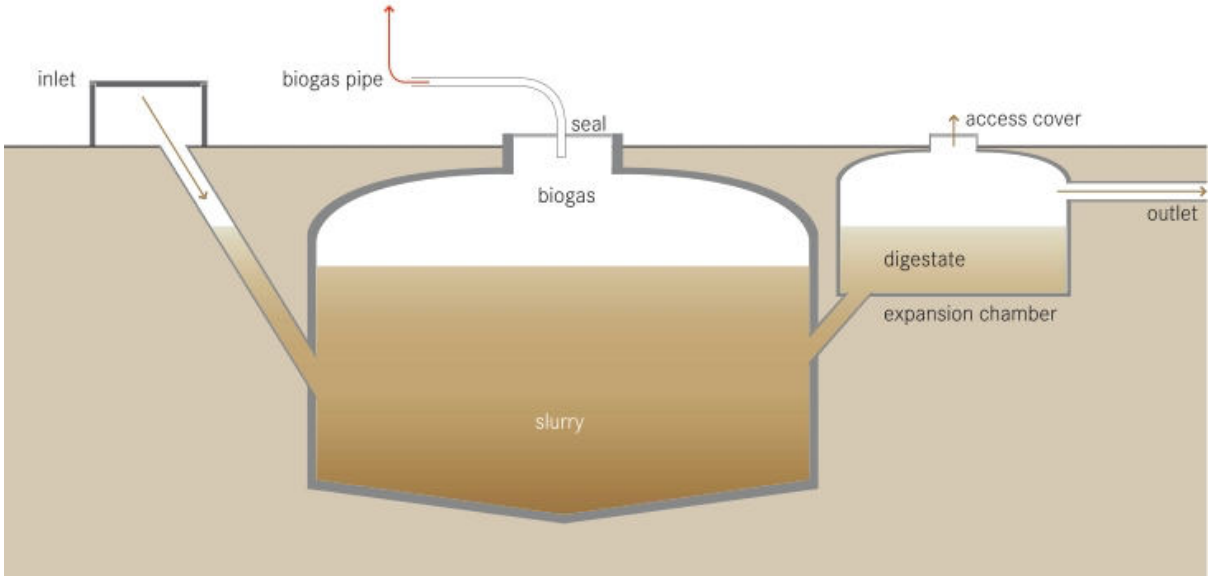


Most of the time these vegetable oils are extracted from rapeseeds soybeans oil palms sunflowers jatropha shrubs and animal fats. In India biodiesel is mainly produced from the jatropha shrub a plant growing mostly in tropical countries like India Brazil and Africa. The important advantage is Jatropha crops grow even in hot dry tropical areas. They don't need frequent rain and fertilizers.
Indian Railway has decided to use biodiesel in a big way in locomotives to reduce fuel consumption and cut down its oil bill.

Next, we can discuss about **Biogas**
Biogas is a mixture of gases like methane carbon dioxide hydrogen sulfide and moisture produced by the breakdown of biodegradable wastes such as agricultural wastes plant residues municipal wastes food wastes.
Biogas is a mixture of gases produced from the decomposition of organic matter in the absence of oxygen. The main constituent of biogas is methane nearly 65% and the rest is a mixture of carbon dioxide hydrogen and hydrogen sulfide. It is produced by anaerobic degradation of various wastes due to microbes and biochemical reactions. That's why a biogas plant is often known as an anaerobic digester.

Most of the time the biogas plant comprises a dome-like structure. In this energy crops such as corn or maize silage or biodegradable wastes including sewage wastes and discarded food residues fats sludge cow dung etc. along with wastewater are fed into the digester through the inlet. The digester is basically an air-tight tank where the anaerobic decomposition of organic matter occurs. During the process the microorganisms transform biomass waste into biogas primarily methane and carbon dioxide and digestate. After that we can draw these gases through pipes from the storage tank above the digester and This biogas can be used for

heating producing electricity and for many other applications. The digestate which is the left out organic matter can be used as a bio-fertilizer and spread directly onto fields.



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Biogas has a lot of advantages.
It is a non-polluting clean and low-cost fuel. A Biogas plant does not require an expensive installation cost.
Very much useful in rural areas since a lot of animal waste is available
India is the top country by cattle population in the world
There is no storage problem since biogas is directly supplied from the plant
The sludge or digestate leftover is rich in fertilizer
Biogas burns without smoke; therefore, it evolves no harmful gases such as CO2 CO NO2 and SO2.
Biogas production depends on the amount of waste produced. Of course, waste production is an endless process in this current population growth.

There are a few disadvantages of biogas. Biogas production is inefficient on a large scale, and it is not economically feasible to use on a large scale. If a large amount of methane leaks it will cause a greenhouse effect and hence global warming.

Let's discuss about the difference between biomass and other fossil fuels
Biomass energy or biofuels can be generated quickly but fossil fuel formation takes millions of years hence it is renewable quickly
Biomass takes carbon out of the atmosphere; hence net CO2 emissions are low compared with fossil fuels.

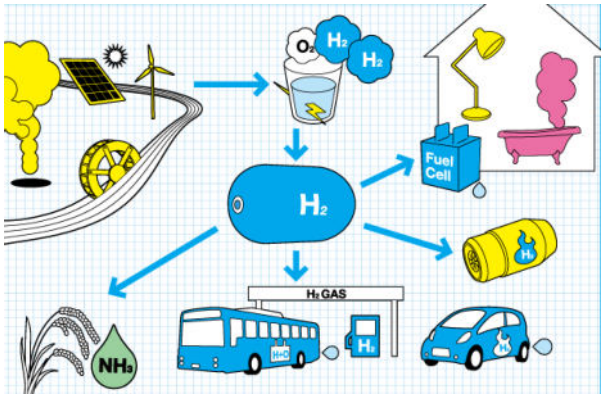
Finally, now we can discuss the advantages and disadvantages of biomass energy.
There are plenty of benefits due to biomass energy

Biomass is always and widely available because the production of biomass is infinite; since we consistently produce wastes such as garbage sewage waste etc. biomass energy is considered as a renewable source of energy.
Biomass energy production maintains carbon neutrality. During the photosynthesis process carbon dioxides are absorbed from the atmosphere by plants. ; When we burn biomass fuels the same amount of carbon dioxides will be released and hence it helps in maintaining carbon neutrality.
Fossil fuel production requires a lot of investment in oil drilling extractions and installing gas pipelines and distillation, but biomass energy production is much cheaper.
Farmers and local investors can generate higher profits from a lower output.
Biomass production adds a revenue source for farmers.
By burning solid wastes, we can reduce the landfills requirement by 60 to 90 percent. and thus it reduces the cost of waste disposal methods like sanitary landfills.
The use of biomass energy greatly reduces greenhouse gas emissions.
The use of biomass can reduce our dependency on fossil fuels because biofuels are the best alternative renewable liquid fuels available for the transportation sector.

There are also some shortcomings including
Some biofuels like bioethanol and biodiesel are relatively inefficient as compared to fossil fuels.
Biomass energy production may increase the risk of deforestation in the future.
It is difficult to find a convenient place for biomass energy plants near the urban area because people are afraid of the toxic and harmful gas emissions.

Hydrogen energy; Solar-hydrogen revolution

We are going to learn about hydrogen energy which is an another important renewable energy resource.
Let's begin with **what is hydrogen energy?**
Hydrogen is one of the simplest element consisting of one electron and one proton. This simple element is always found combining with other elements and forms compounds like water H_2O. Moreover it is most abundantly present in nature. But naturally hydrogen is not present in its gaseous form on the earth.



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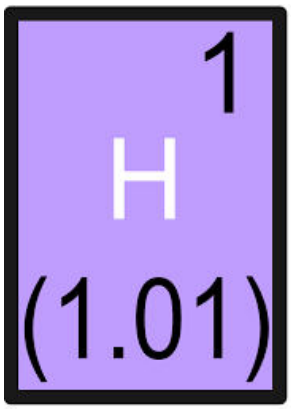
It is very light energy-dense fuel. It can be stored safely in hydrogen tanks. Burning of Hydrogen fuel produces no greenhouse gas emission such as carbon dioxides and other pollutants. Therefore it is a clean and environmentally friendly fuel. Hydrogen when combined with oxygen in a fuel cell it produces heat and electricity with liberation of water vapor as a by-product.



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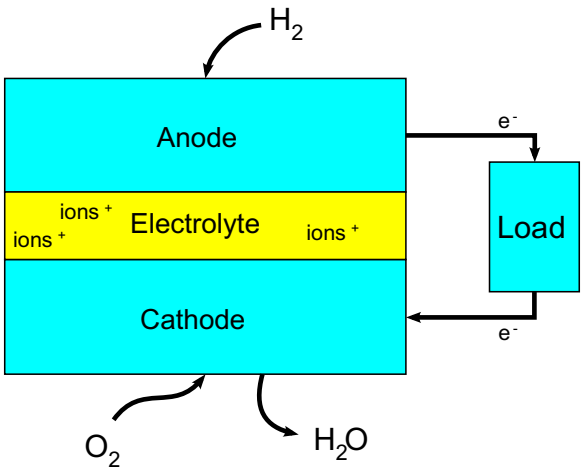
Hydrogen can be produced from fossil fuels or biomass or it can be produced by passing electricity through water. That is Electrolytic splitting of the water into its constituent components hydrogen and oxygen.



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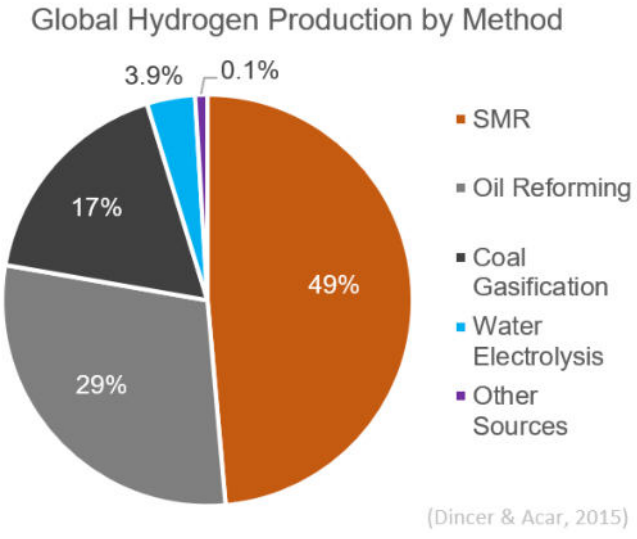
Hydrogen is not an energy source, but it is an **energy carrier**. Because hydrogen does not exist freely in nature, and it is only produced from other sources of energy that's why it is known as an *energy carrier*. This means that hydrogen has to be produced from one of the primary energy sources: such as fossil fuels nuclear energy or renewable energy resources such as solar wind biomass hydro energy or geothermal energy.

As I mention hydrogen does not exist freely in nature then how to produce it?
Hydrogen can be produced from a variety of resources such as natural gas nuclear power biomass and renewable power like solar and wind. These qualities make hydrogen as an attractive fuel option for transportation sector and electricity generation applications. It can be used in cars used in houses for portable power generation.
Today hydrogen fuel can be produced through several methods.
The most common methods today are

1. Natural gas reforming this is a thermal process
2. Thermochemical Water Splitting
3. electrolysis.
4. solar-driven processes or solar hydrogen cycle
5. biological processes.



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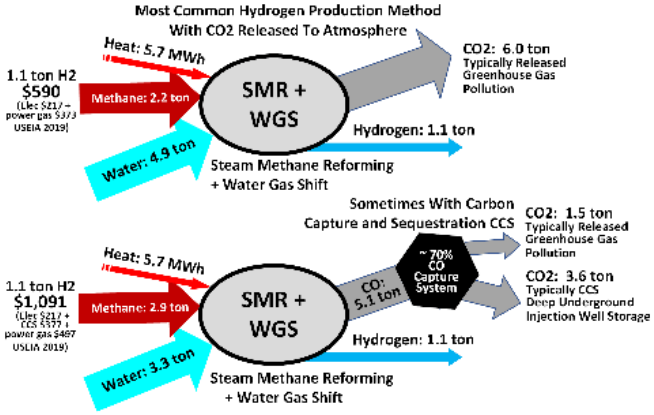
We can discuss above methods one by one

First what is natural gas reforming or thermal processes?

Thermal processes for hydrogen production typically involve steam reforming. That is a high-temperature process in which steam reacts with a fuel which contains hydrocarbons to produce hydrogen. Many hydrocarbon containing fuels can be converted into hydrogen including natural gas diesel renewable liquid fuels coal or biomass. Today >95% of hydrogen is produced from steam reforming of natural gases.

But there is disadvantages associated with this process 1. natural gas is already rapidly becoming limited source and more expensive one. 2. It is also a fossil fuel so the carbon dioxide which is released in the reformation process increase the greenhouse effect and global warming.



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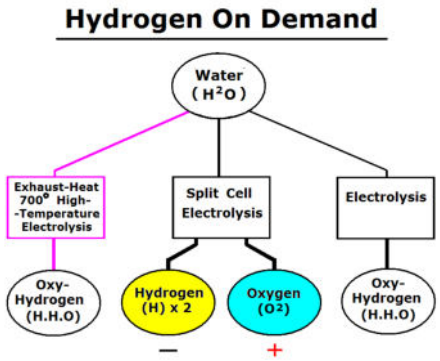
Let's move to the second method of Hydrogen Production That is Thermochemical Water Splitting

Thermochemical water splitting uses high temperatures nearly 500°–2000°C which may be comes from concentrated solar power or from the waste heat from the nuclear power stations. In this process chemical reactions would takes place and then produce hydrogen and oxygen from water. The chemicals such as cerium oxide or copper chloride can be used in the processes. Usually these chemicals are reused within each cycle and consumes only water and produces hydrogen and oxygen.

Solar- or nuclear-driven high-temperature thermochemical water-splitting cycles produce hydrogen with near-zero greenhouse gas emissions using water and sunlight or nuclear energy.



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Let's move to the third method of Hydrogen Production ELECTROLYTIC PROCESSES.

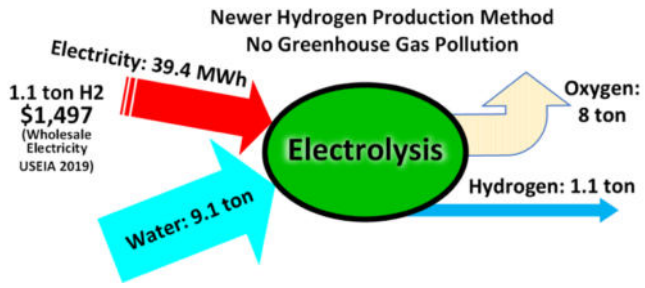
Water can be splitted into oxygen and hydrogen through a process called electrolysis. Electrolysis is the process of using electricity to split water into hydrogen and oxygen. Electrolysis is a promising option for carbon-free hydrogen production from renewable and nuclear resources.

Electrolytic processes take place in an electrolyzer. An electrolyzer creates hydrogen from water molecules. Electrolyzers can range from small-scale hydrogen production to large-scale production facilities that is well-suited for non-greenhouse-gas-emitting electricity production. Electrolyzers consist of an anode and a cathode which is separated by an electrolyte. Different electrolyzers function in different ways mainly due to the different type of electrolyte material involved and the ionic species it conducts.

- First Water reacts at the anode to form oxygen and positively charged hydrogen ions and electrons.
- The electrons flow through an external circuit and the protons selectively moves across the polymer electrolyte membrane (PEM) to the cathode.
- At the cathode hydrogen ions or protons combine with electrons from the external circuit to form hydrogen gas.

Anode Reaction is $2H_2O$ reacts and form $O_2 + 4H^+ + 4e^-$
Cathode Reaction is $4H^+ + 4e^- \rightarrow 2H_2$

Hydrogen produced via electrolysis can result in virtually zero greenhouse gas emissions depending on the source of the electricity used. however the production cost needs to be reduced in the future.



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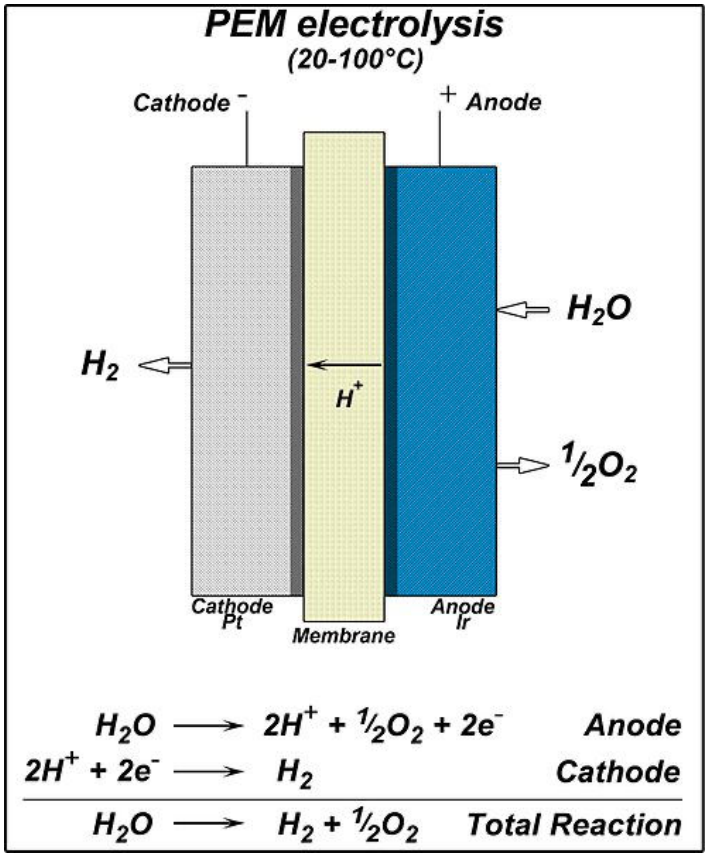

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Let's move to the fourth method of Hydrogen Production SOLAR-DRIVEN PROCESSES

Solar-driven processes use light as the agent for hydrogen production.

A typical Solar–hydrogen energy cycle consist of three components. First one is electrolyzer. Second one is hydrogen storage tank and third one is hydrogen fuel cell.

In a solar–hydrogen energy cycle a solar powered electrolyzer is used to convert water into hydrogen and oxygen. Hydrogen and oxygen produced thus are stored in containers for later use.

The stored hydrogen can be used by a fuel cell to produce electricity when no sunlight is available. Solar–hydrogen energy cycle is also called as Solar-hydrogen revolution

There are a few solar-driven processes including 1. Photobiological processes 2. Photoelectrochemical processes and 3. solar thermochemical processes.

Photobiological hydrogen production processes use the natural photosynthetic activity of bacteria and green algae to produce hydrogen. The photobiological process uses microorganisms and sunlight to turn organic matter into hydrogen.

Photoelectrochemical processes use specialized semiconductors to split water into hydrogen and oxygen.

Solar thermochemical hydrogen production uses concentrated solar power to drive water splitting reactions often with the help of reagents such as metal oxides.

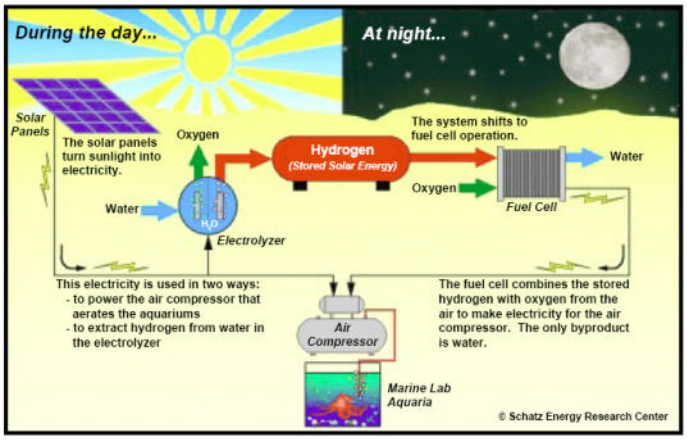

Photo courtesy Ali, Suhaib. (2022). SOLAR-HYDROGEN SYSTEMS FOR REMOTE AREA POWER SUPPLY.

THE LAST METHOD OF HYDROGEN PRODUCTION BIOLOGICAL PROCESSES
Biological processes use microbes such as bacteria and microalgae and can produce hydrogen through biological reactions. In microbial biomass conversion the microbes break down organic matter like biomass or wastewater to produce hydrogen

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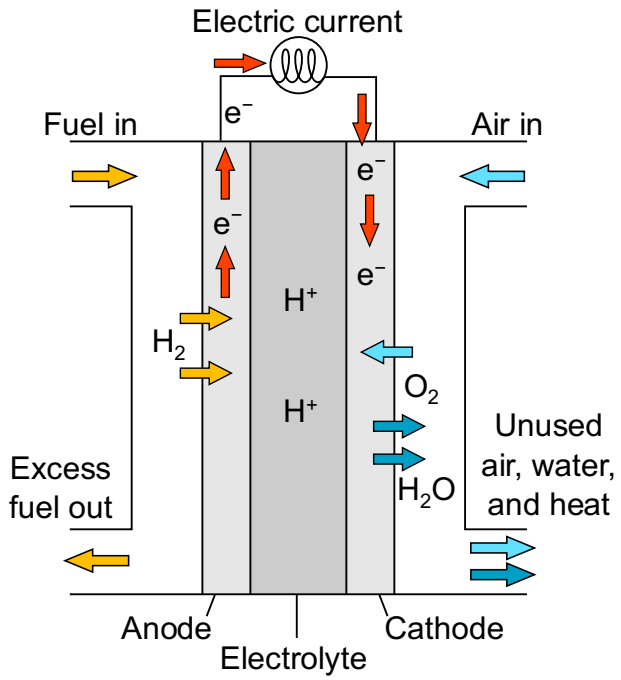
Let me explain how to utilize hydrogen for generating heat or electricity
Typically Hydrogen Fuel cells are used to generate electricity

Let's discuss what is meant by **Hydrogen Fuel Cell?**
To know about hydrogen fuel cell at first you should know what a fuel cell is?
A fuel cell is a device that can convert the chemical energy into electrical energy.
Thus often this fuel cell is compared to batteries. Both fuel cells and batteries produce energy via chemical reactions and transfer that energy into usable electric power.

In a typical fuel cell hydrogen gas is supplied to anode. At anode these hydrogen molecules divide into protons and electrons. The produced electrons flow through wires and generate electricity while the protons pass through a membrane and combine with oxygen gas at cathode to form water vapor. Overall Hydrogen fuel cells produce electricity by combining hydrogen and oxygen atoms. Due to the applications of hydrogen fuel cells these two elements react and produce a huge amount of energy.
In fuel cells three product we can harvest heat electricity and water.

Different types of fuel cells are available for a wide range of applications.
Small fuel cells can power laptop and computers and even cell phones. Large fuel cells can supply electricity to electric power grids and supply emergency power in buildings and supply electricity in places that are not connected to electric power grids.



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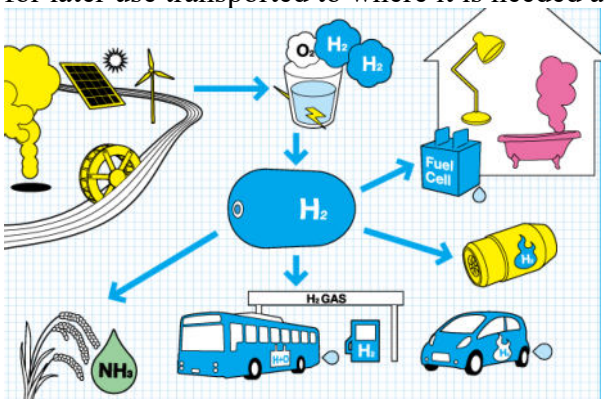
In this module we should learn another important terminology that is Hydrogen Economy
The term ***"hydrogen economy"*** refers to the vision of using hydrogen as a low or zero carbon energy sources. For example replacing natural gas as a heating fuel or replacing gasoline as a transport fuel.
It is expected that in a near future hydrogen is produced from a variety of energy sources stored for later use transported to where it is needed and then converted into heat and electricity.



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Let me explain various applications of hydrogen fuel cells
hydrogen fuel cells would eliminate most of the air pollution problems we face today.

It would also greatly reduce the threats of global warming and climate change because using it emits no carbon dioxides.
Hydrogen also provides more energy per gram than does any other fuel making hydrogen the ideal aviation fuel.
Hydrogen is considered as an alternative vehicle fuel. A fuel cell may be. two to three times more efficient than an internal combustion engine running on gasoline.
Today hydrogen is used mostly in oil refining industries and fertilisers industries.
Another promising application is in homes where a fuel-cell stack. about the size of a refrigerator could provide heat hot water and electricity.
Honda company has developed a home unit hydrogen generator that produces hydrogen from the methane.
Many Japanese homeowners using such units to produce their electricity and hot water

Finally we can discuss now Advantages and disadvantages of hydrogen energy
Advantages: Hydrogen can be produced from ample water. It has low environmental impact. It is considered as renewable energy if hydrogen is produced from the renewable energy for example as indicated in solar hydrogen cycle. It is a good substitute for oil. It is easier to store than the electricity and safer than gasoline and natural gas. Today many high efficiency hydrogen fuel cells are commercially available and are in developmental stages.

Disadvantages: Hydrogen is not found in nature as H2 molecule. hydrogen is chemically locked-up in water and in organic molecules such as methane and gasoline. Hence we need to spend an energy to produce hydrogen from these compounds. Therefore net energy is negative. It is difficult to store hydrogen in fuel tank which is the main problem of using hydrogen fuel cell in cars.
Fuel cells are the best way to use hydrogen to produce electricity to operate vehicles but current versions of hydrogen fuel cells are expensive.

Electric and CNG vehicles

We are going to learn about Electric and CNG vehicles which is the future in transportation sector

Let's begin with **What are Electric Vehicles?**

An Electric Vehicle is a vehicle that operates on an electric motor and uses electrical energy stored in batteries instead of an internal combustion engine that generates power by burning a mixture of fuel and gases.

Unlike vehicles with combustion engines electric vehicles do not produce exhaust gases during operation. This makes electric vehicles more environmentally friendly than the vehicles with conventional technology.

Electric vehicle is considered as a possible replacement for the current-generation automobiles in the near future to address environmental challenges.

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Let see how does **Electric Vehicles** work?

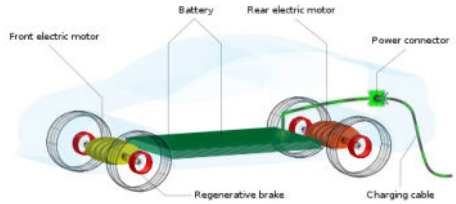
Electric Vehicles needs 3 important components

1. Controllers
2. Battery
3. Electric motor

When the pedal is pushed the controller gathers energy from the battery

Then Controller delivers the appropriate amount of electrical energy to the motor

Thus, this delivered electric energy transforms to mechanical energy therefore Wheels turn vehicles move.



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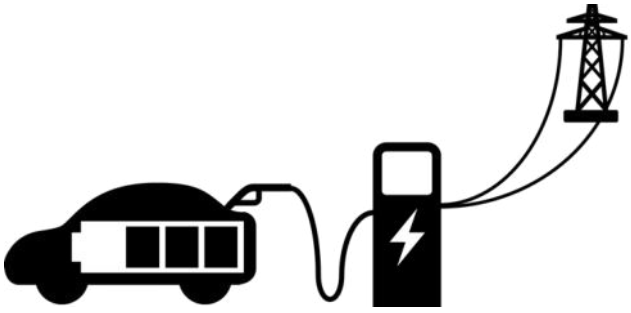
Electric Vehicles are not an new concept. In 1830 - first electric carriage was built.

In 1891 the first electric automobile was built in the USA.

Let's discuss Types of electric vehicles
Four types of electric vehicles on the toad today

1. BEV that is Battery electric vehicles
2. PHEV that is Plug-in hybrid electric vehicle
3. HEV that is hybrid electric vehicle
4. Finally, FCEV that is Fuel-cell electric vehicle

Let's discuss each one of them one by one
What is BEV: Battery electric vehicles.
Another name for Battery electric vehicles is All-Electric Vehicle (AEV)
A Battery electric vehicle runs entirely on a battery and without a need of an internal combustion engine. It is powered by electricity from an external source usually the public power grid. This electricity is stored in onboard batteries that turn the vehicles wheels using one or more electric motors.
BEVs can be charged at home overnight providing enough range for average journeys. However longer journeys or those who require a lot of hill climbs may require charging multiple times before you reach your destination.
The typical charging time for an electric car can range from 30 minutes and up to more than 12 hours. This all depends on the speed of the charging station and the size of the battery.
In the real world range is one of the biggest concerns for electric vehicles but is something that is being addressed by Research and Development and industry.



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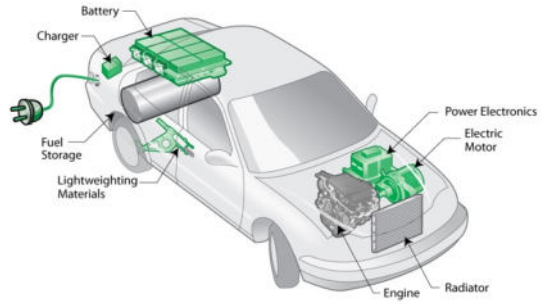
EV batteries are charged by plugging the vehicle into an electric power source.
EVs are far more efficient than conventional vehicles and produce no tailpipe emissions.
They also typically require less maintenance because the battery motor and associated electronics require little to no regular maintenance.
Further electric vehicles experience less brake wear thanks to regenerative braking systems.
Electric vehicles have fewer moving parts relative to conventional vehicles.
Electric vehicles do not contain the typical liquid fuel components such as a fuel pump fuel line or. fuel tank.

Next, we can discuss PHEV- Plug-in hybrid electric vehicle

Plug-in hybrid electric vehicle runs mostly on a battery that is recharged by plugging into the power grid. It is **also equipped** with an internal combustion engine which run on a gasoline or diesel fuel that can recharge the battery and/or to replace the electrical inverter when the battery is low and when more power is required
This makes them better for travelling long distances as you can switch to traditional fuels rather than having to find charge points to top up the battery.

PHEVs have smaller battery packs which means it can be used for medium range distances.
Of course, the same disadvantages that apply to combustion engine vehicles also apply to PHEVs such as the need for more maintenance engine noise emissions and the cost of petrol.



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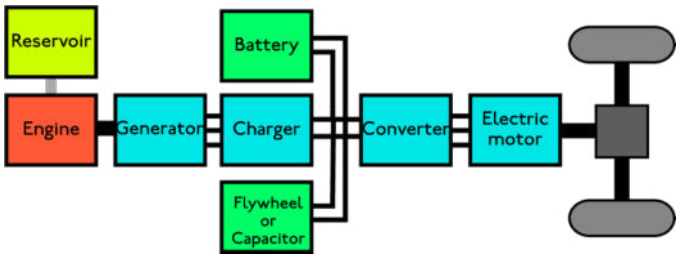
Next, we can discuss HEV Hybrid electric vehicle

An HEV has two complementary drive systems first one is a gasoline engine and fuel tank and the second one is an electric motor battery and controls. The engine and the motor can simultaneously turn the transmission which powers the wheels. The main difference between already discussed electric vehicles is HEV cannot be recharged from the power grid. Their energy comes entirely from gasoline and regenerative braking systems.



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Next, we can discuss FCEV - Fuel-cell electric vehicle more often it is called as hydrogen fuel cell electric vehicle.

A FCEV creates electricity from hydrogen and oxygen instead of storing and releasing energy like a rechargeable battery. Because of vehicles efficiency and water-only emission most of the experts consider these cars to be the best electric vehicles even though they are still in development phases.

Let's discuss about the Advantages and disadvantages of Electric vehicles

Electric vehicles have low running costs as they have fewer moving parts for maintaining

Electric vehicles and also environmentally friendly as they use little or no fossil fuels like petrol or diesel.

Compared to an internal combustion engine battery powered electric vehicles have approximately 99% fewer moving parts that need maintenance. Also, there is no need to lubricate the engines.

Electric vehicles create very little noise. Electric cars put a control on noise pollution as they are much quieter.

In electric vehicles there is no exhaust no spark plugs no clutch or gears.

Finally, it is Easy Driving – you can operate an electric car with just the accelerator pedal brake pedal and steering wheel.

Electric vehicles don't burn fossil fuels instead uses rechargeable batteries.

Electric vehicles are energy efficient

For examples in electric vehicles batteries convert 59 to 62 percent of energy into vehicle movement while gas powered vehicles only convert between 17 and 21 percent.

Electric cars reduce emission. Electric cars are 100 percent eco-friendly as they run on electrically powered engines. Emission reduction including reduced usage of fuel is another advantage for all-electric vehicles. Because they rely on a rechargeable battery

Electric cars are high performance and low maintenance

The driving experience can also be fun because AEV motors react quickly making them responsive with good torque. AEVs are digitally connected with charging stations providing the option to control charging from an even a mobile app.

Finally electrical vehicles are Safe to Drive. - An electric car is safer to use given their lower center of gravity which makes them much more stable on the road in case of a collision.

Disadvantages of electric vehicles

The Initial Investment on **electric vehicles** is Expensive. Keep in mind Electricity isn't Free.

Electric cars can travel only less distances. AEVs on average have a shorter range than gas-powered cars. Most models ranging between 100 and 200 km per charge and some luxury models reaching ranges of 300 miles per charge. This may be an issue **when looking at AEVs if you frequently take long trips.** Availability of charging stations can make AEVs less suitable for activities like road trips.

Electric cars take longer to "refuel".

Fueling an all-electric car can also be an issue. Recharge Points or Electric fueling stations are still in the development stages.

Fully recharging the battery pack can take up to 8 hours and even fast charging stations take 30 minutes to charge. Thus, Electric car drivers have to plan more carefully because running out of power can't be solved by a quick stop at the charging stations.

Electric cars are more expensive and battery packs may need to be replaced. Depending on the type and usage of battery batteries of almost all electric cars are required to be replaced every 3-10 years.

The battery packs within an electric car are expensive and may need to be replaced more than once over the lifetime of the car. These All-electric vehicles are more expensive than gas-powered cars.
Overall all-electric vehicles like any vehicle must be assessed based on personal needs and vehicle usage. There are many pros to owning an electric vehicle such as fuel savings and reduced emissions, but this can come at the cost of relying on battery charging and higher costs.
Electric vehicles create very little noise. Silence can be a bit disadvantage as people like to hear the noise if they are coming from behind them. Therefore, it can lead to accidents in some cases.
There are still challenges with electric vehicle batteries as they can experience thermal runaway which have for example caused fires or explosions.

Let's move to the second topic CNG operated vehicles
What is CNG?
CNG also known as compressed natural gas It is an eco-friendly alternative to gasoline. CNGs are made by compressing natural gas for example methane down to less than 1% of its volume at standard atmospheric pressure or compressed to 3000 - 3600 psi. CNG fuel is safer than gasoline and diesel because it is non-toxic. This natural gas is the same gas that you use daily to cook on the stove. The use of CNG fuel is becoming more popular with both commercial and non-commercial vehicles.
Compressed natural gas is under more pressure and thus takes up a smaller volume than ordinary natural gas.
Compressed Natural Gas is colorless non-carcinogenic and non-toxic. CNG is inflammable and lighter than air.
CNG is superior to petrol it operates at one-third the cost of conventional fuel and hence increasingly becoming popular with automobile owners. Commonly referred to as the green fuel because of its lead free characteristic and it reduces harmful emissions and is non-corrosive.
CNG is comprised of mostly methane gas. When CNG reaches the combustion chamber it mixes with air will be ignited by a spark and generates energy which moves the vehicle.
Please remember it is not a liquid fuel and is not the same as LPG Liquified Petroleum Gas which consists of propane and butane in liquid form. Also, CNG is not to be confused with liquefied natural gas.


Photo courtesy https://commons.wikimedia.org/

Why CNG is better than traditional petrol?

CNG is one of the most viable alternatives to traditional liquid fuels for vehicles.

CNG is one fifth the price of gasoline resulting in substantial savings in fuel costs.

CNG reduces maintenance costs since it contains no additives and burns cleanly leaving no by-products of combustion to contaminate your spark plugs and engine oil.

The engine oil also remains clean which minimizes engine wear and requires less frequent changes.

CNG is more environment friendly and CNG engines are much quieter due to the higher octane rating over gasoline.

CNG produces less exhaust emissions and as a result harmful emissions such as carbon monoxide carbon dioxide and nitrous oxide are generally reduced by as much as 95% when compared to gasoline powered vehicles.

Disadvantages of CNG:

CNG Gas stations have limited availability. In India some states have high number of CNG fuel stations.

CNG tank requires large space, and it is heavy. So, it affects reliability and vehicle performance.

Another issue with CNG vehicles is a longer breaking distance **due to the added weight of the fuel storage system.**

Further the composition of natural gas itself can be an issue. CNG is mainly comprises of methane which is a greenhouse gas which could contribute to climate change if a leak existed.

Environmental Protection Acts (EPA)

1.Introduction

In this modern world a major part of innovation in scientific and technological development has been directed towards generations of elevation of human comforts, thereby increasing the standards of living in the society. As a result there is an enormous increase in industrialization. The improvement in the standards of human life is with respect to the applications of science and technology which includes;

a) Production of more and better quality of food.
b) Innovations in communication systems.
c) Creation of reliable and faster transportation.
d) Need of safe water.
e) Providing healthy environment.
f) Protecting the environment from natural disasters ex.droughts,floods,volcanic eruptions,etc.

As a result these major needs by the growing mankind led to the disturbing side effects such as environmental pollution, deforestation, urbanization, loss of arable land etc. Hence, protecting our earth and environment from all these effects are the responsibility of each and every individual. In addition to this it is also the obligation of the State and all the other State organs including courts.

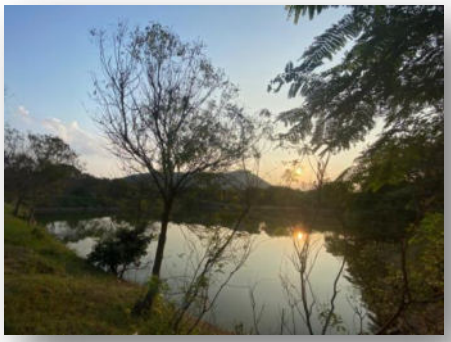
In this regard, environmental protection acts has succeeded in unshackling man's right to life and personal liberty from the clutches of common law of individual ownership. The judiciary in our country has been exhibiting exemplary concern and appreciation towards environmental protection and ecological conservation.

1.1 Environmental legislation in India

Our country has demonstrated its concern for pollution control and environment protection by enacting several legislations and constituting Statutory Bodies dedicated for this cause. The important acts that had been put forwarded regarding the environmental protection are as follows;

1) Air act
2) Water act
3) Forest conservation act
4) Wildlife protection act

The environment where we live, there is an effective interaction of mankind with its components like water, air and land.The human activities with the ecosystem results in deteriorating phase A on account of the overexploiting the natural resources. Hence it is needed that every individual,Institutions,and Organisations along with the Government should come forward to protect the environment where we live.



This was first discussed in the "United Nations Conference on the Human Environment" , held in Stockholm on 5th June 1972,during which the various issues related to environmental pollution was discussed in detail by the participating countries. India was one among them and raised its concern regarding the environmental protection. The outcome of the conference resulted in declaring various guidelines mentioning the role of individual and the Government in safeguarding the natural resources. To emphasis the decisions taken and also to signify the importance of protecting the environment 5th June is observed as "World Environment Day" every year.

2.The Environment (Protection) Act

One of the important outcomes of this event is, "**The Enviromment (Protection) Act"** put forward in the year 1986. The act was passed under Article 253 of the Constitution, and came into force 19 Nov 1986- birthday of Late Prime minister, Indira Gandhi who was one of the world's first leaders to embrace policies to protect the environment, long before it became a survival imperative. This was a welcoming venture in the field of environmental legislation which was a long –felt need. This act provides overall protection and preservation of the ecosystem. In our country this was enacted after the Bhopal gas tragedy. The Act consists of 26 sections and divided into four chapters. This relates to some of the preliminary aspects which have to be concentrated on. This speaks about the general powers of the central government.

This also includes the prevention control, and abatement of environmental pollution to prevent the contamination and also how to avoid the pollution due to air water as well as the other pollutants.

The four chapters formulated address the following;

Chapter-I: Related to preliminary information and definitions on Environment, Environmental Pollutant, Environmental Pollution and Hazardous Substance.

Chapter-II: Explains the powers of the Central government regarding the protection and improving the quality of the environment.

Chapter-III: Prevention, control and abatement of environmental pollution

Chapter-IV: Miscellaneous; Protection of action taken in good faith.

2.1 Objectives of EPA

- To Provide protection and improvement
- To Prevent environmental pollution
- To tackle specific environmental problems in different parts of the country
- To coordinate activities of various regulatory agencies already in existence
- To appoint environmental officers to check for pollution
- To improve the quality of life by protection of environment
- To establish environmental laboratories and to monitor the pollution level at various parts of the country.
- To protect forests and wildlife in the country

2.2 Environmental Protection Acts Need:

We have been witnessing a decline in the quality of the environment, and we are evidencing that this is due to the increase in the population, which is resulting in environmental pollution and because of which there is heavy loss of vegetation as well as the biodiversity. There is also excessive chemical concentration that is happening, which is also contributing to the pollution and growing risk of environmental accidents.

Example: Bhopal gas tragedy.

This was proposed in 1986 after witnessing the consequences of the Bhopal tragedy. This is supposed to be one of the worst industrial disasters in history, which took place in 1984 from December 3rd to 4^{th}. This was due to the chemical compound abbreviated as MIC, which is methylisocyanate. It was released from the Union Carbide plant at Bhopal. This gas leakage led to various environmental issues. After witnessing the impacts of this particular accident, the Act was passed severely, and that came into the picture, which is called the Environmental Protection act. This Act was passed under article 253 of the Constitution and came into force on November 19th, 1986.To honor Mrs. Gandhi's birthday, November 19th, that particular Act was passed on November 19th, 1986. This Act acts as umbrella legislation, which is designed to provide a framework for central government and also to coordinate the various activities of various Central as well as state authorities.

2.3 Provisions of the Environmental Protection Act:

It lays the standards for the quality of air, water, and soil. This comes out with the maximal permissible limit of the pollutants. Procedures to handle and safeguard the hazardous substance were formulated. Initiation has taken place to identify some areas that are called restricting.

In the area where the hazardous materials are handled, the disposal and treatment of the hazardous material can be treated by throwing the waste into those restricting areas, and the required process can occur. There is the involvement of both pollution control boards, the State and the central boards to monitor the pollution level and also to prevent and avoid the accidents which might be causing the pollution:

2.4 Role of pollution control boards:

- Advise the industries about the treatment of effluents and using Advanced Technologies.
- Emphasize the importance recycle and reusing then reducing waste.
- To encourage the recovery of biogases, to make the people understand the importance of energy and how to convert the materials into reusable materials.
- Importance to implementation of cleaner Technologies in the industries.

Example: leather tanneries-the leather processing units are set up in the various parts of the State, especially in the Tamil Nadu

2.4 Critical definitions

Environment

It includes the major components like water, air, land, and interrelationships among them and between the living beings.

Environmental pollutant

This could be any substance like gas, liquid, or solid substances, which could also be a chemical compound. It is supposed to be present in the environment beyond its permissible limit, an environmental pollutant.

Environmental pollution

Environmental pollution is nothing but the process in which the pollution is happening.

Several sets of Rules relating to various aspects of management of hazardous chemicals, wastes, micro-organisms etc. have been notified under this Act.

2.5 Some important features of this Act:

- The Central Government may also put restrictions on an area in which any industry, operation or process or class of industries or operations shall not be carried out. If they are to be carried out, they may be permitted with certain safeguards.
- Emissions and effluent standards in respect of 61 categories of industries have been evolved notified so far.
- The standards in respect of pollutants are to be achieved within a period of one year from the date of their notification, especially by those industries identified as highly polluting.
- However, if a particular SPCB may so desire, it may reduce the time limit and also specify more stringent standards in respect of a specified category of industries within their jurisdiction. The SPCB however cannot relax either the time limit or the standards.
- Those industries that require consent under the Water Act, Air Act or both, or authorization under the Hazardous Waste (Management and Handling) Rules, 1989, are

required to submit an environmental audit report to the concerned SPCB/PCC on or before 30 September every year.

3. The Water (Prevention and Control of Pollution) Act, 1974

The pollution of water is an important fact which was felt by each citizen and this was brought as a major problem faced all over the world. To address the pollution of water due to various activities caused by the growing industries and the excess use and exploitation of the ground water conservation of water and its optimal use is being insisted. To address the pollution and prevention of water the Water Act was enacted by Parliament in 1974 with a focus on the prevention of control of water pollution and the maintaining or restoring of wholesomeness of water. The act is applicable in all the states of India. Some salient features of this Act are as follows:

- No person shall knowingly cause or permit any poisonous, noxious or polluting matter determined in accordance with such standards as may be laid down by the State Board to enter (whether directly or indirectly) into any stream or well or sewer or on land;
- No person shall knowingly cause or permit to enter into any stream any other matter which may tend, either directly or in combination with similar matters, to impede the proper flow of the water of the stream in a matter leading or likely to lead to a substantial aggravation of pollution due to other causes or of its consequences.
- No person shall, without the previous consent of the State Pollution Control Board (SPCB):

  a) establish or take any steps to establish any industry, operation or process, or any treatment and disposal system or an extension or addition thereto which is likely to discharge sewage or trade effluent into a stream or well or sewer or on land, or

  b) Bring into use any new or altered outlets for the discharge of sewage, or

  c) Begin to make any new discharge of sewage.

The act also advises the investor intending to set up an industry is required to apply in the prescribed form to the SPCB concerned to obtain the consent to establish as well as the consent

to operate the industry after establishment. While granting the consent, the SPCB also stipulates specific conditions relating to the temperature, volume, composition, rate and point of discharge emissions, effluents, etc. The consent to operate an industry is granted for a specific period after which the conditions stipulated at the time of granting consent are reviewed by the SPCB. Even before the expiry of the consent period, the SPCB authorized to carry out random checks on any industry to check if the standards prescribed are being complied with by the industry; in case the standards are not being met, the SPCB is authorized to serve a notice to the concerned person. The owner of a defaulting industry may be required to construct a sewage/effluent treatment system. In the event of non-compliance of the standards, the SPCB may issue directions for disconnecting electricity and water supply or any other services to the industry, in extreme cases even to close down the unit. Stringent penalties are prescribed in this Act for those who operate their industry without the valid consent or in violation of consent conditions. Any person aggrieved by an order of the SPCB in the above context may appeal to the Appellate Authority constituted by the concerned State Government. As per the provisions under the Water Act and the Air Act, all state governments, are required to constitute Appellate Authorities for addressing the appeals received against SPCB.

3.1 Salient features of the water Act

- Provide the prevention control and abandonment of water pollution.
- Maintenance or restoration of the wholesomeness of the water.
- It is designed to assess the pollution level and punish the polluters
- Central as well as the State Board has been set up to monitor the water pollution and is expected to provide the guidelines.

3.2 Roles of central Pollution Control boards

- advise the central government regarding the corrective measures that have to be taken
- coordinate with the state government to provide technical guidance and both the pollution control boards
- organizing some training programs where in which they can Define the functions of various authorities

- create awareness through the different Communications media and Technical and statistical data collection
- come up with some manuals which could address the treatment of sewage as well as the industrial effluents
- establish the standards for the water quality parameters
- develop and recognize labs for the analysis

3.4 Roles of State pollution-controlled boards

- Advise the state government regarding the corrective measures to be taken if the water bodies are severely polluted,
- Empowered to take samples from various water bodies and give the guidelines that they can monitor the water level to what extent it is contaminated.
- Powers to close down any Industries if they are crossing the permissible limit
- and any new Industries if the people want to set up, then they are supposed to get the concern from the state pollution control board

example: standard effluent treatment plant (ETP). It has been installed near ranipet in Vellore to address the effluent problem that is cast from the various tanneries Industries.

4. The Air (Prevention and Control of Pollution) Act, 1981

The act is one of the outcomes of the International Conference where the environmental protection was discussed. The air act speaks about the prevention and control of the air. This addresses the pollution that is due to the solid-liquid and gaseous substances.

This consists of 50 sections, and it was amended in the year 1987, where noise pollution was also inserted.

The objective of the Air Act is to prevent, control and reduce air pollution including noise pollution and to establish Boards at the State/UTs for this. Under the provisions of this Act, no person shall establish or operate any industrial plant without the consent of the SPCB/ PCC

Industry, Vehicles, power plants, Etc are not permitted to release particulate matters which might be including lead, carbon, carbon monoxide, sulfur dioxide, and nitrogen oxides, as well as volatile organic compounds or other toxic substances beyond a prescribed level.

This is an Act to provide for the prevention, control and abatement of air pollution, for the establishment of boards with a view to carrying out the air pollution control and for conferring on and assigning to such Boards powers and functions relating thereto and for matters connected therewith. It is considered necessary to implement the decisions aforesaid in so far as they relate to the preservation of the quality of air and control of air pollution..

For obtaining consent to establish an industry, the investor has to apply to the SPCB/PCC in the prescribed form accompanied by the prescribed fees. The Board is required to grant consent within 4 months of receipt of the application. The consent would contain conditions relating to specifications of pollution control equipment to be installed. Other Provisions of the Act are similar to those of the Water Act.

5. The Forest (Conservation) Act 1980

The forest is supposed to be a natural resource that is available abundantly. The earth is covered these forest resources, which will be seen as green in color, called the green blanket of the world. In addition to this, it also has various value-added products. They are classified into different categories like ecological significance products, commercial products, environmental applications, and societal applications. It is also a natural source of medicinally important compounds.

It is also identified as a home for wildlife. It provides wildlife habitat. There are about seven million species that depend on this forest. Forest also contributes to the regulation of the hydrological cycle in which 50 to 80 of the moisture in the air is transformed into various transpiration processes.

It reduces global warming by absorbing the carbon dioxide gas from the atmosphere, contributes to soil conservation where the soil is tightly packed. Protection and conservation of forest and its resources are the important requirement to protect the mother earth.

Objectives

1. To protect and conserve the forest.
2. To ensure judicious use of forest products

5.1 Salient features

- To protect and the forest from illegal cutting, encroachments, fire, grazing and shift agriculture
- To prevent deforestation activities
- The reserve forest should not be de-reserved without the prior permission of the Central Government.

6.The Wildlife Protection Act 1971(Amended in 1982, 1986, 1991, 1993, 2002 and 2006)

This act was enacted for providing protection to wild animals and birds. It provides for establishment of sanctuaries and national parks. It has provisions for dealing with zoos, trade in wild animals and for taking action for the specific protection of certain species. The act also provides for the constitution of a Wild Life Advisory Board, appointment of Chief Wild Life Warden and other employees by the State Governments for the protection of wildlife. It has been observed that "The Act failed to frighten poachers and miners, but was used against animal and environment-friendly tribals".

The Act resulted in establishing the following national parks, Sanctuaries,conservation reserves and biosphere reserves in our country.

- 104 National Parks,
- 551 Sanctuaries,
- 86 conservation reserves and
- 11 biosphere reserves in India.
- Endangered Wildlife list is created and updated every year.

7. The Environmental Impact Assessment

The following are the two distinct stages in EIA.

1. Preliminary Assessment: Carried out in the early stage of planning.
2. Detailed Assessment: Carried out during project planning until the project plan is completed and is reported formally as Environmental Impact Statement.

7.1 The key elements of an EIA are the following:

1) Screening

2) Scoping

3) Impact ID and prediction

4) Impact assessment and mitigation

5) EIA report

6) Decision making

7) Monitoring and evaluation

It has to be followed when a project or a policy has been proposed

Scoping is used to identify the key issues of concerns at an early stage in the planning process. . The scoping process should involve all interested parties such as the proponent and planning or environmental agencies and members of the public. The results of scoping will determine the scope, depth and terms of reference to addressed within the Environmental Statement. The following are the major objectives of the scoping.

- To identify the key issues and concerns of the interested parties
- To identify who is concerned
- To identify what their concerns are
- To identify why they concerns are
- To identify what is the threshold of concern where change becomes unacceptable.

Screening

This is used to decide whether an Environmental Assessment is required. There are two lists, referred to as schedules.

Schedule 1 – Environmental Assessment are required in every case. Schedule 1 projects range from "an integrated works for the initial melting of castiron and steel" to "a thermal power station or other combustion installation with a heat output of 300 MW or more".

Schedule 2 – Environmental Assessment are required if the project is likely to give rise to significant environmental effects by virtue of factors of their nature, size or location. The list of Schedule 2 project is greater than that of Schedule 1.

Screening is comprehensive and clear method of decision making. It is practical, quick and easy to use.

The other process like Impact ID and prediction, Impact assessment and mitigation insists about the steps involved in the implementation of the project or policy.

This would include the various pollution abatement techniques that would be required to reduce emissions to the permissible limits. If the uncertainties are great, with the possibility of grave consequences and no mitigating measures, then the development plan is rejected. If there are uncertainties that might be reduced by further studies then the applications deferred until further studies are carried out.

7.2 Environmental Statements/Reports

The EIA is the process required to produce the Environmental Statement. The environmental impact statement is a comprehensive document that reports the findings of the EIA. This is the final stage of the EIA process and is now often required by law before any new project can proceed.

Once if all the requirements are met with then the decision making will be made by the officials involving State and Central Board. However, once the project is approved continuous monitoring is emphasized to address the requirements of the environmental protection act.

7.3 Methodologies for EIA

There are various methodologies or tools available to assess the impact of any activity that can be approved. It includes;

1. Ad hoc method- Simple
2. checklist methods
3. matrix method
4. network methods
5. overlay methods

These are the significant methodologies that are proposed to implement the environmental impact assessment. The best method should be able to

- Organize a large mass of heterogeneous data
- Allow summarization of data
- Aggregate the data into smaller sets with least loss of information
- Consider the target audience

7.3.1 The first method is known as Ad-hoc approach, this is straightforward method all people will be able to understand. There are various characteristics that have been included like wildlife, the species, the natural vegetation and the groundwater quality, noise pollution, air quality grazing, and also the other component that are needed to be considered before that particular project could be implemented. It gives a clear idea regarding the stages as well as the parameters that has to be considered before bringing in that particular method.

It could be done by the opinion poll method, expert opinion method, and Delphi method.
The opinion poll method is based on the opinions that the various stakeholders. We can get the information through taking a survey to get the details on particular project will be effectively implemented in that particular area and the second one is the expert opinion. When the proposal and policy have been drafted it will be given to an expert. The particular policies or the

proposals that has been submitted will be given to the experts to evaluate the project. There will be an opinion that is obtained by an expert and based on which the method can be approved.

The third one is the Delphi method, which will be a questionnaire which consists of questions that will be distributed among the various stakeholders to gather the information pertaining to the project proposed. The responses will be analyzed seriously, and then that particular project can be implemented.The advantage is that it is very simple and easily understandable and it is a draft method that will give us information about the impact on the environment.

The disadvantages of Ad hoc method:

- It requires expertise.
- It is not applicable to large data.
- It is on a guest basis.
- It gives only minimal guidance
- It does not allow us to address the actual impacts on the specific parameters that will be affected.

7.3.2.The second method is known as the checklist method.

This checklist method lists the various environmental factors in a structured format. The checklist method can be classified into four different types

- Simple – list of environmental factors with no guidelines
- Descriptive- includes the guidelines and identification of parameters.
- Scaling- similar to checklist method but with the additional information on parameters.

- Weighing – similar to scaling but with additional information for the evaluation of each parameters.

Example:

Resources	Potential Impact

	Site clearance	Laying pipelines	Treatment process	Import materials
Air Quality	✔			
Water quality			✔	
Floara		✔	✔	
Founa			✔	
Noise				✔

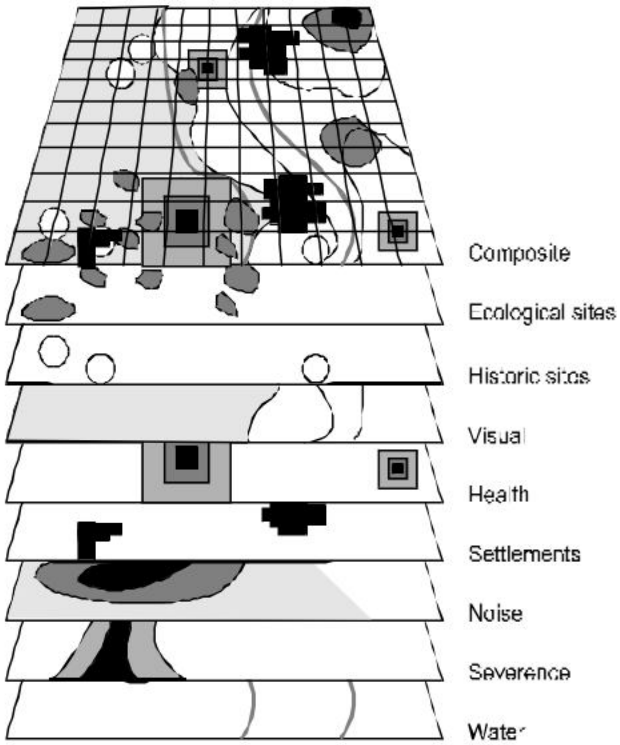
7.3.3 The third method is Matrix method. This matrix method involves a two-dimensional checklist in which one axis represents the project activities, and the other can represent the environmental characteristics. It is a 2-Dimensional check list where one axis represents project activities and the other represents environmental characteristics.It can evaluate the degree of impact on the environment.It can evaluate the cumulative and indirect impacts and interaction with natural resources.

Example: Leopold Matrix Method

Fourth method is known as Network method. This method

- Identifies the pathway using series of network
- Integrated assessment –integrates all aspects
- It extends to include both the primary as well as the secondary impacts.
- It is shown in reference or sequence diagram.
- Identification of direct, indirect along with short, long term impact is a crucial and basic step of making an impact tree

7.3.5. Finally the overlay method involves set of transparent map.



It dispaly the spacial distribution of environmental characteristics. It can display both physical and social aspects of area under study. The impacts of the project are well predicted before and after implementation of the project. This involves advanced techniques like GIS technique which is used to predict and study the project area and assessments accurately.

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URBAN ENVIRONMENTAL PROBLEMS

This lecture notes enlightens you on Urbanization, help identify major problems that have surfaced due to the unprecedented rate of urban growth in India.

Urbanization refers to the population shift from rural to urban areas, the corresponding decrease in the proportion of people living in rural areas, and the ways in which societies adapt to this change.

Reasons for urbanization:

• Employment opportunities	Increase in population
• Better education for children	• Rural to urban migration
• Better commodity availability	• Better standards of living
• Better health care facilities	• Rural push factors and urban pull factors

Impacts of urbanization on the Environment:

1. **Habitat loss and deforestation:** Forest fires because of natural or manmade causes are devastating to the flora and fauna, resulting in the loss of biodiversity.

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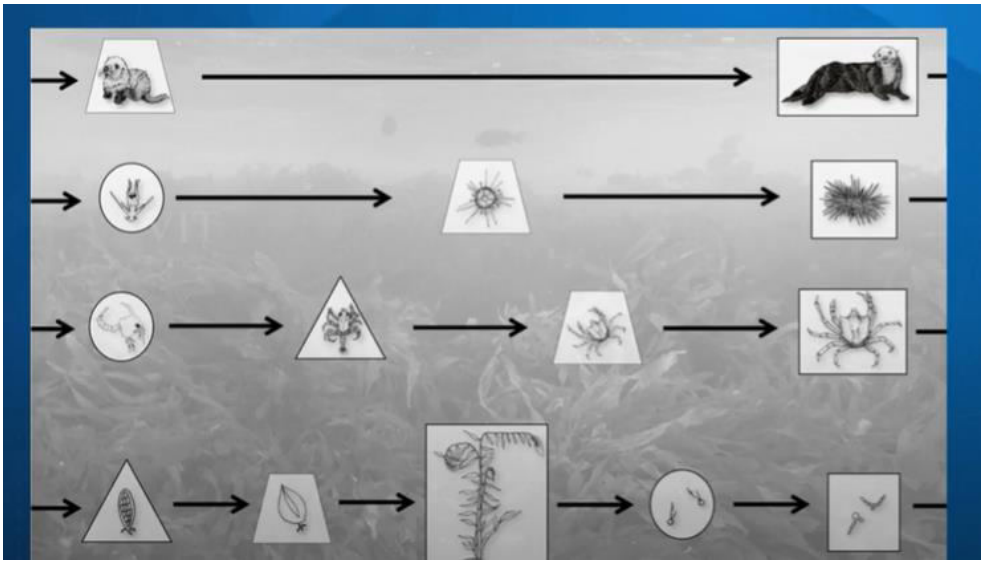
2. **The evolution of lifecycle and traits**

Urbanization alters abiotic and biotic environments over time and space. Several ecological changes are associated with urbanization and have the potential to strongly affect the evolution of the urban population

Therefore, urbanization can also have an impact on the evolution of life cycles and traits that help different species to survive and reproduce in disturbed or altered ecosystems. For example, some bird populations living in urban environments have altered their beak shape to be able to more effectively eat the seeds in human-made bird feeders.



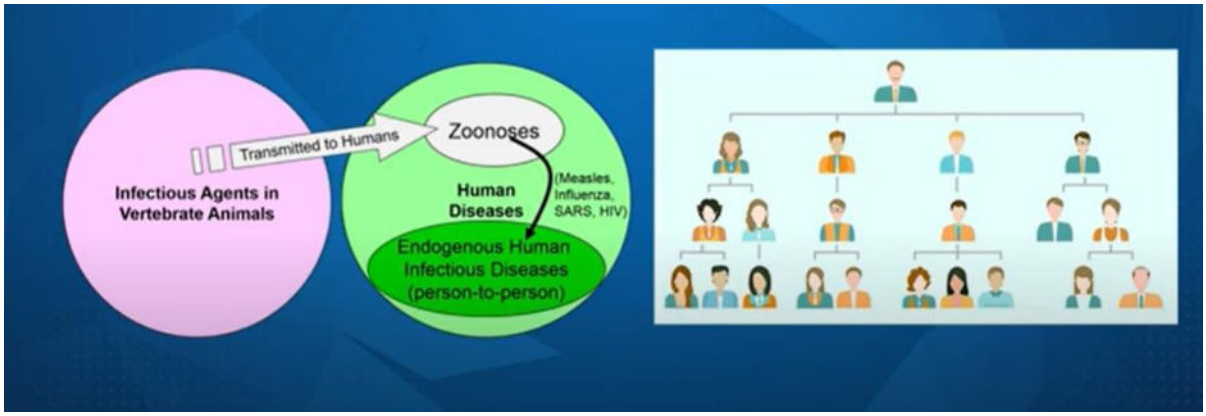
3. Transmission of diseases

The most predominant health problems associated with urbanization are poor nutrition, pollution-related health conditions, the emergence of infectious diseases, inadequate sanitation, and housing conditions, resulting in adverse health outcomes. They influence the individual's quality of life while also compromising on public health, placing burdens on public health systems and resources.

For example, the impact of urbanization on the transmission of disease can be clearly seen in the recent COVID-19 pandemic. In India, metropolitans contributed three-fourths of total cases from the beginning. The transport networks attributed significantly to transmitting the virus from the urban containment zones.

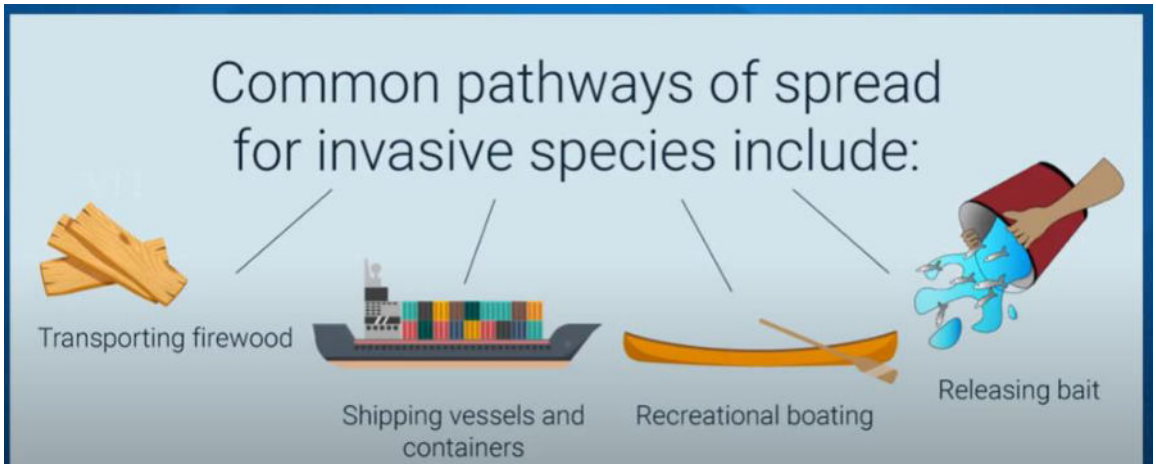
The outbreak of the COVID-19 epidemic has triggered the discussion of the relationship between urbanization and the spread of infectious diseases. One hypothesis attributes the intensified transmission of COVID-19 to the “urban diseases” caused by the rapid urban expansion, such as increased population ratio, dense buildings, environmental pollution, and deteriorated sanitation by many people, which finally threatens residents’ public health. The

main basis of this hypothesis is that there is a significant gap in the number of confirmed COVID-19 cases between urban and rural areas in various cities.



The above figure shows that because of urbanization, the people live much more closure in the small apartments/houses and a little sneeze or a cough can easily and very quickly transmit the disease (COVID-19) to a large population in a short- duration of time.

4. Increasing the transport of invasive species



What Makes a Species "Invasive"?

An invasive species can be any kind of living organism—an amphibian (like the cane toad), plant, insect, fish, fungus, bacteria, or even an organism's seeds or eggs—that is not native to an ecosystem and causes harm. They can harm the environment, the economy, or even human health. Species that grow and reproduce quickly, and spread aggressively, with the potential to cause harm, are given the label "invasive."

How Invasive Species Spread

Invasive species are primarily spread by human activities, often unintentionally. People, and the goods we use, travel around the world very quickly, and they often carry uninvited

species with them. Ships can carry aquatic organisms in their ballast water, while smaller boats may carry them on their propellers. Insects can get into the wood, shipping palettes, and crates that are shipped around the world. Some ornamental plants can escape into the wild and become invasive, while some invasive species are intentionally or accidentally released to pets.

Threats to Native Wildlife

Invasive species cause harm to wildlife in many ways. When a new and aggressive species is introduced into an ecosystem, it may not have any natural predators or controls. It can breed and spread quickly, taking over an area. Native wildlife may not have evolved defenses against the invader, or they may not be able to compete with a species that has no predators.

5. **Paving the land with concrete**

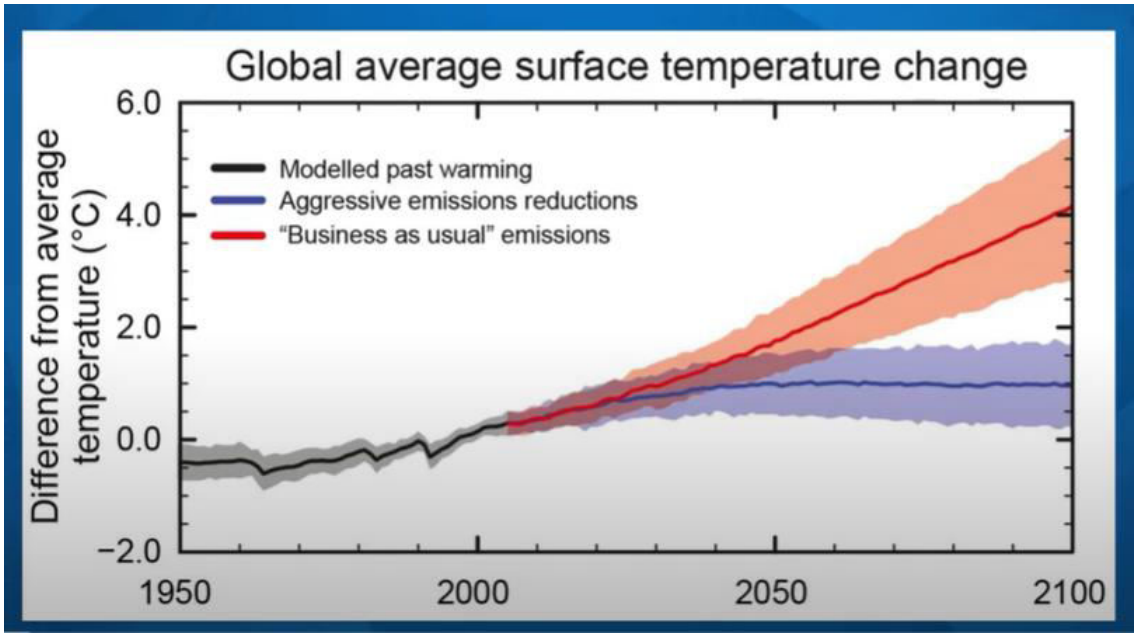
Paving land with concrete has a huge impact on the ecosystem such as:

- Increase in water runoff
- Increase in erosion
- Decrease in soil quality
- Decreases water quality by increasing sediment and pollutants in rivers and streams.

6. **Increase in the regional temperature**

As cities add roads, buildings, industry, and people, heat islands are created in urban areas. An urban heat island is a name given to describe the characteristic warmth of both the

atmosphere and surfaces in urban sprawls as compared to their non-urbanized or less urbanized surroundings



In the above figure with the time frame 1950-2100, there is Modelled past warning followed by Aggressive emissions reductions and then Business as usual emissions.

Impact of high temperature on human health and environment:

- Drinking lots of water to lower the body temperature and prevent dehydration.
- Vitamin D deficiency because of non-exposure to sunlight and avoiding high temperature
- Occurrence of several new diseases
- Plant growth, yield, and harvesting time have been changed and affected

7. Other impacts of urbanization:

- Industrial growth
- Increase in employment
- Social factors (moving more people from rural to urban)
- Economic problem during epidemic/pandemic
- Political turmoil
- Modernization
- Increase in population density
- Closely constructed houses
- Increased chance of epidemics

- Increased traffic resulting in traffic jams
- More need of resources- Energy, water, and fuel, stress has been increased on locally available resources
- High level of pollution in the air, water, soil-waste dumping
- Decreased aesthetic appeal of the landscape
- Loss of farmland
- Reduced species diversity
- Increased storm water runoff, because of the construction of pavement. As paving land with concrete can increase water runoff, increase erosion and decrease soil quality.
- Increased risk of flooding
- Excessive removal of native vegetation
- Ecosystem of fragmentation

8. Positive impacts of Urbanization

- More employment opportunities
- Access to recreation, ecotourism,
- Consumerism

Sustainable Urban Development: is important because urban areas contribute significantly to the Gross Domestic Product (GDP). They contribute increasingly to export and is a rich place for capital formation. Cities offer quality education and health care; arts and science; technology and innovation and transport and communication.

- Some of the pre-requisites of sustainable urban development are:
- Income and output to be produced at a constant or even increasing return to scale.
- City should assure a minimum level of living to its inhabitants.
- A shift in the attitude of the people in the direction towards enterprise and equity.
- City should become self-reliant and sustain itself without much depending on external sources.
- The developmental institutions undergo a continual renewal to maintain their relevance to the needs of the urban areas.
- Participation of the private sector, NGOs, and CVOs should be encouraged in order to maintain the level of development.

- Management of Urban growth to promote minimal use of environmental capital, while meeting social and economic goals.
- Zero waste disposal to be adopted and to become a habit. Japan leads the world in zero waste management. Indore, an Indian city has bagged the first prize for five consecutive years for their waste management.

The Agenda 21 of WCED held in 1992 in Rio-de-Janerio for promoting Sustainable Human Settlement Development is

- Providing adequate shelter to all
- Improving human settlements management
- Promoting Sustainable land use planning and management.
- Promoting the integrated provision of environmental infrastructure: water, sanitation, drainage, hazardous and solid waste management.
- Promoting sustainable energy and transport systems in human settlements.
- Promoting human settlement planning and management in disaster-prone areas.
- Promoting sustainable construction industry activities.
- Promoting human resources development and capacity building for human settlement development

9. Pros and Cons of Urbanization

Pros of Urbanization	**Cons of Urbanization**
Better public transport	Higher level of air pollution
Better overall infrastructure	More particles pollution
More education opportunities	Noise pollution
Increasing property prices of homeowners	Light pollution
People can use their time more efficiently	Littering
More conveniently if you have kids	Cities may become quite crowded

Connection to the electricity grid and sewer system	Traffic jams
Better internet connection	Higher level of stress
More efficient in terms of land use	Increasing health issues
People in cities are usually more tolerant	Increasing rent for tenants
Better connection of healthcare facilities	Higher chances of homelessness
Better R&D opportunities to foster technological progress	Development of slums
Urbanization attracts tourists	Spread of diseases
Multicultural attitude	Waste management of problems
Easier to socialize	Pets may not like the city life
Lower Unemployment rates	Lack of natural spaces

10. Summary

We understood urbanization, the reasons for urbanization and its problems, the impact of urbanization on the environment, discuss the problems of housing, water supply, transport, and environmental pollution in urban India, and the association of urbanization with human development and progress. Let's ensure to consciously reduce the problems of urbanization using advanced technical and apt solution.

Population Age structure

Introduction:

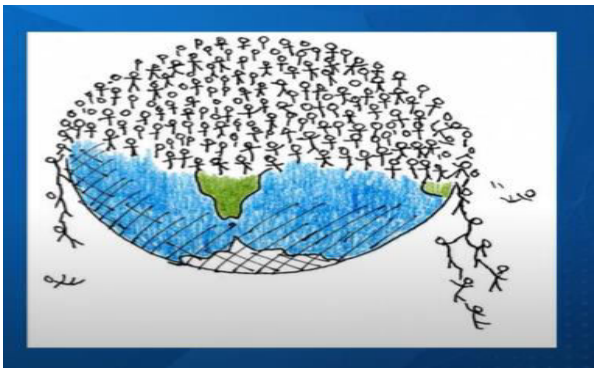
The **age structure** of a population refers to the proportionate numbers of people in different age categories in a given population for a **defined time**. It is a natural characteristic of a population in a country or a region. The age structure is closely related to the birth rate, death rate and migration of a population

1. Few concepts are needed to understand the population age structure

1.1 Total fertility rate: The average number of children that would be born to a woman in her lifetime if the age-specific birth rates remain constant.

- In developed nations TFR: 1.9
- In developing nations TFR: 4.7
- In 1960's in India TFR was ~6
- It is 2.68 in 2007, 2.40 in 2015, and **2.159 is 2022**

1.2 The earth's carrying capacity:



Carrying capacity: The number of individuals who can be supported in a given area within natural resource limits, and without degrading the natural, social-cultural, and economic environment for present and future generations.

- If the carrying capacity is exceeded, it will negatively impact sustainable development
- No population can live beyond the environment's carrying capacity for a long time

- A study indicates the earth's carrying capacity as 10 billion people.

1.3. Exponential growth:

- When any quantity increases by a constant amount per unit time, 1,3,5,7 etc., it is called linear growth. However, when it increases by a fixed percentage, it is called exponential growth. This exponential growth is the reason for the enormous rise in global population.

1.4. Doubling time:

The time needed for a population to double its size at a constant annual rate is called doubling time. It is calculated as follows:

Td = 70/r, where

Td = doubling time in years

r = annual growth rate.

If a nation has a 2% annual growth rate, its population will double in 35 years.

1.5. Population size: is the number of individuals present in the country

1.6. Mortality: is the number of deaths of individuals per unit time.

1.7 Zero population growth (ZPZ)

When birth plus immigration in a population is just equal to deaths plus emigration, it is said to be zero population growth

1.8. Population profile: It is also called **age structure**. It is a bar graph plotted with number of males and females for successive ages in the population, with the oldest or the aged at the top of the pyramid. The males are represented on the left hand side in blue, while the females are represented on the right using a pink colour..

It is common in demography to split the population into three broad age groups:

Stage1: **pre-reproductive stage** 0-14 years, children and young adolescents

Stage2: **reproductive stage** 15-60 years, the working-age population

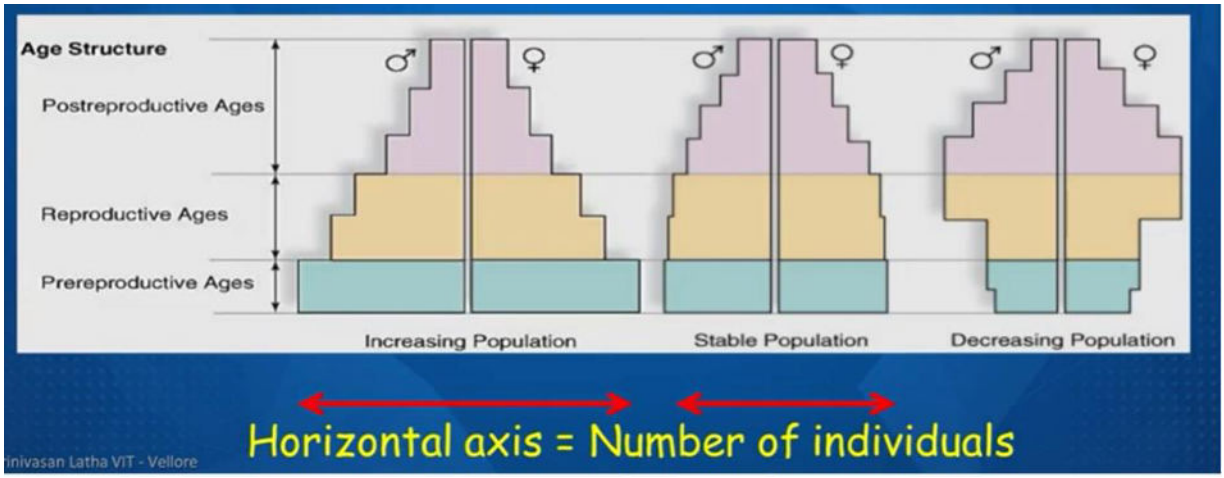
Stage3: **post-reproductive stage** 60 or 65 plus, the elderly population

Note that:

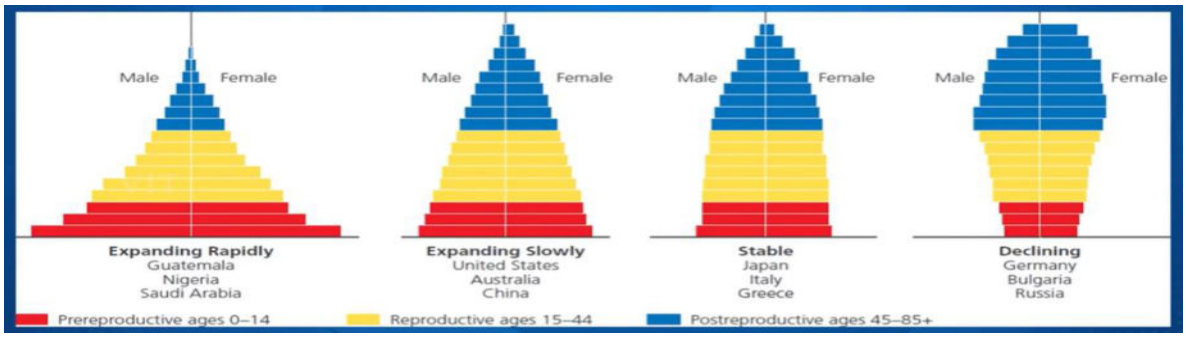
(In some demographic graphs age groups are grouped as 0-14; 15-44 and 45 and above years)

2.Age Structure and their types:

Different types pyramid, bell, urn shape, population growth can be predicted. Here horizontal axis is the number of individuals and the vertical axis represents age structure. Age structure is divided into three stages: pre-reproductive ages, reproductive age, and post-reproductive age.



Here are some more examples of countries with expanding rapidly, expanding slowly, stable, and declining population age structures.



In these images, we can see the shape of the population according to the three stages discussed earlier: depending on pre-reproductive, productive, and post-reproductive stages. In these images, males are represented on the left hand and females on the right hand.

2.1 Pyramid shaped:

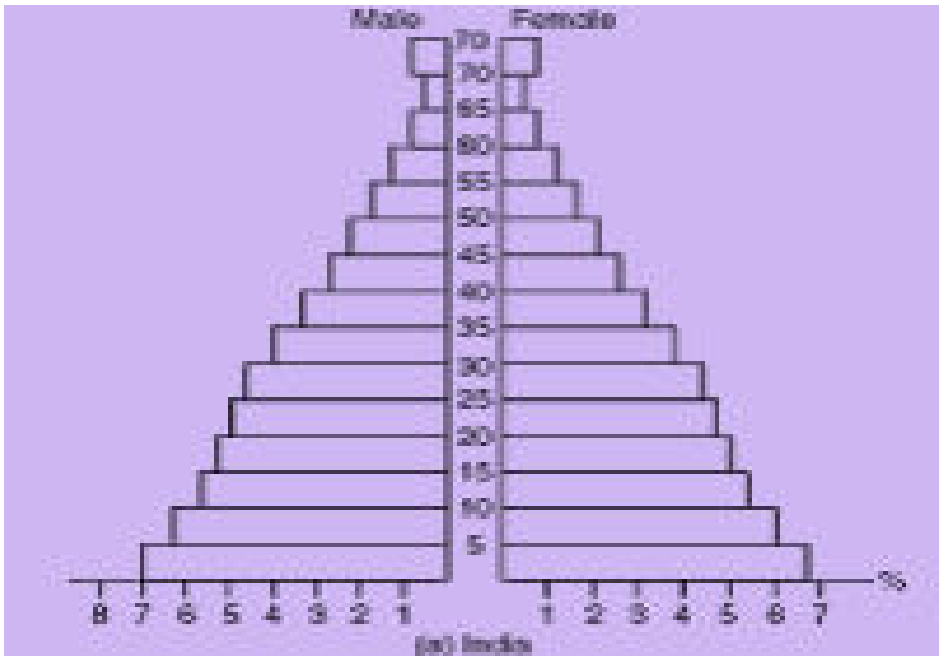
Here the very young population is more, making a broad base and old people are less. This type indicates **growing** population.

●The large number of individuals in very young age will soon enter into reproductive age, thus causing an increase in population, whereas

●Less number of people in old age indicate less loss of population due to death.

●India, Bangladesh, Ethiopia, Nigeria are examples of this type

Case 1: increasing population: A progressive age structure is one in which both birth and death rates are high. Here, wide base of pre-reproductive individuals, indicating a high fertility rate and growing population. Children account for only 45-55% of the total population and the aged for only 5-10%. Such a structure is common in developing countries where social, cultural, and perhaps religious and economic conditions lead to high fertility, and poor living conditions, bad diets, and little medical aid lead to high levels of mortality.

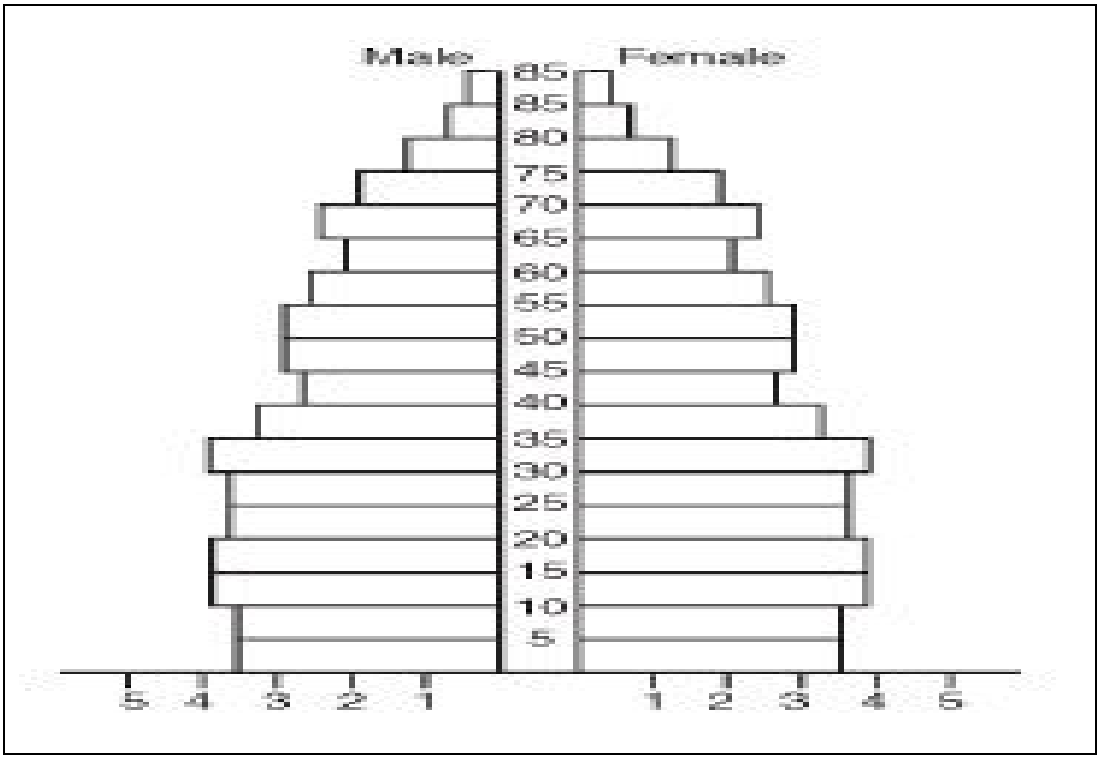


India as an illustration: Source courtesy: Textbook: Environmental Science and Engineering, Kaushik and Kaushik, New age publishers.

2.2 Bell shaped:

It occurs in countries like France, USA and Canada where birth rates have in the past one or two decades declined resulting in people of almost equal number in age group 0-35 years.

So in the next 10 years, the people entering into reproductive age group is not going to change much and such age-pyramids indicate **stable** populations.

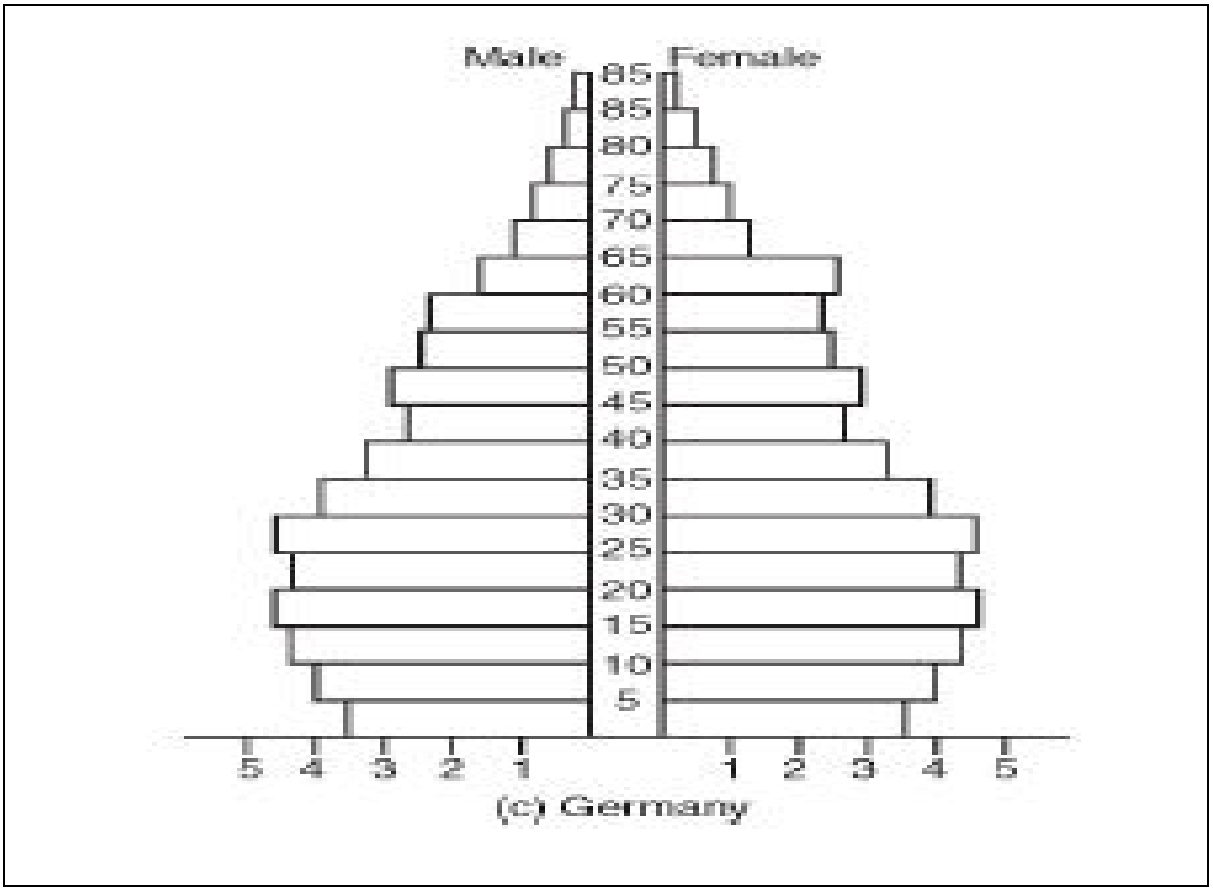


France as an illustration: Source courtesy: Textbook: Environmental Science and Engineering, Kaushik and Kaushik, New age publishers.

Case 2: stable population: A stationary age structure is one in which birth and death rates are both low and children account for about 35-40% of the total population and the aged for about 10%. Here, Pre-reproductive and reproductive groups have similar widths, indicating a fertility rate at about replacement level and results in a stable population. This pattern may remain the same for many years

2.3 Urn shaped:
Here number of individuals in very young class is smaller than the middle reproductive age class.
In the next 10 years the number in reproductive age class will thus become less before resulting in a **decline** of population.

Germany, Italy, Hungary, Sweden and Japan are examples of this type.



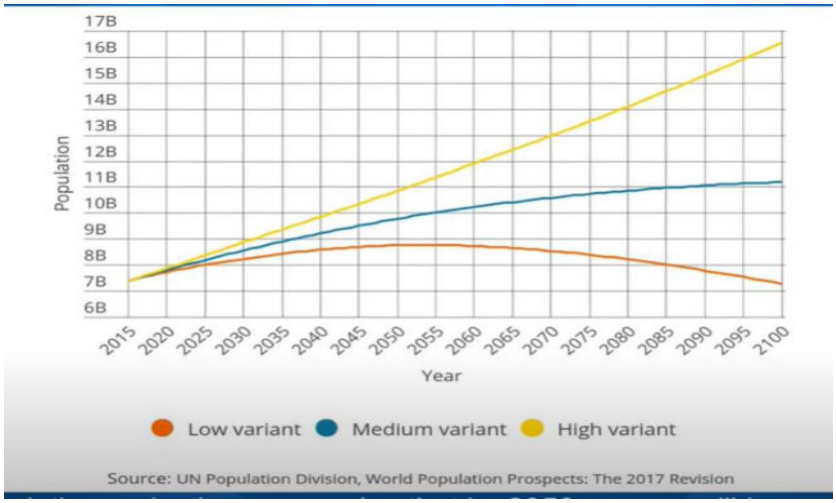
Germany as an illustration: Source courtesy: Textbook: Environmental Science and Engineering, Kaushik and Kaushik, New age publishers.

Case 3: Decreasing population: A regressive age structure is one in which birth and death rates are low and declining. Here, pre-reproductive age groups are narrower than reproductive age groups, indicating a low fertility rate and resulting in a shrinking population. Children account for about 30% of the total population and the aged for above 15%. This pattern is common in developed countries (especially those in Western Europe), where high living standards, education, and social awareness are accompanied by good food and medicine.

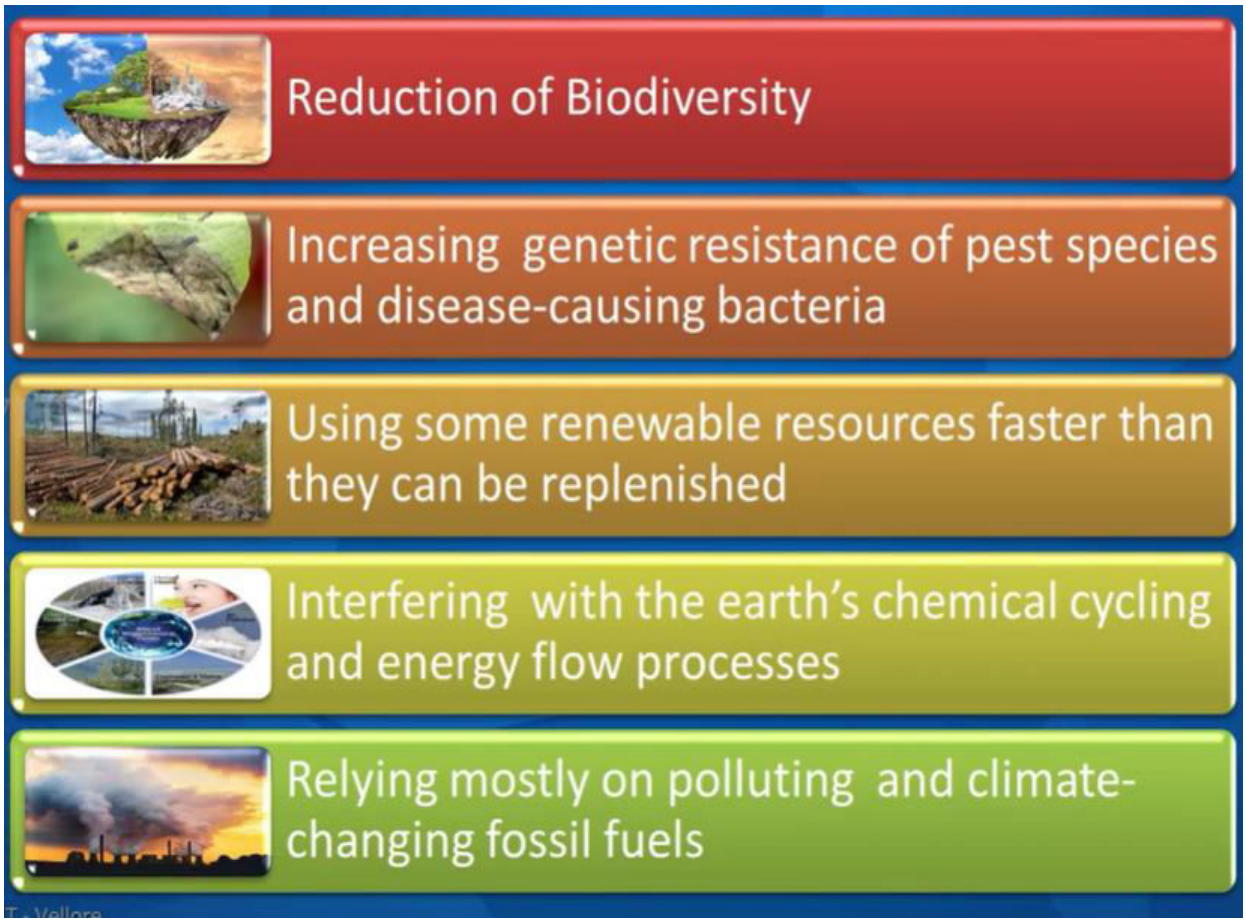
3.India population:

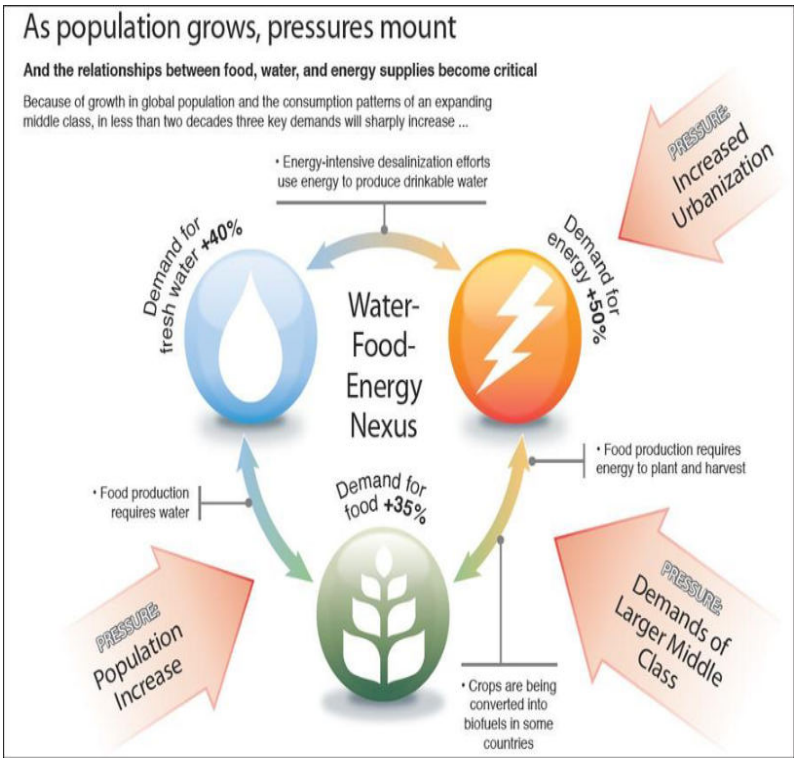
The present population of India is 1.21 billion and these numbers are increasing every day. From the figure shown below, it can be concluded that by 2050 women will have an average

of 2.5 children which is the highest estimate to the lowest estimate of 1.5 childre



4.Effect of growing population on the nature





source courtesy: https://www.blendspace.com/lessons/SzQzdtRv3gVK5Q/population-growth-and-natural-resources

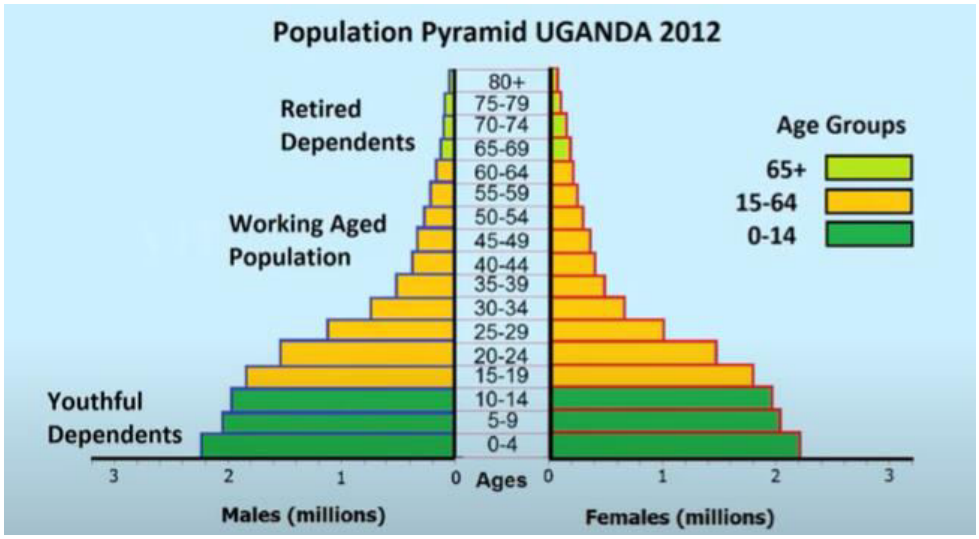
5. Factors that are influenced by the age structure:

The age structure of a population affects a nation's key socioeconomic issues.

- Countries with young populations (high percentage under age 15) need to invest more in schools
- Countries with older populations (high percentage ages 65 and over) need to invest more in the health sector.
- The age structure can also be used to help predict potential political issues. For example, the rapid growth of a young adult population unable to find employment can lead to unrest

6. Interpretation of age structure using examples:

Example 1:Population pyramid of UGANDA 2012



i. As a result of lower mortality but still high fertility, Uganda has developed a very youthful age structure.

ii. Uganda's population will continue to grow because of the large number of people who are either currently at an age when they are having children or who will soon enter that age group.

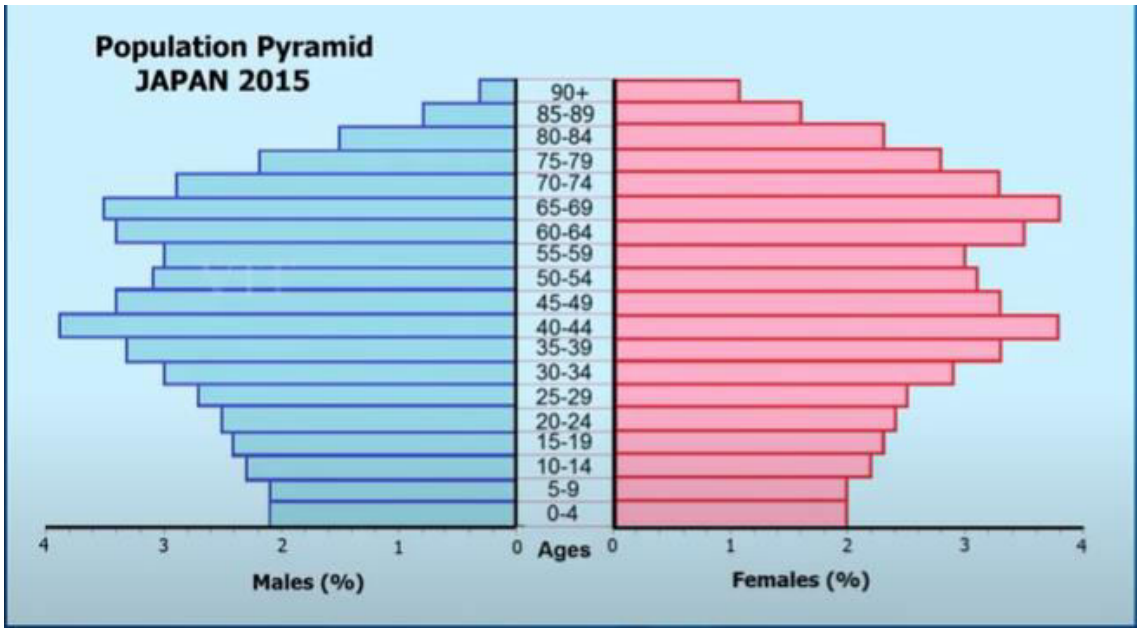
iii. More youthful dependence means the government has to give more money and adapt schemes for child welfare, schools and their policies.

iv. These policies or schemes are important to implement considering they are going to be the next reproductive stage. T

v. herefore, government has to concentrate on education, health and psychological impacts considering that these children who will be adults in the future impact the country.

vi. So, UGANDA is progressing as these children grow up provided, they are given good opportunities for education, better resources for upskilling and will also be productive to the nation in the future.

Example 2: Population pyramid of JAPAN 2015



The above figure is the population age structure in Japan in 2015, where we can see a big urn-like structure. We see the male and female congregation and also people living up to 90 plus age. Also, we see a smaller number of pre-reproductive populations i.e., a smaller number of children whether it is male or female. Therefore, a large number of populations are in the middle group / middle band, which is working for the band and making sufficient money for their living. Also, the nation can use the talent and convert it into a progressive ratio of the country based on this talent pool which is available with the working population. Here, government can provide training opportunities and nurturing of their population's talent to convert into productive outcomes. Here government focus is on training process, workplace ethics and etiquette, targeted skills, and skill training structures for a particular band. However, there is a hitch in this graph as the life expectancy of the Japanese is pretty high, which means the elderly persons at home. This means the government has to spend lots of money on medical facilities to provide health care facilities and also to the ones who are taking care of elderly people and address their emotional physical and psychological needs. Because of the lots of development in the healthcare systems, and medical transformations, peoples have much better lifestyles.

How to slow down population

- Promote economic development

- Promote-family-planning

- Promote women empowerment

7. Summary:

We learned about population age structure, characteristics of population age structure, how to draw it and depiction, understanding the number of male and female age structure in the groups and its impact on the population size. We also learned about the definitions of the fertility rate, doubling time, and zero population growth.

Sustainable Human Societies

Economic growth and development

• **Economic growth** is an increase in a nation's capacity to provide goods and services to people.
It involves making an economy bigger. Its goal is to use political and economic systems to *encourage environmentally beneficial and more sustainable forms of economic development, and to discourage environmentally harmful and unsustainable forms of economic growth.*
• **Economic development** is the improvement of human living standards made possible by economic growth.

Economic Systems Are Supported by Three Types of Resources

●**An economic system is a social institution** through which goods and services are produced, distributed, and consumed to satisfy people's needs and wants, ideally in the most efficient way possible.
●Three types of capital, or resources, are used to produce goods and services.
♦**Natural capital** includes resources and services produced by the earth's natural processes, which support all economies and all life.
♦**Human capital, or human resources**, includes people's physical and mental talents that provide labor, organizational and management skills, and innovation.
♦**Manufactured capital, or manufactured resources**, refers to items such as machinery, equipment, and factories made from natural resources with the help of human resources.

Natural capital:

Environmental and ecological economists have developed various tools for estimating the values of the earth's natural capital.

The three goals of this study are to

(1) integrate economic and ecological knowledge in order to estimate the economic and ecological values of ecosystem services;

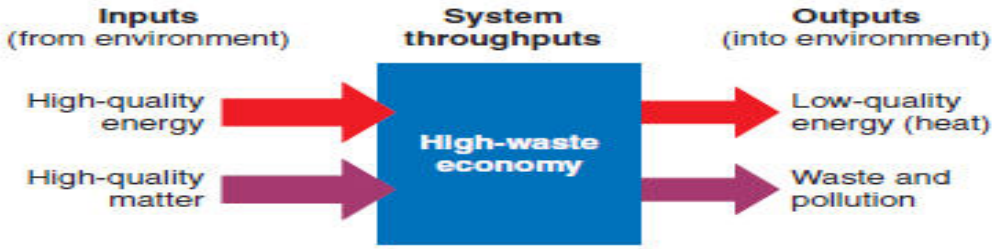
(2) to evaluate the costs and benefits of actions that could be taken to prevent the decline of these services;

(3) to develop toolkits to help local, regional, and international policy makers promote more sustainable development that conserves ecosystems and biodiversity.

Ecological and environmental economists have developed ways to estimate ***non-use values*** *of natural resources and ecological services that are not represented in market transactions. One such value is an* ***existence value****—a monetary value placed on a resource such as an old-growth forest or endangered species just because it exists, even though we may never see it or use it. Another is* ***aesthetic value****—a monetary value placed on a forest, species, or a part of nature because of its beauty. A third type, called a* ***bequest or option value****, is based on the willingness of people to pay to protect some forms of natural capital for use by future generations.*

High-throughput economies of most developed countries

• The high-throughput economies of most developed countries rely on continually increasing the rates of energy and matter flow to increase economic growth.



• This practice produces valuable goods and services, but it also converts high-quality matter and energy resources into waste, pollution, and low-quality heat, and in the process, can deplete or degrade various forms of natural capital that support all life and economies.

Environmental economists believe that conventional economic growth eventually will become unsustainable. Their reasoning is that such growth will lead us to deplete or degrade much of the natural capital.

• Ecological economists see all economies as human subsystems of the biosphere that depend on natural resources and services provided by the sun and earth. They urge us to shift from our current high throughput economies to more *economically sustainable economies, or eco-economies.*

Environmental Economic Indicators

• Economic growth is usually measured by the percentage of change in a country's **gross domestic product (GDP): the annual market** value of all goods and services produced by all firms and organizations, foreign and domestic, operating within a country

• Changes in a country's economic growth per person are measured by **per capita GDP: the GDP divided by the country's total** population at midyear.

• Environmental and ecological economists and environmental scientists call for the development and widespread use of new indicators—called *green indicators—to help monitor environmental* quality and human wellbeing.

• One such indicator is the **genuine progress indicator (GPI)**

Subsidies

• Subsidies activities and projects which prevent pollution or don't degrade environment.

• Tax the activities and projects which pollute and degrade environment.

• Japan, France, and Belgium have phased out all coal subsidies and Germany plans to do so by 2018. China has cut coal subsidies by about 73% and has imposed a tax on high-sulfur coals.

• Governments could phase in environmentally beneficial subsidies and tax breaks for pollution prevention, eco-cities, sustainable forestry, sustainable agriculture, sustainable water use, energy efficiency and renewable energy use, and actions to slow projected climate change.

• The economy also will grow because of this.

Use Lessons from Nature to Shift to More Sustainable Economies-*low-throughput economy*

Learning and applying lessons from nature can help us design and manage more sustainable economies.

A*low-throughput economy*, based on energy flow and matter recycling, works with nature to reduce excessive throughput and the unnecessary waste of matter and energy resources (green boxes).

This is done by

(1) reusing and recycling most non-renewable matter resources;
(2) using renewable resources no faster than they are replenished;
(3) reducing resource waste by using matter and energy resources more efficiently;
(4) reducing unnecessary and environmentally harmful forms of consumption;
(5) emphasizing pollution prevention and waste reduction; and
6) controlling population growth to stabilize the number of matter and energy consumers.

We can use certain principles for shifting to more environmentally sustainable economies, or *eco-economies*, during this century.

Economics:

Use full cost pricing

Sell more services instead of more things

Reduce poverty

Use eco-labels

Use environmental indicators to measure progress

Ecology and population

Mimic nature

Preserve biodiversity

Repair ecological damage

Stabilize human population.

Resource use and control pollution

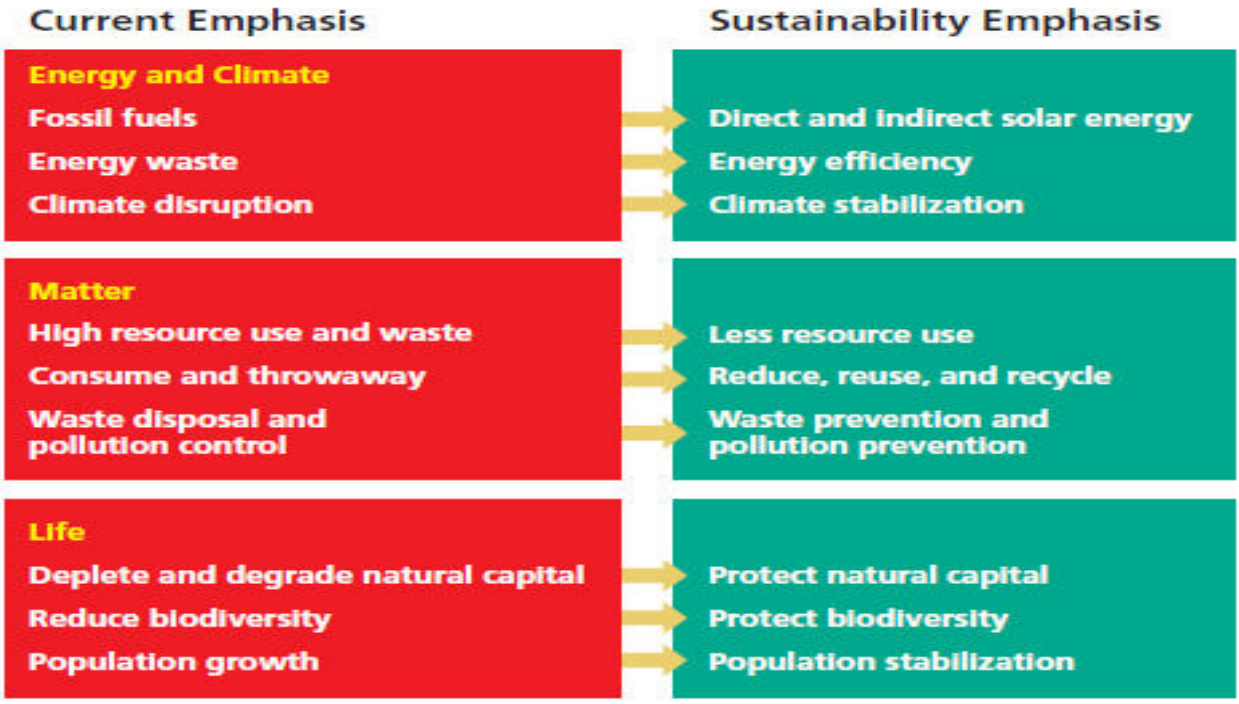
Improve energy efficiency

Rely more on renewable resources

Shift to a non-carbon renewable energy economy

The environmental revolution

These are some of the cultural shifts in emphasis that will be necessary to bring about the environmental or sustainability revolution.



Education on the ecological index is one of the key parameters in leading towards a sustainable developed nation. So let's all become socially and ecologically responsible.

Sustainable Human Societies

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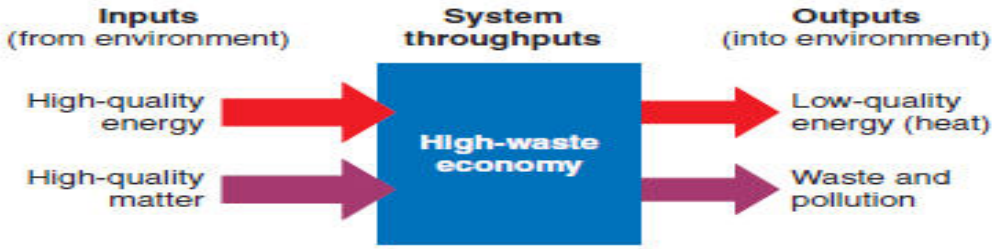
(2) to evaluate the costs and benefits of actions that could be taken to prevent the decline of these services;

(3) to develop toolkits to help local, regional, and international policy makers promote more sustainable development that conserves ecosystems and biodiversity.

Ecological and environmental economists have developed ways to estimate ***non-use values*** *of natural resources and ecological services that are not represented in market transactions. One such value is an* ***existence value****—a monetary value placed on a resource such as an old-growth forest or endangered species just because it exists, even though we may never see it or use it. Another is* ***aesthetic value****—a monetary value placed on a forest, species, or a part of nature because of its beauty. A third type, called a* ***bequest or option value****, is based on the willingness of people to pay to protect some forms of natural capital for use by future generations.*

High-throughput economies of most developed countries

• The high-throughput economies of most developed countries rely on continually increasing the rates of energy and matter flow to increase economic growth.



• This practice produces valuable goods and services, but it also converts high-quality matter and energy resources into waste, pollution, and low-quality heat, and in the process, can deplete or degrade various forms of natural capital that support all life and economies.

Environmental economists believe that conventional economic growth eventually will become unsustainable. Their reasoning is that such growth will lead us to deplete or degrade much of the natural capital.

• Ecological economists see all economies as human subsystems of the biosphere that depend on natural resources and services provided by the sun and earth. They urge us to shift from our current high throughput economies to more *economically sustainable economies, or eco-economies.*

Environmental Economic Indicators

• Economic growth is usually measured by the percentage of change in a country's **gross domestic product (GDP): the annual market** value of all goods and services produced by all firms and organizations, foreign and domestic, operating within a country

• Changes in a country's economic growth per person are measured by **per capita GDP: the GDP divided by the country's total** population at midyear.

• Environmental and ecological economists and environmental scientists call for the development and widespread use of new indicators—called *green indicators—to help monitor environmental* quality and human wellbeing.

• One such indicator is the **genuine progress indicator (GPI)**

Subsidies

• Subsidies activities and projects which prevent pollution or don't degrade environment.

• Tax the activities and projects which pollute and degrade environment.

• Japan, France, and Belgium have phased out all coal subsidies and Germany plans to do so by 2018. China has cut coal subsidies by about 73% and has imposed a tax on high-sulfur coals.

• Governments could phase in environmentally beneficial subsidies and tax breaks for pollution prevention, eco-cities, sustainable forestry, sustainable agriculture, sustainable water use, energy efficiency and renewable energy use, and actions to slow projected climate change.

• The economy also will grow because of this.

Use Lessons from Nature to Shift to More Sustainable Economies-*low-throughput economy*

Learning and applying lessons from nature can help us design and manage more sustainable economies.

A*low-throughput economy*, based on energy flow and matter recycling, works with nature to reduce excessive throughput and the unnecessary waste of matter and energy resources (green boxes).

This is done by

(1) reusing and recycling most non-renewable matter resources;
(2) using renewable resources no faster than they are replenished;
(3) reducing resource waste by using matter and energy resources more efficiently;
(4) reducing unnecessary and environmentally harmful forms of consumption;
(5) emphasizing pollution prevention and waste reduction; and
6) controlling population growth to stabilize the number of matter and energy consumers.

We can use certain principles for shifting to more environmentally sustainable economies, or *eco-economies*, during this century.

Economics:

Use full cost pricing

Sell more services instead of more things

Reduce poverty

Use eco-labels

Use environmental indicators to measure progress

Ecology and population

Mimic nature

Preserve biodiversity

Repair ecological damage

Stabilize human population.

Resource use and control pollution

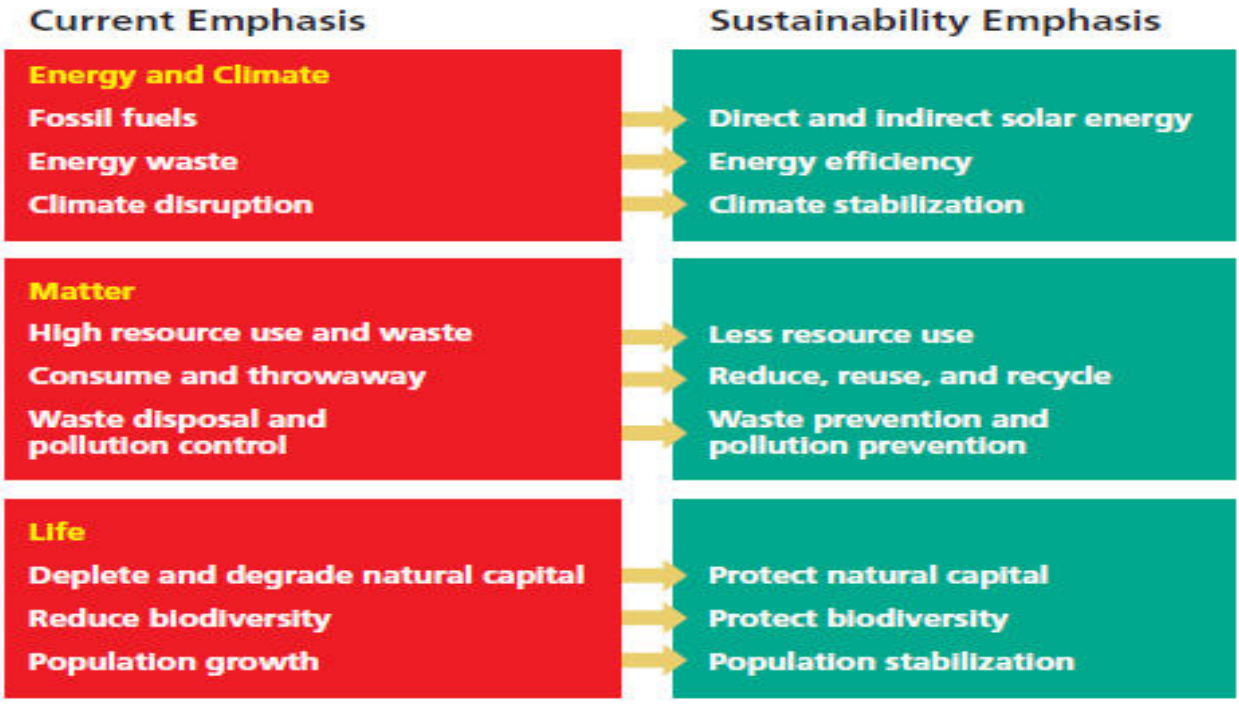
Improve energy efficiency

Rely more on renewable resources

Shift to a non-carbon renewable energy economy

The environmental revolution

These are some of the cultural shifts in emphasis that will be necessary to bring about the environmental or sustainability revolution.



Education on the ecological index is one of the key parameters in leading towards a sustainable developed nation. So let's all become socially and ecologically responsible.

Sustainable Development Goals (SDGs)

The concept of sustainable development

Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs. The concept of sustainable development does imply limits - not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities. But technology and social organization can be both managed and improved to make way for a new era of economic growth. The Commission believes that widespread poverty is no longer inevitable. Poverty is not only an evil in itself, but sustainable development requires meeting the basic needs of all and extending to all the opportunities to fulfil their aspirations for a better life. A world in which poverty is endemic will always be prone to ecological and other catastrophes.

Meeting essential needs requires not only a new era of economic growth for nations in which the majority are poor but an assurance that those poor get their fair share of the resources required to sustain that growth. Such equity would be aided by political systems that secure effective citizen participation in decision-making and by greater democracy in international decision-making.

Sustainable global development requires that those who are more affluent adopt lifestyles within the planet's ecological means - in their use of energy, for example. Further, rapidly growing populations can increase the pressure on resources and slow any rise in living standards; thus sustainable development can only be pursued if population size and growth are in harmony with the changing productive potential of the ecosystem.

Yet in the end, sustainable development is not a fixed state of harmony, but rather a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are made consistent with the future as well as present needs. We do not pretend that the process is easy or straightforward. Painful choices have to be made.

The genesis of sustainable development goals

World Summit on Sustainable Development which was held in Johannesburg renewed international commitment to the pursuit of sustainable development with the Johannesburg Plan of Implementation (JPOI); 2012 resulted in an outcome document "The Future We Want". In the document, the States reaffirmed the commitments to all previous sustainable development agreements, plans and targets. They also committed to developing a suite of Sustainable Development Goals (SDGs) building on the priorities identified in Agenda 21 and the JPOI, and decided to replace the Commission for Sustainable Development with a 'high-level political forum' to progress implementation of Agenda 21 and the JPOI, and the achievement of the SDGs. The Sustainable Development Goals (SDGs) were agreed upon at the United Nations in New York in September 2015.

Sustainable Development Goals are

Goal 1: End poverty in all its forms everywhere

Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture;

Goal 3: Ensure healthy lives and promote well-being for all at all ages;

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

Goal 5: Achieve gender equality and empower all women and girls;

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

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

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

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

Goal 10: Reduce inequality within and among countries;

Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable;

Goal 12: Ensure sustainable consumption and production patterns;

Goal 13: Take urgent action to combat climate change and its impacts;

Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development;

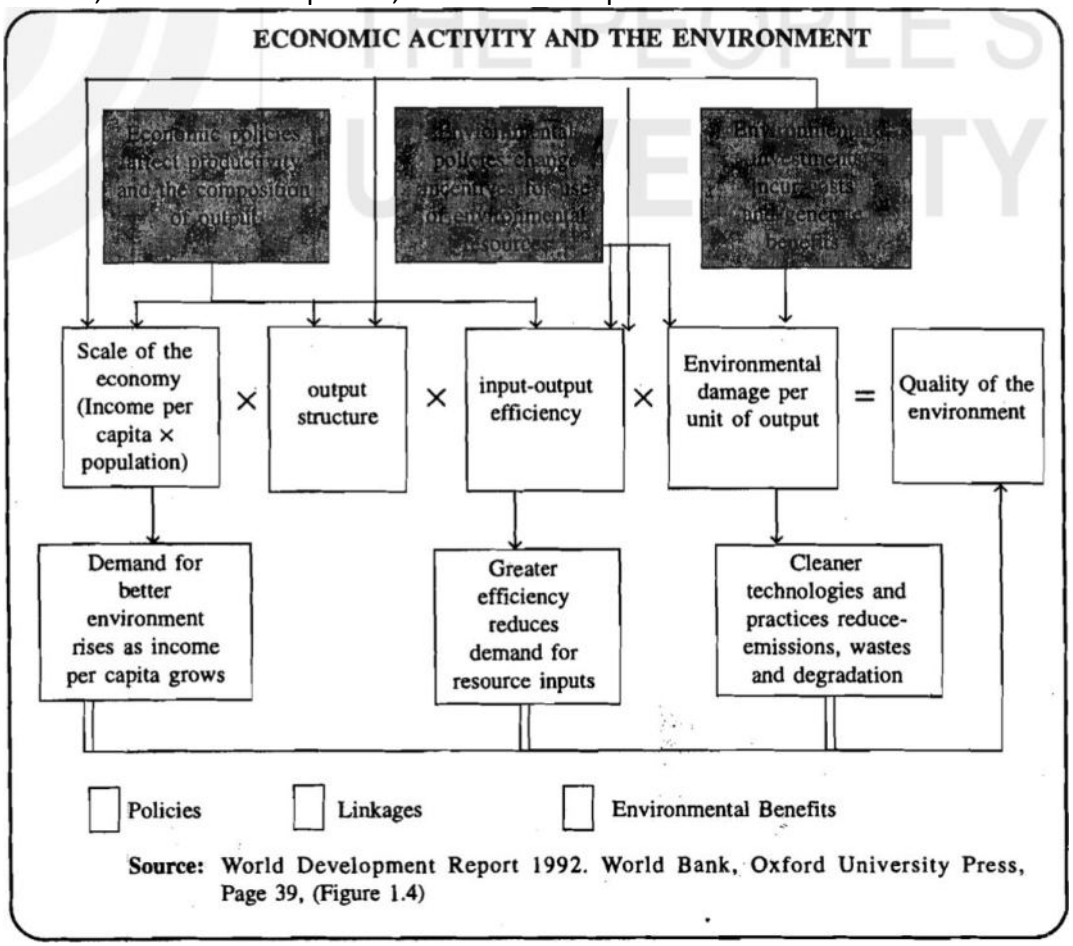
Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss;

Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels; and

Goal 17: Strengthen the means of implementation and revitalize the global partnership for sustainable development.

Sustainable human development and the environment

Economic development and sound environmental management are complementary aspects of the same agenda. Without adequate environmental protection, development will be undermined; without development, environmental protection will fail.



Source: World Development Report 1992. World Bank, Oxford University Press, Page 39, (Figure 1.4)

Awareness

Environmental conservation and regeneration are emerging concerns for one and all. These should not be seen as someone else's responsibility. The results are the consequence for all of us across all age groups and social strata.

The nation today needs a well-developed policy on the environment. This would mean awareness at the nationwide level. This would also mean well-planned action. For this, it is necessary to understand the causes of ignorance about the environment and the misconceptions about it.

In India, ignorance and misconceptions prevail because of illiteracy on a large scale, lack of proper orientation and training of functionaries and leaders, and lack of organised effort on the part of the educational system to address these problems systematically.

Environmental matters of vital concern relate to the areas of agriculture, industry and health. Knowledge about these and other areas can be imparted to the concerned people through various educational programmes such as formal education at school and college levels, non-formal education at the adult level, and special orientation and training of the functionaries

and opinion leaders. Mass media can play a vital role in this matter. It should be the concern of the recipient to seek this knowledge rather than wait to be exposed to it.

WOMEN AND CHILD WELFARE

Women empowerment in India is the most effective tool for development as these days; women across the world are actively working as a leader and surpassing others in all the spheres of life. As the entire world is clasping its breath and praying every single day for an incredible escape from the COVID-19 Pandemic, it is the women governors and nations steered by these amazing figures who are taking over the responsibility and marching ahead in the battle alone wherever required.

Definition:Empowerment
Empowerment means individuals acquiring the power to think and act freely, exercise choices and fulfil their potential as full and equal members of the society.

Women Empowerment: Goal and Objectives

●The goal of this Policy is to bring about the advancement, development, to encourage active participation and empowerment of women**.**

●The objectives of this Policy:

♦Creating an environment through positive economic and social policies for the development of women

.♦In all human rights and fundamental freedom for women on equal basis with men in all: political, economic, social, cultural and civil.

♦Equal access to participation and decision making of women in

Social, Political, Economic life of the nation,

Health care, Employment Quality education at all levels,

Equal remuneration, Occupational health and safety,

Social security and public office etc.

♦Strengthening the legal systems aimed at elimination of all forms of discrimination against women

.♦Changing societal attitudes and community practices by active participation.

♦Elimination of discrimination and all forms of violence against women and the girl child.

♦Building and strengthening partnerships with civil society, particularly women's organizations.

Education is the initial line of defense for women. With a meaningful education, the women's status strides beyond the restrictions of motherliness. Advancement of education of women and girls allots to the postponement of their marriage timing and the ensuing constriction in the volume of their families.

NATIONAL POLICY FOR THE EMPOWERMENT OF WOMEN (2001)

Women Empowerment in India:

●**Very essential for the development of society.**

Empowerment of women has becoming a burning issue all over the world including India since last few decades.

●The **principle of gender equality** is enshrined in the Indian Constitution in its Preamble, Fundamental Rights, Fundamental Duties and Directive Principles.

The Constitution not only grants equality to women, but also empowers the State to adopt measures of positive discrimination in favour of women.

●From **the Fifth Five Year Plan** (1974-78) onwards has been a marked shift in the approach to women's issues from welfare to development.

In recent years, the empowerment of women has been recognized as the central issue in determining the status of women.

●**The National Commission for Women** was set up by an Act of Parliament in 1990 to safeguard the rights and legal entitlements of women.

The 73rdand 74thAmendments (1993) to the Constitution of India have provided for reservation of seats in the local bodies of Panchayatsand Municipalities for women, laying a strong foundation for their participation in decision making at the local levels.

Women Empowerment Schemes:

Some schemes are:

●Rajiv Gandhi National Creche Scheme For the Children of Working Mothers

●Ministry approves new projects under Ujjawala Scheme and continues existing projects

●UJJAWALA: A Comprehensive Scheme for Prevention of trafficking and Resue, Rehabilitation and Re-integration of Victims of Trafficking and Commercial Sexual Exploitation

●Working Women Hostel

●SWADHAR Greh (A Scheme for Women in Difficult Circumstances)

●Revision under IGMSY in Accordance with National Food Security Act, 2013 in XIIthPlan

●Support to Training and Employment Programme for Women (STEP)

●NARI SHAKTI PURASKAR

●Awardees of Stree Shakti Puruskar, 2014 & Awardees of Nari Shakti Puruskar

●Awardees of Rajya Mahila Samman& ZilaMahilaSamman

●Indira Gandhi Matritva Sahyog Yojana(IGMSY) -A Conditional Maternity Benefit Scheme

●One Stop Centre Scheme

●Women Helpline Scheme

- **POSHAN Abhiyaan**

Malnutrition is not a direct cause of death but contributes to mortality and morbidity by reducing resistance to infections. There are a number of causes of death of children such as prematurity, low birth weight, pneumonia, diarrhoeal diseases, non-communicable diseases, birth asphyxia & birth trauma, injuries, congenital anomalies, acute bacterial sepsis and severe infections, etc.

POSHAN Abhiyaan (National Nutrition Mission) is a flagship programme of the Ministry of Women and Child Development (MWCD), Government of India, which ensures convergence

with various programmes i.e., Anganwadi Services, Pradhan Mantri Matru Vandana Yojana (PMMVY), Scheme for Adolescent Girls (SAG) of MWCD Janani Suraksha Yojana (JSY), National Health Mission (NHM), Swachh-Bharat Mission, Public Distribution System (PDS), Department Food & Public Distribution, Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) and Ministry of Drinking Water & Sanitation.

The National Nutrition Mission (NNM) has been set up with a three year budget of Rs.9046.17 crore commencing from 2017-18. The NNM is a comprehensive approach towards raising nutrition level in the country on a war footing.

Photo courtesy :https://poshangyan.niti.gov.in/poshan-abhiyaan-logo

Goals:

The goals of NNM are to achieve improvement in nutritional status of Children from 0-6 years, Adolescent Girls, Pregnant Women and Lactating Mothers in a time bound manner during the next three years beginning 2017-18.

BENEFITS:

More than 10 crore people will be benefitted by this programme. All the States and districts will be covered in a phased manner i.e. 315 districts in 2017-18, 235 districts in 2018-19 and remaining districts in 2019-20

- **BETI BACHAO BETI PADHAO YOJANA:**

Beti Bachao Beti Padhao (BBBP) was launched by the Prime Minister on 22nd January, 2015 at Panipat, Haryana. BBBP addresses the declining Child Sex Ratio (CSR) and related issues of women empowerment over a life-cycle continuum. It is a tri-ministerial effort of Ministries of Women and Child Development, Health & Family Welfare and Human Resource Development.

In 2015, the Indian government introduced the Beti Bachao, Beti Padhao (BBBP) scheme to address concerns of gender discrimination and women empowerment in the country. The name Beti Bachao, Beti Padhao translates to 'Save the girl child, educate the girl child'. The scheme aims to educate citizens against gender bias and improve efficacy of welfare services for girls. It was launched with an initial funding of Rs. 100 crore (US$ 13.5 million).

GOAL:

The Beti Bachao Beti Padhao Yojana aims to achieve the following goals:

- Improve the child sex ratio
- Ensure gender equality and women empowerment
- Prevent gender-biased, sex selective elimination
- Ensure survival and protection of the girl child
- Encourage education and participation of the girl child

Beneficiaries

Categories	Description
Primary Segment	Young and newly married couples; pregnant and lactating mothers; and parents
Secondary Segment	Youth, adolescents (girls and boys), in-laws, medical doctors/ practitioners, private hospitals, nursing homes and diagnostic centres
Tertiary Segment	Officials, PRIs, frontline workers, women SHGs/collectives, religious leaders, voluntary organisations, media, medical associations, industry associations and the people at large

Photo courtesy :https://www.logopeople.in/blog/free-vector-logo-download-of-beti-bachao-beti-padhao-yojana/

ANGANWADI:

Anganwadi is a government-sponsored child-care and mother-care development programmes in India at the village level. The meaning of the word 'Anganwadi' in the English language is "courtyard shelter" It primarily caters to children in the 0-6 age group. They were started by the Indian government in 1975 as part of the Integrated Child Development Services (ICDS) program to combat child hunger and malnutrition. An Anganwadi centre provides basic health care facilities in Indian villages. It is a part of the Indian public health-care system.

Objectives

(i) to improve the nutritional and health status of children in the age-group 0-6 years

(ii) to lay the foundation for proper psychological, physical and social development of the child

(iii) to reduce the incidence of mortality, morbidity, malnutrition and school dropout

(iv) to achieve effective co-ordination of policy and implementation amongst the various departments to promote child development and

(v) to enhance the capability of the mother to look after the normal health and nutritional needs of the child through proper nutrition and health education.

In order to achieve the Anganwadi Services objectives, a package of six services comprising'

(i) Supplementary nutrition

(ii) (ii) Pre-school non-formal education; (iii) nutrition & health education; (iv) immunization; (v) health check-up; and (vi) referral services are provided to the targeted beneficiaries i.e. all children below 6 years, Pregnant Women and Lactating Mothers. Three of the six services namely Immunisation, Health Check-up and Referral Services are delivered through Public Health Infrastructure under the Ministry of Health & Family Welfare

All the children in the age group 6 months to 6 years, Pregnant Women and Lactating Mothers are eligible for services under Anganwadi Services. Anganwadi Services is a self selecting scheme and no targets are fixed for the beneficiaries of either Supplementary Nutrition or Pre-school non-formal education. As on 31.03.2021, there are 675.07 lakh children and 156.73 lakh Pregnant and Lactating Mothers receiving Supplementary Nutrition at Anganwadi Centres.

Photo courtesy :https://www.waytwojobs.com/2021/07/wcd-anganwadi-jobs-recruitment.html

INTEGRATED CHILD PROTECTION SCHEME (ICPS)

- About ICPS

The Integrated Child Protection Scheme (ICPS) is a centrally sponsored scheme aimed at building a protective environment for children in difficult circumstances, as well as other vulnerable children, through Government-Civil Society Partnership.

- The ICPS : Objectives

ICPS brings together multiple existing child protection schemes of the Ministry under one comprehensive umbrella, and integrates additional interventions for protecting children and preventing harm. ICPS, therefore, would institutionalize essential services and strengthen structures, enhance capacities at all levels, create database and knowledge base for child

protection services, strengthen child protection at family and community level, ensure appropriate inter-sectoral response at all levels.

The scheme would set up a child protection data management system to formulate and implement effective intervention strategies and monitor their outcomes. Regular evaluation of the programmes and structures would be conducted and course correction would be undertaken.

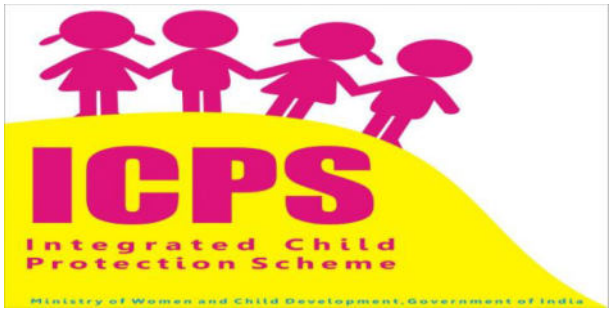


Photo courtesy :https://journalsofindia.com/the-integrated-child-protection-schemeicps/

NATIONAL CRECHE SCHEME FOR THE CHILDREN OF WORKING MOTHERS

A crèche is a facility which enables parents to leave their children while they are at work and where children are provided stimulating environment for their holistic development. Crèches are designed to provide group care to children, usually up to 6 years of age, who need care, guidance and supervision away from their home during the day.

OBJECTIVES

(i) To provide day-care facilities for children (6 months to 6 years) of working mothers in the community.
(ii) To improve nutrition and health status of children.
(iii) To promote physical, cognitive, social and emotional development (Holistic Development) of children.
(iv) To educate and empower parents /caregivers for better childcare.

SERVICES The scheme will provide an integrated package of the following services:

(i) Day-care Facilities including Sleeping Facilities.
(ii) Early Stimulation for children below 3 years and Pre-school Education for 3 to 6 years old children.
(iii) Supplementary Nutrition(to be locally sourced)
(iv) Growth Monitoring.
(v) Health Check-up and Immunization.

S.No.	Age group of children	Number of children to be enrolled	Number of Crèche Worker	Number of Crèche Helper
1	6 months to 3 years.	10 (preferably)	01	01
2	3+ to 6 years	15		
	Total	25	01	01

Photo courtesy: https://www.adda247.com/upsc-exam/national-creche-scheme/

- **MAHILA SHAKTI KENDRA SCHEME**

1. Government of India has approved a new scheme namely, Mahila Shakti Kendra for implementation during 2017-18 upto 2019-20 to empower rural women through community participation and to create an environment in which they realize their full potential. It will provide an interface for rural women to approach the government for availing their entitlements also empowering them through training and capacity building.

Components of MSK scheme:

National level : Domain based experts provide support in implementation of all women centric schemes/programmes of the Government with the aim to strengthen the conceptual and programmatic basis of such schemes through convergence with Ministries and State Government /UT Adm.

State level : At the state level, the State Resource Centre for Women (SRCW) under the State Governments (Department of WCD/Social Welfare) provide technical assistance towards implementing programmes, laws and schemes meant for women through effective coordination at the State/UT level.

District level : District Level Centre for Women (DLCW) collate information on government programmes, schemes and services meant for women empowerment (including Beti Bachao Beti Padao (BBBP), One Stop Centre, Women Helpline, Mahila Police Volunteers, Swadhar, Ujja wala, etc.) to serve as a link between village/block and state level.

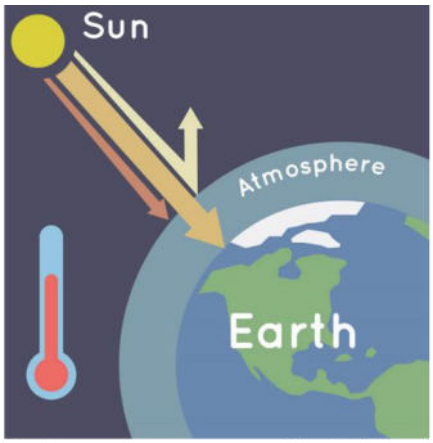
Block level : Activities under MSK was implemented at the Gram Panchayat level and facilitated through Block/Taluk level centres, which serve as the focal points and called MSK- Block Level

Photo courtesy: https://www.voiceofmargin.com/mahila-shakti-kendras-online-programme-for-creating-awareness/

Global Climate Change

Greenhouse Effect

The earth's atmosphere constitutes several gases such as water vapor (H_2O), carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) that absorb and release heat, thus warming the atmosphere. These gases, are called greenhouse gases, and allow mostly visible light and a certain amount of infrared and ultraviolet (UV) radiation from the sun, to pass through the atmosphere. This is absorbed by the earth's surface, which transforms it into longer-wavelength infrared radiation (heat), which then rises into the lower atmosphere. Some of this heat escapes into space, while the rest are absorbed by these greenhouse gases and emitted into the lower atmosphere as even longer-wavelength infrared radiation. This natural warming effect of the troposphere is called the natural greenhouse effect, and is essential in maintaining the temperature of the earth's surface.



Earth's atmosphere traps some of the Sun's heat, preventing it from escaping back into space at night. Credit: NASA/JPL-Caltech

Human activities such as burning fossil fuels, clearing forests and growing crops release carbon dioxide, methane and nitrogen oxide into the atmosphere in increasing amounts to such as extent that it has resulted in a significant increase in the average temperature of the earth. Global warming is defined as the human-enhanced warming of the atmosphere.

Global Climate Change

Climate change is the long-term shift in temperatures and weather patterns, that usually occur naturally over a period of time. But the last two hundred years have witnessed human activities to be the main cause of climate change, driven primarily by industrial activities. But a small change of even 1-2°C can cause potentially dangerous shifts in the weather and climate patterns. These real, observable changes are what we designate as climate change impacts. The effects of climate change on the different aspect of the environment are discussed below.

1. More Frequent and Severe Weather

Warmer temperatures increase the frequency, intensity, and duration of heat waves, which can pose health risks, particularly for young children and the elderly. Warmer atmosphere can hold more moisture, which is eventually dumped back to the earth, resulting in extreme weather, including increasing number of droughts, intense storms, and floods. Drought conditions jeopardize access to clean drinking water, fuel wildfires, and result in dust storms, extreme heat events, and flash flooding. At the opposite end of the spectrum, heavier rains cause streams, rivers, and lakes to overflow, which damages life and property, contaminates drinking water, creates hazardous-material spills, promotes mold infestation and unhealthy air. A warmer, wetter world also promotes food-borne and waterborne illnesses and disease-carrying insects such as mosquitoes, fleas, and ticks.

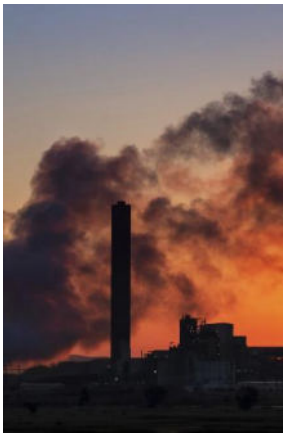
2. Melting Ice Caps

When solar radiation hits snow and ice, approximately 90% of it is reflected back out to space. As global warming causes more snow and ice to melt each summer, the ocean and land that were underneath the ice are exposed at the Earth's surface. Because they are darker in color, the ocean and land absorb more incoming solar radiation, and then release the heat to the atmosphere. In this way, melting ice causes more warming and so more ice melts.

3. Melting Permafrost Releases Greenhouse Gases.

Global warming is causing soils in the polar regions that have been frozen for as much as 40,000 years to thaw. As they thaw, carbon trapped within the soils is released into the atmosphere as carbon dioxide and methane. These gases, released to the atmosphere, cause more warming, which then thaws even more of the frozen soil

4. Higher Air Pollution



Rising temperatures also worsen air pollution by increasing ground level ozone, which is created when pollution from cars, factories, and other sources react to sunlight and heat. Ground-level ozone is the main component of smog, and the hotter things get, the more of it we have. Dirtier air is linked to higher hospital admission rates and higher death rates for asthmatics. It worsens the health of people suffering from cardiac or pulmonary disease. And warmer temperatures also significantly increase airborne pollen, which is bad news for those who suffer from hay fever and other allergies.

5. More Acidic Oceans

Oceans are becoming more acidic, due in large part to their absorption of some of our excess emissions. As this acidification accelerates, it poses a serious threat to underwater life, particularly creatures with calcium carbonate shells or skeletons, including molluscs, crabs, and corals. This can have a huge impact on shellfisheries and other industries that depend on the harvest of oysters, clams, and other shelled molluscs.

6. Rising Sea Levels

Global sea level has risen by about 8 inches since the year 1880, at a rate of 1-2 mm each year.

This is the result of added water from melting land ice and the expansion of seawater as it warms. Polar regions are particularly vulnerable to a warming atmosphere. Average temperatures in the Arctic are rising twice as fast as they are elsewhere on earth. And it has been estimated that by the year 2100, our oceans will be 1-8 feet higher. This increase threatens coastal systems and low-lying areas, including entire island nations, including Some of the world's largest cities, including New York, Los Angeles, Miami, Mumbai,

Sydney, and Rio de Janeiro. For example, for a low-lying island nation like the Maldives in the Indian Ocean, even a small rise in sea levels could spell disaster for of its people. About 80% of the 1,192 small islands making up this country lie less than 1 above sea level. Rising sea levels and higher storm surges during this century could flood most of these islands and their coral reefs. Next, let us talk about the increasing death rates due to climate change.

7. Higher Death Rates

Today's scientists point to climate change as "the biggest global health threat of the 21st century." It's a threat that impacts all of us—especially children, the elderly, low-income communities, and minorities—in a variety of direct and indirect ways. As temperatures spike, so does the incidence of illness, emergency room visits, and death. Climate change also has impacts on the wildlife species, both terrestrial and aquatic. Climate change has resulted in higher wildlife extinction rates.

8. Higher Wildlife Extinction Rates

As humans, we face a host of challenges, due to climate change, but we're certainly not the only ones catching the heat. As land and sea undergo rapid changes, the animals that inhabit them are doomed to disappear if they don't adapt quickly enough. Some will make it, and some won't. Many land, freshwater, and ocean species are shifting their geographic ranges to cooler climes or higher altitudes, in an attempt to escape climate warming. They're changing seasonal behaviours and traditional migration patterns as well. And yet, many face "increased extinction risk due to climate change." a 2015 study has revealed that vertebrate species—animals with backbones, like fish, birds, mammals, amphibians, and reptiles—are disappearing 114 times faster than they should be, a phenomenon that has been linked to climate change, pollution, and deforestation. Let us know understand the important factors that are responsible for these devastating climate change events. The first and foremost driver of climate change is the greenhouse effect, which is mostly driven by human activities.

Causes of Global Climate Change

1. Human Vs Natural Causes

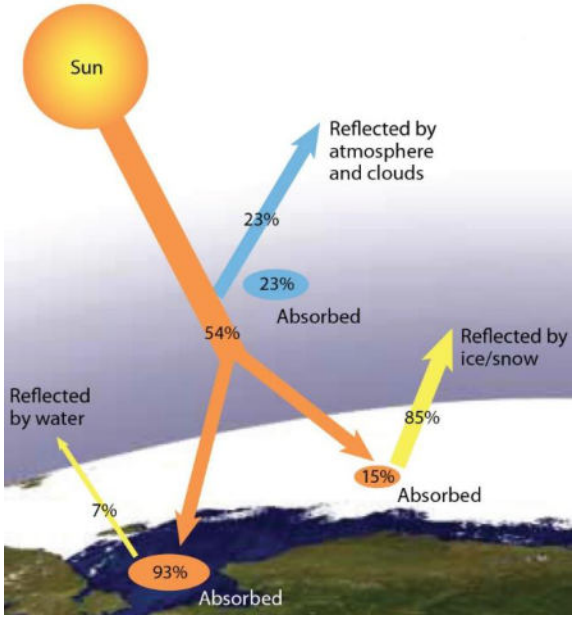
Scientists have pieced together a record of the earth's climate by analyzing a number of indirect measures of climate, such as ice cores, tree rings, glacier lengths, pollen remains, and ocean sediments, and by studying changes in the earth's orbit around the sun. This record shows that the climate varies naturally over a wide range of time scales. but this variability does not explain the warming that's been observed since the 1950s. it is extremely likely (> 95%) that human activities have been the dominant cause of this warming. CO_2 produced by human activities is the largest contributor to global warming. Methane is a more powerful greenhouse gas than CO_2, but has a shorter lifetime. Nitrous oxide is a long-lived greenhouse gas that accumulates in the atmosphere over decades to centuries. Currently, the CO_2 levels are at a record high of 414.8 ppm, a concentration that has not been seen on Earth for millions of years. Some of these activities include:

- Burning coal, oil and gas, producing carbon dioxide and nitrous oxide.
- Cutting down forests (deforestation). Trees help regulate the climate by absorbing CO_2 from the atmosphere. When cut down, that beneficial effect is lost and the carbon stored in the trees is in turn released into the atmosphere, adding to the greenhouse effect.

- Manufacturing and industry produce emissions, mostly from burning fossil fuels to produce energy for making things such as cement, iron, steel, electronics, plastics, clothes, and other goods. Mining and other industrial processes also release gases.
- Increasing livestock farming such as cows and sheep produce large amounts of methane when they digest their food.
- Fertilisers containing nitrogen produce nitrous oxide emissions.
- Fluorinated gases are emitted from equipment and products that use these gases. Such emissions have a very strong warming effect, up to 23,000 times greater than CO_2. Let us look at certain natural events that can affect the earth's surface temperature. The first factor is a change in the Reflectivity or Absorption of the Sun's Energy.

2. Reflectivity or Absorption of the Sun's Energy

Activities such as agriculture, road construction, and deforestation can change the reflectivity of the earth's surface, leading to local warming or cooling. This effect is observed in the form of heat islands, which are urban centres that are warmer than their surroundings, less populated areas. One reason for these effects is that urban centres house more buildings, pavements, and roofs that tend to reflect less sunlight than natural surfaces. Dark objects and surfaces, like the ocean, forests, and soil, tend to absorb more sunlight. Light-coloured objects and surfaces, like snow and clouds, tend to reflect more sunlight. About 70% of the sunlight that reaches the earth is absorbed. Natural changes in the earth's surface, like the melting of sea ice, have contributed to climate change in the past, often acting as feedbacks to other processes.



3. Changes in the Earth's Orbit and Rotation

Changes in the earth's orbit and its axis of rotation have had a big impact on climate in the past. For example, the amount of summer sunshine on the Northern Hemisphere, which is affected by changes in the planet's orbit, appears to be the primary cause of past cycles of ice ages, during which the earth has experienced long periods of cold temperatures (ice ages), as well as shorter interglacial periods (i.e., periods between ice ages) of relatively warmer temperatures.

4. Variations in Solar Activity

Variations in the sun's energy output can also affect the intensity of the light that reaches the earth's surface. Satellites have been measuring the amount of energy that the earth receives from the sun since 1978. And These measurements show no net increase in the sun's output, even as global surface temperatures have risen.

5. Volcanic Activity

Explosive volcano eruptions can throw particles (e.g., SO_2) into the upper atmosphere, where they can reflect enough sunlight back to space to cool the surface of the planet for several years. These particles are an example of cooling aerosols, which reflect the sunlight away from the

earth's surface. Volcanic particles from a single eruption do not produce long-term climate change because they remain in the atmosphere for a much shorter time than greenhouse gases.

6. Changes in Naturally Occurring Carbon Dioxide Concentrations

Over the last several hundred thousand years, carbon dioxide levels have varied in tandem with the glacial cycles. During warm interglacial periods, carbon dioxide levels were higher. During cool glacial periods, carbon dioxide levels were lower. These changing concentrations have acted as a positive climate feedback, amplifying the temperature changes caused by long-term shifts in the earth's orbit.

Kyoto Protocol & Paris Agreement

Global Climate Action in the form of Treaties & Conferences

In this section, we will discuss some of the measures taken in the form of conferences and treaties that were formulated to mitigate the anthropogenic effects of global climate change. The earliest among these efforts was the treaty known as the United Nations Framework Convention on Climate Change (UNFCCC), followed by the Kyoto protocol, the annually conducted Conference of parties.

United Nations Framework Convention on Climate Change (UNFCCC)

The UNFCCC is an international treaty that was established to combat "dangerous human interference with the climate system". The UNFCCC was informally known as the Earth summit, and was held at Rio de Janeiro from 3-14 June 1992.

Its main objectives were to

- Stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system
- Set non-binding limits on greenhouse gas emissions for individual countries. It did not contain any enforcement mechanisms, due to which it was deemed unsatisfactory in reaching the required emission reduction goals.

Conference of the Parties (COP)

Conference of the Parties (COP) is the supreme decision-making body of the UNFCCC, which meets annually to assess progress in dealing with climate change. The first COP meeting was held in Berlin, Germany in March 1995. Usually, COP meets in Bonn, which is the seat of the secretariat, unless any member country offers to host the session. The latest COP was its 26th meeting, held from 31 October-12 November 2021. At COP-26, India pledged to become a net-zero carbon emitter by 2070 and announced enhanced targets for renewable energy deployment and reduction in carbon emissions.

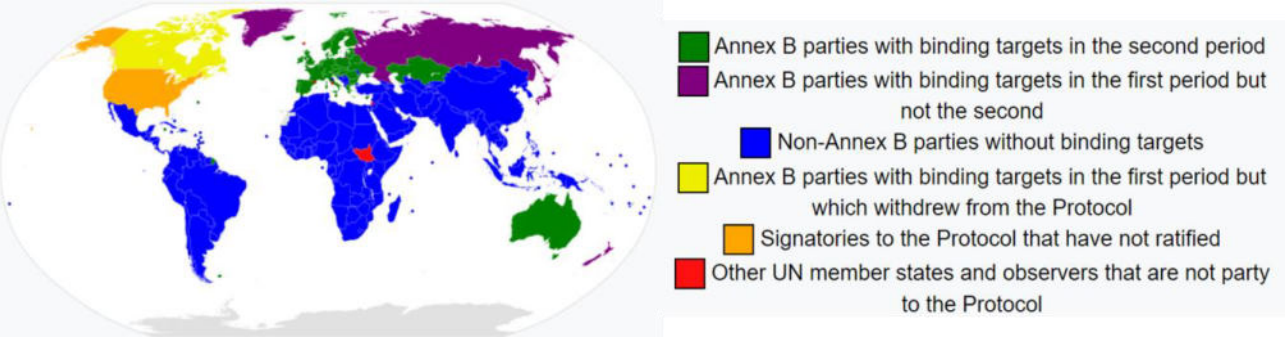
The Kyoto Protocol

Kyoto Protocol is an international treaty that was signed in 1997. it was the first implementation of measures formulated under the UNFCCC. It ran from the year 2005-2020. It was first adopted in Kyoto, Japan on the 11 December 1997 and entered into force on 16 Feb 2005; currently, there are 192 parties in the protocol. The Kyoto Protocol had two commitment periods, the first of which lasted from 2008 to 2012. It was amended again in 2012 to include the Doha amendment for the period 2013-2020.

Salient points of the Kyoto Protocol

- The Kyoto Protocol established three categories of signatory states, namely developed countries, developed countries with special financial responsibilities, and the third, developing countries.
- The developed countries, also called Annex 1 countries, originally consisted of 38 states, 13 of which were Eastern European states in transition to democracy and market economies, and the European Union.

- Annex II countries consisted of Developed countries with special financial responsibilities. E.g., Russia, Baltic states, Central and Eastern European states.
- Those countries not categorized under the Annex I and II countries were categorized as developing countries, including India and China, for example.



- The protocol was based on the principle of common but differentiated responsibilities: it acknowledged that individual countries have different capabilities in combating climate change, based on their economic development, and therefore placed the obligation to reduce current emissions on to developed countries on the basis that they are historically responsible for the current levels of greenhouse gases in the atmosphere. This included the Annex-I countries that were legally bound to lower their GHG emissions to 1990 levels. They were called upon to adopt national policies and take appropriate measures to mitigate climate change.

Goals of the Kyoto Protocol

The Kyoto Protocol applied to the seven greenhouse gases listed in carbon dioxide (CO_2), Methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), nitrogen trifluoride (NF_3), which was added during the Doha amendment.

- Emission reduction targets were assigned for different countries, expressed as levels of assigned amount units (AAUs).
- The Kyoto protocol was legally binding, and any Annex-I or II country failing to meet targets were penalized.
- The US did not ratify the Kyoto Protocol, while Canada denounced it in 2012. The Kyoto Protocol was ratified by all the other Annex I Parties. All countries that remained parties to the Kyoto Protocol met their first commitment period targets.
- developing countries were required to only report their emissions to the UNFCCC.
- Flexibility mechanisms were established to help countries achieve their emission targets.

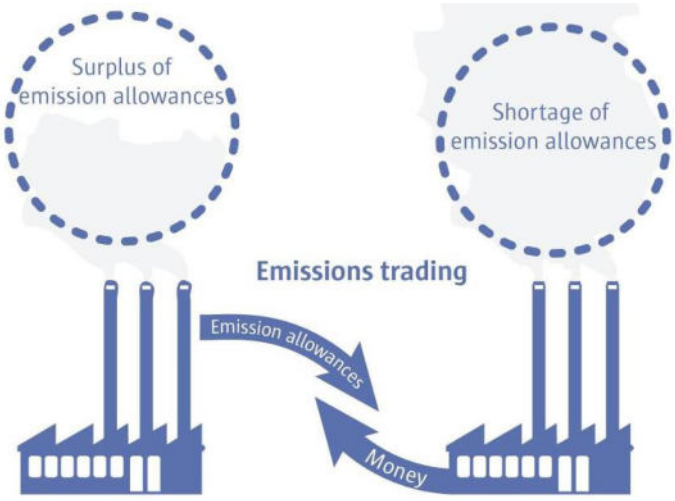
Flexibility Mechanisms of the Kyoto Protocol

The Protocol defines three "flexibility mechanisms" that can be used by the Annex I Parties in meeting their emission limitation commitments. These mechanisms aimed to lower the overall cost of achieving emission targets. The three mechanisms are:

- International Emissions Trading (IET)
- The Clean Development Mechanism (CDM)
- Joint Implementation (JI).

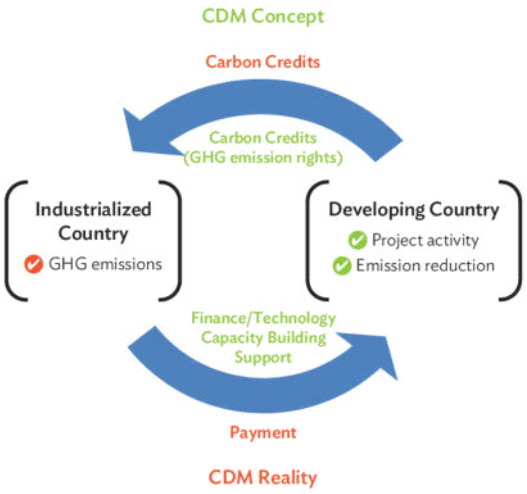
International Emissions Trading (IET)

International Emissions Trading (IET) allowed countries to trade unused emissions to other countries that exceeded their targets. For example, Country A has 100 emission units, of which it has used only 70. It can trade the remaining 30 units to another country B that has exceeded their permissible emission units. Thus, a new commodity was created in the form of emission reductions. Since CO2 is the principle GHG, it is also referred to as carbon trading. Countries under the Kyoto protocol that were assigned targets for reducing their GHG emissions were expressed as levels of allowed emissions, or assigned amount units (AAUs). Emission trading currently operates across 35 countries in 4 continents.



Clean Development Mechanism (CDM)

Clean Development Mechanism (CDM) is a United Nations-run scheme that allows countries to fund GHG-reducing projects in other countries and claim the saved emissions as part of their own efforts to meet international emissions targets. These projects were also aimed at assisting developing countries achieve sustainable development and reduce their own carbon footprint. Here, let me introduce you to another form of carbon trading, known as Certified Emission Reductions (CER) units, also called as a carbon credit.



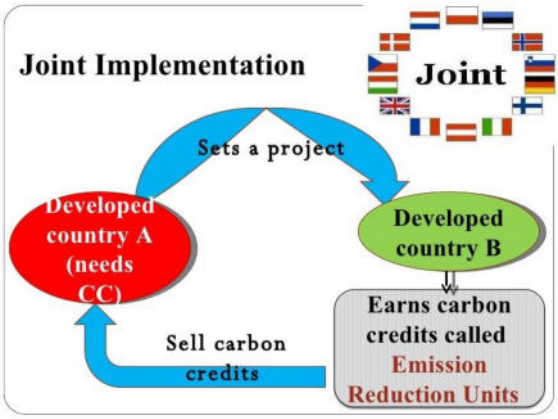
CDM = clean development mechanism, GHG = greenhouse gas.
Source: Asian Development Bank.

Carbon Trading

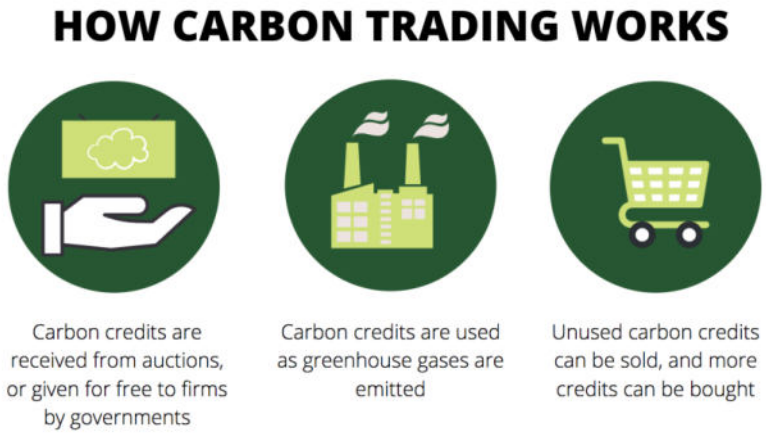
CER is a type of emission unit issued under the Clean Development mechanism to Annex-1 countries to help them comply with their emission reduction targets. CERs can be purchased either from a primary market (i.e., the country that makes the reduction) or from a secondary market (resold from a marketplace). CERs give the owner/country the right to emit 1 metric tonne of CO_2 or other equivalent GHG. CERs can be gained by developing projects that reduce GHG emissions.

Joint Implementation (JI) scheme

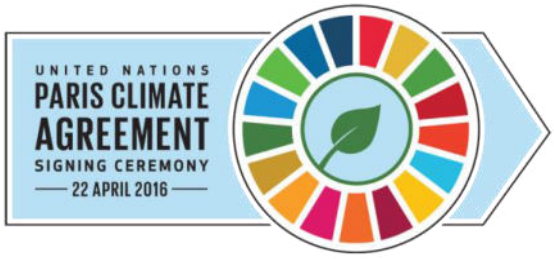
Under the Joint Implementation (JI) scheme, any Annex-I country could invest in a project to reduce GHG in any other Annex-I country as an alternative to reducing them domestically. This was introduced to lower the cost of reducing GHGs, as it may be expensive to do so in certain countries and cheaper in others. Under the JI scheme, another form of



carbon trading, known as the Emission Reduction Unit (ERU) was introduced. 1 ERU represents the reduction of 1 tonne of CO_2.



Paris Agreement

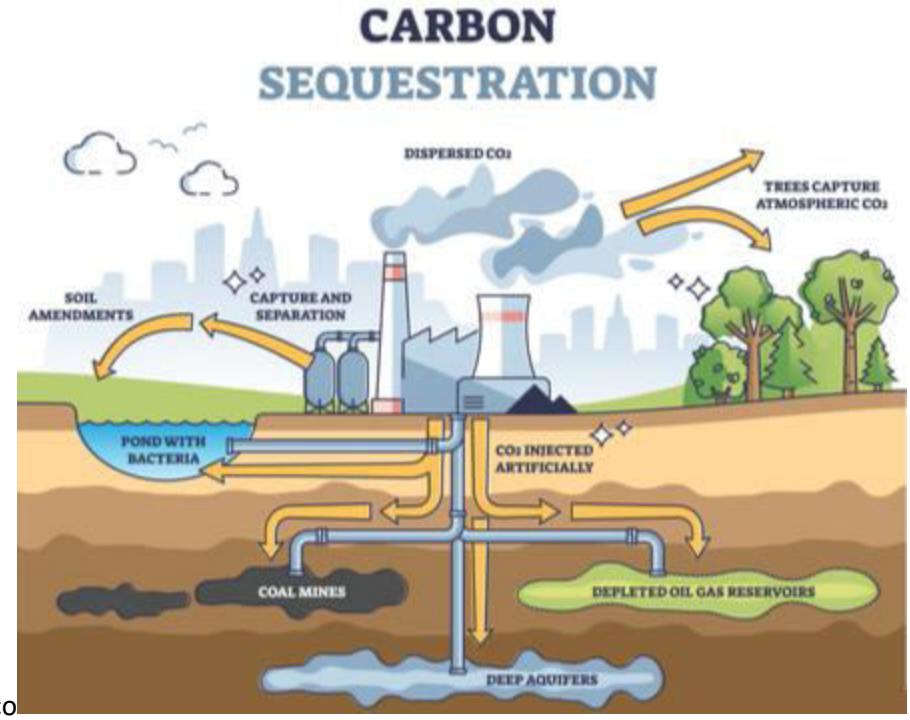


The Paris agreement, or the Paris Climate Accords is an international treaty on climate change that was adopted in 2015. It covers climate change mitigation, adaptation and finance. The agreement was negotiated by 196 parties at the 2015 UNFCCC near Paris, France. It opened for signature on 22 April 2016 (Earth Day), and entered into force on 4 November 2016. As of November 2021, 193 members of the UNFCCC ratified the Paris agreement, and only 4 countries have not ratified, of which Iran is the major emitter. USA withdrew from the agreement in 2020, but re-joined in 2021.

The long-term goal of the Paris agreement was to restrict the rise in mean global temperature to <2°C, and if possible, to 1.5°C. to achieve this goal, it has been estimated that emissions need to be cut by 50% by 2030. No specific emission targets were enforced on countries like in the case of the Kyoto protocol, but it was mandated that targets should not exceed the previous ones set out by the Kyoto protocol.

Carbon Sequestration

Carbon sequestration is the long-term storage of carbon dioxide or other forms of carbon with the aim of mitigating global warming and climate change. The natural carbon cycle is responsible for the exchange of carbon among the biosphere, pedosphere (soil layer), geosphere (rocks), hydrosphere and the atmosphere. Human activities have disrupted the carbon cycle since the past few centuries by the modification of land use and by excessive burning of fossil fuels. As a result, CO_2 has increased by over 52% higher than pre-industrial levels as of the year 2020. This increased CO_2 has disbalanced the carbon cycle, causing catastrophic changes in the climate, which we discussed in the section 1 of this module. Therefore, it is essential for us to restore this balance by removing excess CO_2 from the atmosphere by artificial methods and depositing them in a reservoir. This can be achieved using biological, physical and chemical methods.



CO

Natural Carbon Sinks

Carbon sink is a natural reservoir that absorbs and stores CO_2 from the atmosphere in the form of various carbon-based compounds. This is known as the natural process of carbon sequestration. In order to understand these completely, it is necessary for us to understand the carbon cycle, which is the mechanism of transfer of carbon between the atmosphere, lithosphere and hydrosphere. There are two major types of carbon sinks, namely terrestrial and oceanic sinks.

- Terrestrial sinks include soil, grasslands, trees, plants and any organic matter that act as both long-term and short-term sinks. Soil contains more carbon than all terrestrial vegetation and atmosphere combined.
- Ocean sinks: are the world's primary long-term carbon sink, absorbing more than 25% of CO_2 emitted by humans. Plankton and aquatic life in the oceans absorb CO_2 via photosynthesis; eventually die eventually, sink to the bottom, carrying the carbon deposits with them. When they decompose, the carbon-based compounds are transformed into other forms, utilized by the other aquatic species at the bottom of the ocean.

Terrestrial Biosequestration

Biosequestration can be utilized for the capture and storage of atmospheric greenhouse gas carbon dioxide by enhanced biological processes. This can be done via increased rates of photosynthesis by via reforestation, sustainable forest management, and genetic engineering. Manipulation of these processes can enhance sequestration.

Peat Production

Peat bogs act as a sink for carbon because they accumulate partially decayed biomass that would otherwise continue to decay completely. By creating new bogs, or enhancing existing ones, the amount of carbon that is sequestered by bogs would increase.

Peat bogs

Forestry Practices

Forestry practices such as afforestation, proforestation, reforestation and urban forestry can be utilized to enhance carbon sequestration. Reforestation is the process of planting trees in a forest where the number of trees has been decreasing. Afforestation is when new trees are planted where there were no trees before, creating a new forest. Proforestation is the practice of protecting an existing forest, and allowing it to grow to its full potential so as to enhance carbon accumulation and structural complexity. Urban forestry is the care and management of tree populations in urban areas so as to enhance carbon sequestration over the trees' lifetime.

Wetlands

Wetland soil is found in coastal wetlands such as mangroves, sea grasses, and salt marshes. Wetlands are an important carbon sink, containing 20-30% of the world's soil carbon.

Agriculture

Cropland soils contain less soil organic carbon (SOC) as compared to natural vegetation by ~30-40%. This loss is due to the removal of plant material containing carbon, in terms of harvests. Agricultural practices can be modified by the following methods such as:

- Leaving harvest residues on field
- Perennial crop rotation, thus increasing the amounts of soc.

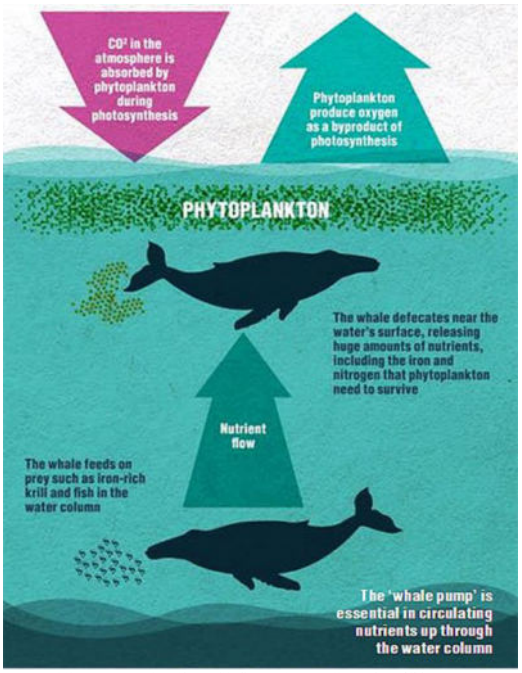
Deep Soil

Soils hold four times the amount of carbon stored in the atmosphere. About half of this is found deep within soils, stabilized by mineral-organic associations.

Reducing emissions: Increasing yields and efficiency generally reduces emissions as well, since more food results from the same or less effort. Techniques include more accurate use of fertilizers. E.g.: no-till farming requires less machine use and burns less fuel per acre.

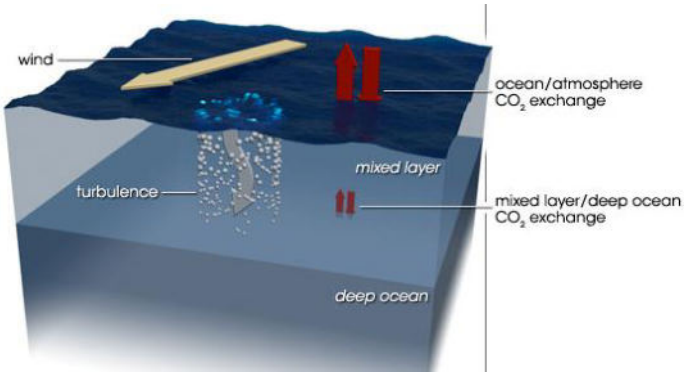
Oceanic Sequestration

Ocean iron and urea fertilization: It is a geoengineering technique. fertilization of ocean with urea and/or iron encourages phytoplankton growth, which removes carbon from the atmosphere. This technique is controversial as it not completely understood, and can result in release of nitrogen oxides that can disrupt the ocean's nutrient balance. But this process occurs naturally, mediated by sperm whales. Sperm whales act as agents of iron fertilization when they transport iron from the deep ocean to the surface during prey consumption and defecation. The iron-rich faeces cause phytoplankton to grow and take up more carbon from the atmosphere. When the phytoplankton dies, some of it sinks to the deep ocean and takes the atmospheric carbon with it.



Sperm whales defecate releasing large amounts of nutrients, which offset carbon

Mixing Layers



Encouraging various ocean layers to mix can move nutrients and dissolved gases around. Mixing can be achieved by placing large vertical pipes in the oceans to pump nutrient rich water to the surface, triggering blooms of algae, which store carbon when they grow and export carbon when they die. This produces results somewhat similar to iron fertilization.

Seaweed Farming

Seaweed grows in shallow and coastal areas, and capture significant amounts of carbon. Seaweed also grows fast, and can also be used to generate biomethane to produce electricity. It has been estimated that if seaweed farms covered 9% of the ocean, they could produce enough biomethane to supply Earth's equivalent demand for fossil fuel energy, remove 53 gigatonnes of CO2 per year from the atmosphere and sustainably produce 200 kg per year of fish, per person, for 10 billion people.

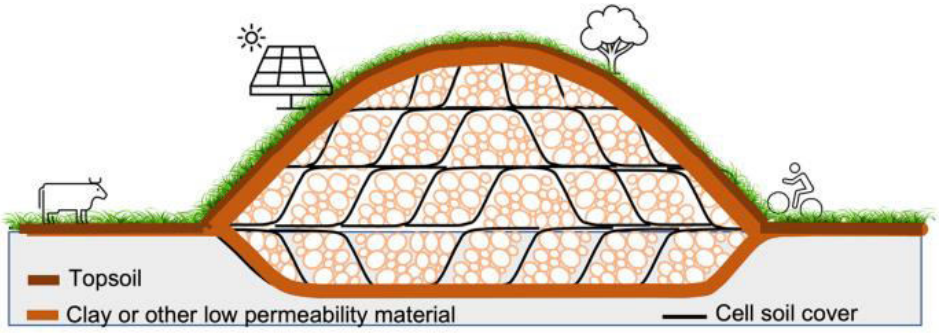
Underwater Seaweed Farming

Physical Sequestration

Physical sequestration methods make use of biomass burial, or use of biomass to capture carbon in different forms so as to create a terrestrial carbon sink. Let us review a few of these processes briefly:

Bioenergy with carbon capture and storage (BECCS)

BECCS is the process of extracting bioenergy from biomass, and capturing and storing the carbon, thereby removing it from the atmosphere. The carbon in the biomass comes from the greenhouse gas carbon dioxide (CO_2) which is extracted from the atmosphere by the biomass when it grows. Energy is extracted in useful forms (electricity, heat, biofuels, etc.) as the biomass is utilized through combustion, fermentation, pyrolysis or other conversion methods.



Wood Vault Version 1.1: Burial Mound (Tumulus)

Physical Burial

Burial of biomass (e.g., trees) directly, mimics natural processes that created fossil fuels.

Biochar Burial

Biochar is charcoal created by the pyrolysis of biomass waste. The resulting material is added to a landfill or used as a soil improver to create terra preta, in other words, fertile black soil.

Physical Oceanic Carbon Sequestration

Solubility of CO_2 is directly proportional to water pressure, and inversely proportional to temperature. This makes ocean beds, with high pressure and low temperature, the perfect long-term carbon sink. If CO_2 were to be injected to the ocean bottom, the pressures would be great enough for CO_2 to be in its liquid phase. This could create stationary pools of CO_2 at the ocean floor. The ocean could potentially hold over a thousand billion tons of CO_2. Let us review some of the commonly used methods for oceanic physical sequestration.

Dilute CO_2 injection

The carbon dioxide is usually injected at 1000 m depth to reduce carbon dioxide bubbles from escaping. These bubbles are dispersed up the water column via oceanic currents.

Release Of Solid Carbon Dioxide at Depth

CO_2 storage is facilitated via solid CO_2 or hydrate of CO_2 is 1.5 times heavier than seawater, thus it sinks to the ocean floor. Hydrate formation takes place when the dissolved concentration of Liquid Carbon Dioxide Is Around 30% And 400 Meters Below Sea Level.

Mineralization and deep-sea sediments

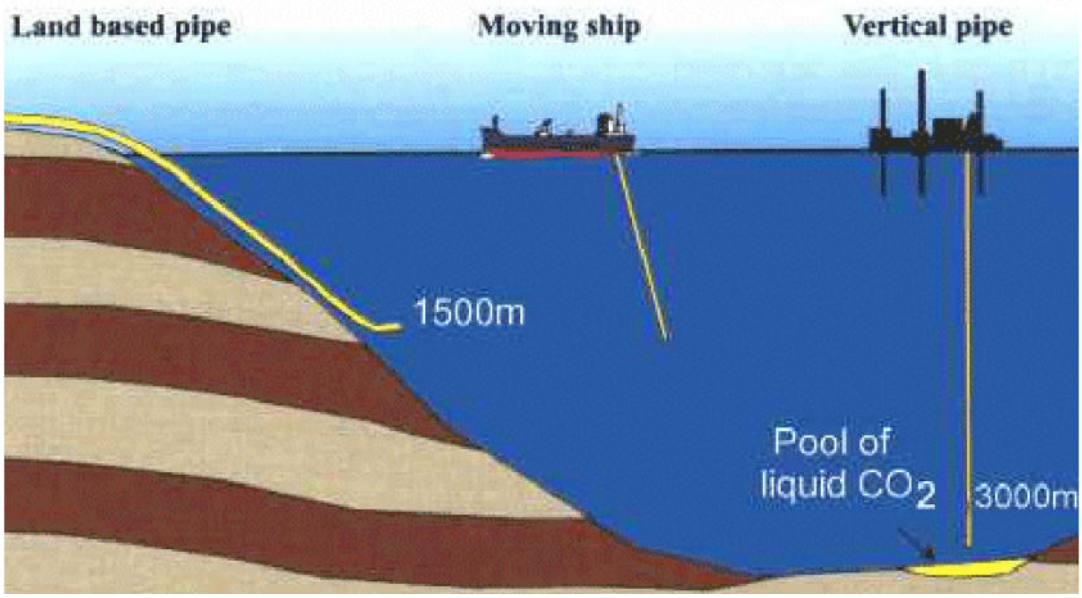
Similar to terrestrial processes, CO_2 mineralization can also occur under the sea. In addition, deep-sea sediment injects liquid CO_2 at least 3000 m below the surface, directly into ocean sediments to generate CO2 hydrates.

CO_2 Plumes

a mixture of dense CO_2 plumes and seawater is injected at 3 km depths, that sink due to their density, and are circulated by ocean currents.

CO_2 Lakes

Carbon dioxide lakes form on ocean floors in depressions or trenches through isolation. They also do not mix easily with the surface ocean since deep ocean has a very slow rate of mixing.



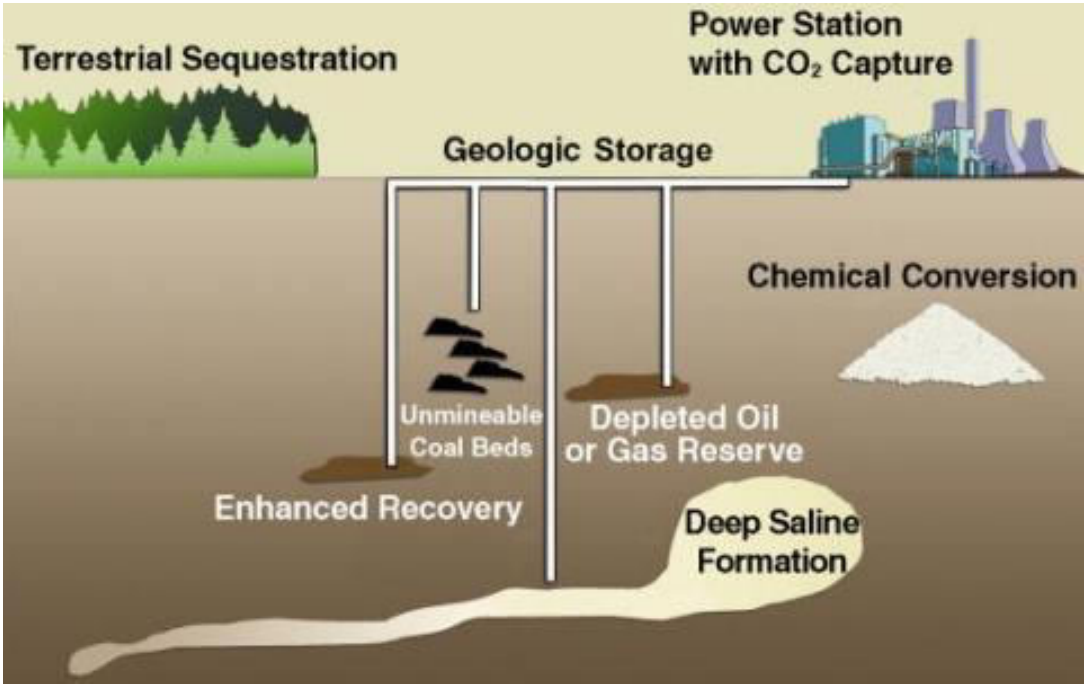
Environmental Impacts of Deep-Sea Ocean Sequestration

Deep-sea ocean sequestration is still largely unexplored. Scientists are studying their impacts through small-scale experiments. The spatial range of the ocean makes it extremely challenging to extrapolate results.

- Ocean sequestration in deep sea sediments has the potential to impact deep sea life. The chemical and physical composition of the deep sea does not undergo changes in the way that surface waters do. Due to its limited contact with the atmosphere, most organisms have evolved with very little physical and chemical disturbance and exposed to minimal levels of carbon dioxide. Deep sea ecosystems do not have rapid reproduction rates nor give birth to many offspring because of their limited access to oxygen and nutrients. Introducing lethal amounts of carbon dioxide into such an environment can have a serious impact on the population size and will take longer to recover relative to surface water species.
- Effects of pH vs CO_2: increased amounts of CO_2 cause acidification of water. Organisms are affected, not just by the acidification of water; but CO_2 itself interferes with their physiological function.
- Long-term effects: these are difficult to predict, but also important to understand, as it would impact not just deep oceans, but surface waters eventually as well

Physical Geo-sequestration

Geological sequestration refers to the storage of CO_2 underground in depleted oil and gas reservoirs, saline formations, or deep, un-minable coal beds. CO_2 released from fossil fuel combustion can be captured and compressed into a supercritical fluid, and injected deep underground, about 1 km depths, where it would be stable for up to millions of years.

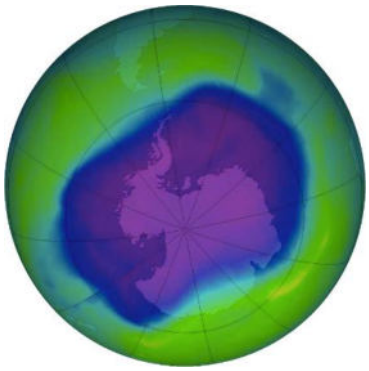


Mineral carbonation

in this method, CO_2 is converted into stable carbonates of calcium or magnesium. removal and storage of CO_2 as calcium or magnesium carbonates; this reaction occurs naturally through the weathering of rocks over geologic time periods.

Ozone Layer Depletion

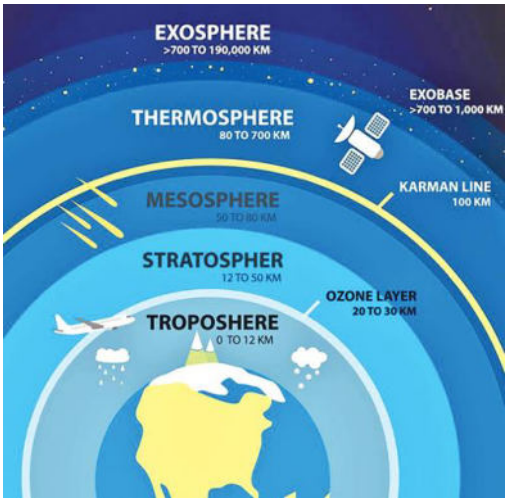
What is the ozone layer?



The ozone layer is a region of Earth's stratosphere that absorbs most of the Sun's ultraviolet radiation. This layer contains a high concentration of ozone (O_3) as compared to other parts of the atmosphere. The concentration of ozone in this layer is < 10 parts per million of ozone, whereas the average ozone concentration in Earth's atmosphere as a whole, is 0.3 parts per million. This layer is located mainly in the lower portion of the stratosphere, ranging from approximately 15-35 km above Earth. And its thickness varies seasonally and geographically.

Role of ozone in the stratosphere

Ozone is present in the lower stratosphere. It absorbs ~95% of the sun's harmful UV radiation, thus preventing it from reaching the earth's surface. UV radiation is classified based on its wavelength into UV-A (400–315 nm), UV-B (315–280 nm), and UV-C (280–100 nm). Amongst these, UV-C, which is very harmful to all living things, is entirely screened out by ozone at around 35 kilometres altitude. UV-B radiation harmful is the main cause of sunburn, it can also cause cataracts and problems such as skin cancer. The ozone layer is very effective at screening out most of the UV-B as well, even though some longer wavelengths do reach the surface. Most of the UV-A, which is significantly less harmful, is not absorbed by ozone, and reaches the earth's surface.

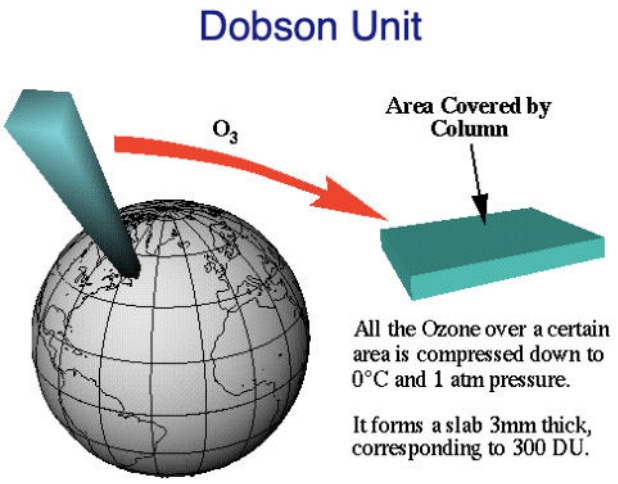


Distribution in the stratosphere

The thickness of the ozone layer varies worldwide, and is generally thinner near the equator and thicker near the poles. Thickness refers to how much ozone is present in a column over a given area, and varies from season to season. The reasons for these variations are mostly due to atmospheric circulation patterns and solar intensity.

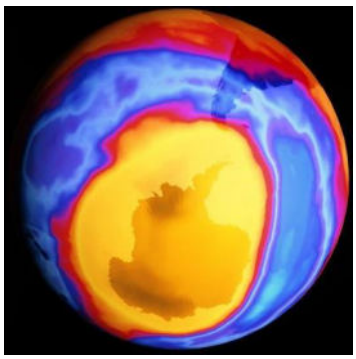
Ozone hole and its measurement

The ozone hole is not technically a "hole" where ozone is completely absent, but rather, it is a region where ozone is exceptionally depleted in the stratosphere over the Antarctic circle. The thickness of the ozone layer is measured across the entire atmospheric column from the surface to the edge of space. If the total amount of ozone was compressed to a pressure of 1 atm, its height in mm is given by Dobson units. 1 mm: 100 Dobson (DB) units; 2 mm: 200 Dobson units and so on. The global average thickness of ozone is 300 DB, and in the ozone 'hole', the thickness



reduces to 100 DB. The ozone hole is not permanent, it thins down and thickens up at times. Ozone values less than 220 DB are termed as Ozone holes.

Certain observations about the ozone hole

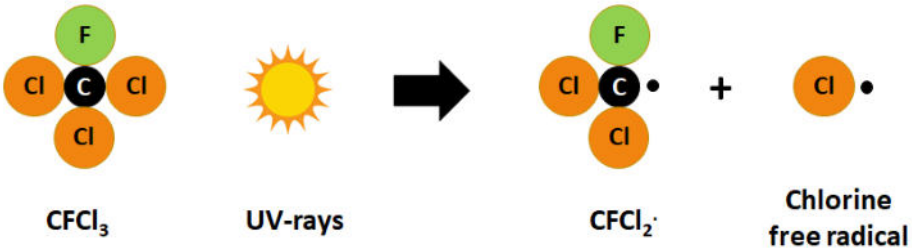


The size of the ozone hole in the Antarctic covers ~20-23 million km^2 depending on the seasons. The largest, single-day ozone hole was recorded by satellite to be 29.9 million km^2 in Sept. of 2000. The southern polar ozone hole usually lasts from mid Aug to end of Dec., while the northern polar hole, over the Arctic circle, lasts a few days. So, the Ozone hole is largest above the Antarctic, and just to put its size in perspective, its area is three times larger than the entire land mass of the USA.

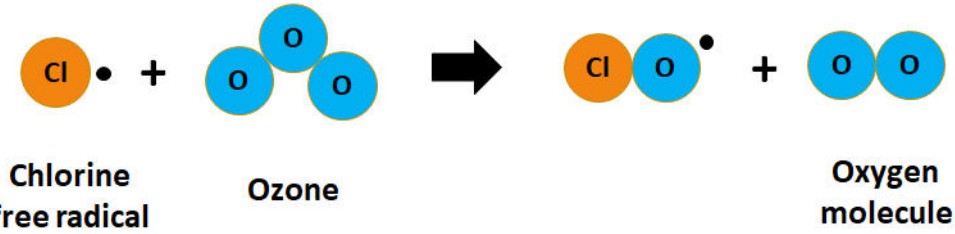
What causes depletion of ozone?

The main causes of the ozone hole are certain man-made chemicals containing halogens, that are used as refrigerants, solvents, propellants, and foam-blowing agents (chlorofluorocarbons (CFCs), HCFCs, halons), referred to broadly as ozone-depleting substances (ODS). So, how exactly do these chemicals reach the stratosphere and cause ozone depletion? CFC molecules are made up of chlorine, fluorine and carbon atoms and are extremely stable. Most molecules decompose before they can cross into the stratosphere from the troposphere). CFC's, being extreme stable, make their way into the stratosphere, reaching very high altitudes, where photons are more energetic. When the CFC's come into contact with these high energy photons, their individual components are freed from the whole.

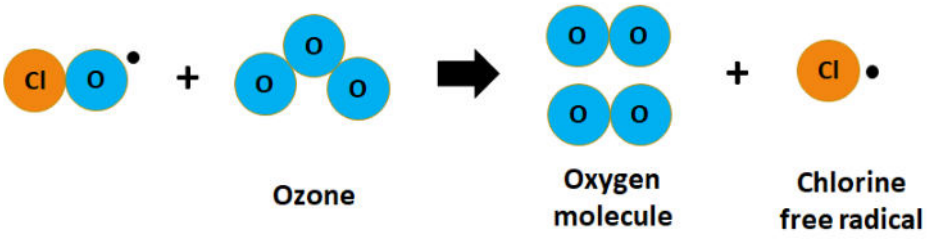
- When UV lights hits a halocarbon, such as chlorofluorocarbon such as $CFCl_3$, one chlorine atom breaks off, leaving $CFCl_2$ radical and Cl radical.



- The chlorine free radical attacks an ozone molecule, pulling out an oxygen atom, leaving behind an O_2 molecule.

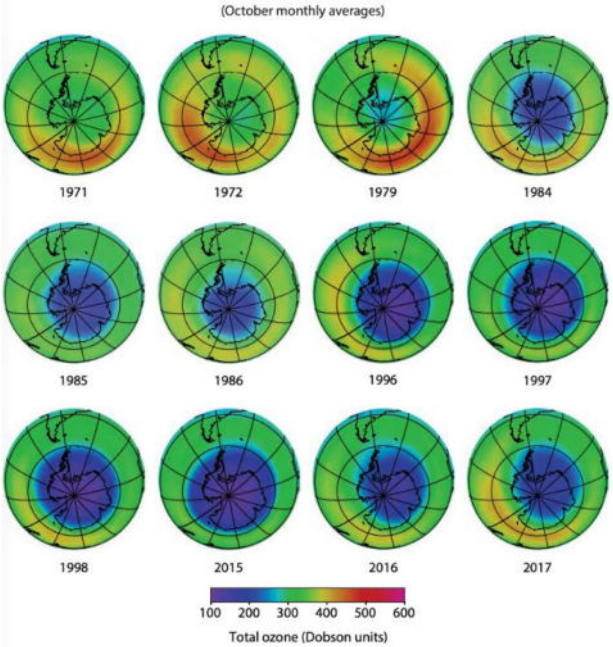


- The Cl and O atoms combine to form a chlorine monoxide molecule (ClO). X



- Another oxygen radical pulls out the oxygen from ClO, leaving the Cl free radical free to attack another ozone molecule and begin the cycle all over again. So, Cl acts as a catalyst here. One chlorine atom can thereby destroy thousands of ozone molecules.

Reasons for the massive ozone hole over Antarctica



So, why is the ozone hole so massive in size over Antarctica, and not in other regions? People don't even live there and emit harmful gases. So, let's look at it from a scientific and mechanistic point of view. The ozone hole occurs during Antarctic springs, i.e., from Sept. to early Dec., during this time, ~50% of ozone is destroyed. Let us try and understand the reason for its seasonal depletion.

- Antarctica has the coldest winters on earth, often reaching -80°C. These extreme temperatures result in the formation of polar stratospheric clouds (PSC's) which are basically, a conglomeration of frozen H_2O and HNO_3. Due to their extremely cold temperatures, PSC's form an electrostatic attraction with CFC molecules as well as other halogenated compounds.
- During winter, there is no sunlight to drive chemical reactions. The frozen crystals, of water and nitric acid, that make up polar stratospheric clouds, provide a surface for the reactions that will free chlorine atoms in the Antarctic stratosphere. These reactions are initiated in spring, with the arrival of the sun, and high energy photons, causing the PSCs to melt.
- As a result, CFCs react with the high energy photons, releasing Cl radical, which then causes the depletion of the ozone layer.
- So, to summarize, extreme low temperature and solar energy, both of which are readily available in the Antarctic spring, result in a large-scale ozone layer depletion.

So, how can we combat this depletion in the ozone layer?

The role of CFCs in depleting the ozone layer was identified by two scientists, Molina and Rowland, from the USA, who were later awarded the Nobel prize in 1995 for their work on this problem. Countries across the globe began recognizing the seriousness of the issue, which resulted in the Montreal protocol. The Montreal Protocol is an international treaty that was designed to protect the ozone layer by phasing out the production substances responsible for

ozone depletion. It began with the Vienna convention for the Protection of the Ozone Layer, which was signed on 22nd March 1985, and was followed by the Montreal Protocol on 16th September 1987. It was universally ratified by all 197 nations of the United Nations, and came into force on 16 September 1989.

On the 19th June 1991, India became a party to the Vienna convention, and on the 17th September 1992, India became a party to the Montreal Protocol. As a result of these treaties, the ozone hole in Antarctica is slowly, but steadily recovering. Climate projections indicate that the ozone layer will return to 1980 levels between the years 2050 and 2070. The Montreal Protocol is a landmark agreement that has successfully reduced the global production, consumption and emission of ozone-depleting substances (ODSs), which are also greenhouse gases that contribute to global warming. Under this treaty, all countries have accepted legally binding obligations to phase out the production and consumption of ODSs including CFCs, halons and other substances that release chlorine or bromine into the atmosphere.

Ozone depleting substances (ODSs)

Ozone depleting substances were defined under the Montreal Protocol, as chemicals that destroy the ozone layer. Several groups of halogenated hydrocarbons (~96) were identified under this category. They contain either chlorine or bromine (fluorine- only-containing compounds do not harm the ozone layer). ODSs are categorized into two groups, namely, the Class I ODSs, such as chlorofluorocarbons (CFCs), and Class II ODS, such as hydrochlorofluorocarbons (HCFCs). Chlorofluorocarbons (CFCs): are a group of compounds containing C, F, Cl, whereas Hydrochlorofluorocarbons (HCFCs): group of compounds containing H, C, F, Cl. Class II ODSs include Hydrofluorocarbons (HFCs): which were produced mostly in developed countries. Since they contain only, H and F, they do not harm the ozone layer, but they have been identified as GHG with a high global warming potential (GWP) as compared to CFCs and HCFCs. Halomethanes, Carbon tetrachloride (CCl4) and Hydrogen chloride (HCl) have also been classified as ODSs by the Montreal Protocol.

Uses of ODSs in everyday life

1. CFCs used as propellants in Inhalers
2. Fire extinguishers: contain haloalkanes
3. Hairsprays: originally contained CFCs, now HFCs
4. CFCs and HCFCs are used as propellants in Pest sprays
5. Foam insulation contains HCFCs.

The year 2012 marked the 25th anniversary of the signing of the Montreal Protocol. Since its inception, the world has phased-out 98% of the Ozone-Depleting Substances (ODS) contained in nearly 100 hazardous chemicals worldwide; every country is in compliance with stringent obligations; the MP has achieved the status of the first global regime with universal ratification.

Role of Information Technology in the Environment

Technological Advancements: a bane or boon?

Technology has caused many environmental and social problems, but it is also key to addressing environmental degradation, climate change, food scarcity, waste management, and other pressing global challenges. A recent rise in global concern for climate change has led to the development of new environmental technology aiming to solve some of the biggest environmental concerns that we face as a society, by transitioning towards a more sustainable, low-carbon economy. Environmental technology is also known as 'green' or 'clean' technology and refers to the development of new technologies which aim to conserve, monitor or reduce the negative impact of technology on the environment and the consumption of resources.

This section will focus on the role of information technology in improving the fields of environmental education and human health. The emerging growth of internet services and facilities, geographic information system or GIS, and the data that gets transmitted through satellites have generated a wealth of updated information on several aspects of the environment, as well as health. Let us look at some ways in which technology is helping the environment.

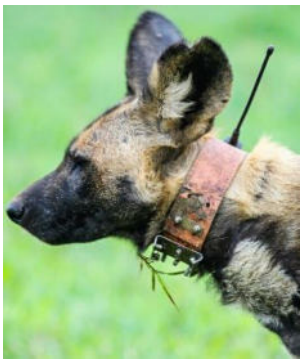
1) Advancements in Energy Efficiency

The advancement of technology has made us more energy-efficient in terms of electricity consumption. Slowly, but surely, out electrical applications have become more efficient, and these incremental changes over a period of time have a dramatic effect in the long run. For example, a modern LED light is around 60% more efficient than traditional incandescent bulbs and has a lifespan that's 50 times longer. Now, we don't need to make and constantly discard more lights. This is a huge step in reducing waste, using fewer resources and less energy; so LED bulbs are a small but important part of tackling our environmental troubles.

2) Role of Technology in Saving Wildlife

Technology is being used widely in saving wildlife. Some of the measures taken worldwide in protecting the fauna are:

1) Smart collars embedded with GPS, meters, and sensors to keep track of endangered species like rhinos and elephants.
2) Remote monitoring of wildlife sounds and noises to detect any predator harm or natural distress.
3) SIM-based collars for animals near human habitats to reduce animal-human conflicts.
4) Gene sequencing techniques to save endangered species from incurable diseases like cancer.



5) Conservation drones to track and monitor wild forest regions for any natural disasters like forest fires that can cause animals to be killed. 6) Predictive analytics for animals to gather information about every species on the planet and work comprehensively in protecting them.

3) Greener Energy Production

The process of energy production is becoming cleaner. As we learn to harness the power of the sun, wind and water, our dependence on power sources that are exhaustible and produce pollution is reduced year by year. Renewable energies made up 25% of total global energy production in 2017 and this number is predicted to be bumped up to 85% by the year 2050. Clean energy systems themselves are becoming more efficient. For example, in 1960, the maximum efficiency we could achieve from solar cells was 16%. Recently, a group of scientists in the US announced they were able to achieve 44.5% efficiency.

4) Energy-Efficient Farming

Our ways of farming are becoming less harmful to the environment as we begin to understand how our actions affect surrounding ecosystems. Genetically modified crops are able to improve yields dramatically, and as we better understand how to get the most out of our crops, we need less land to produce the same amount of food. Meat grown definitely raises a few raised eyebrows, but it is predicted to become a valuable source of cleaner, greener protein for humans. It can also be tailored to our specific nutritional needs and cut out harmful compounds.

5) Improvements in Recycling Technology

The next important contribution is the improvement in recycling technology. In the future, humans may be able to create a 100% closed loop system by recycling the majority of the materials we use. This would be one of the most significant advancements for the planet as the lifecycle of something as simple as a water bottle can lead to resource depletion, industrial waste, air and water pollution, habitat erosion, animal extinction and more.

6) Cleaner Technologies that Prevent Pollution

Advancements in technology have helped prevent an incredible amount of harm to our planet towards the end of the last century. For example, inventions such as the catalytic converter, found in most cars, have prevented billions of tons of toxic pollutants from entering the atmosphere. Similar industrial systems, such as filters and other converters, have also helped reduce pollutants. Shifting towards electric vehicles will also remove a huge percentage of greenhouse gas emissions.

As people have greater access to information, more people can realize their impact and find ways to combat it. For example, the hole created by CFCs in the ozone was only discovered due to the

invention of the Dobson Ozone Spectrophotometer, which allowed us to understand the full extent of damage these gases were having. Artificial intelligence (AI) is another advancement that could transform our perspective of the environment. It could help us to better understand the long-term effects of our actions through simulations and predictions.

Apart from the obvious advancements in technology that have led to the betterment of the environment, there exist databases and certain other management systems that assimilate information on the various aspects of the environment.

7) Databases on the Environment

So, what are Databases on the environment: Database is a collection of connected data on certain subjects. It comes in a computerized form, and can be retrieved at any hour of the day, whenever necessary. Some of the available databases include

- Wildlife databases,
- Forest cover database, and
- Conservation database, etc. They are also available on
- Diseases including malaria, fluorosis, HIV/AIDS, etc.

Some of the commonly used databases include

1. National management information system (NMIS).
2. Environmental information system (ENVIS).
3. Remote sensing and geographical information system (GIS), and last and not the least,
4. The World Wide Web (WWW).

National Management Information System (NMIS)

NMIS is a division under the Department of Science and Technology (DST, India) that is responsible for the collection, collation, analysis and dissemination of information on resources devoted to science & technology activities in the country. NMIS maintains a close collaboration with UNESCO, NSF, OECD, etc. for matters relating to S&T statistics and indicators. The next database is the

Environment Information System (ENVIS)

ENVIS is a one stop, web-enabled, comprehensive portal which provides information on the environment and related subject areas to researchers, academicians, policy planners, environmentalists, scientists, engineers and the general public. It is a decentralized network of databases in operation since 1982 and is run by the Ministry of Environment Forests and Climate Change. ENVIS serves as the backbone of decision making and environment management at all levels of Government and it has been making valuable contribution in environmental protection and its improvement. Some of the information available in ENVIS include topics such as:

1. Pollution control
2. Clean technologies
3. Remote sensing
4. Coastal ecology
5. Biodiversity
6. Western and eastern Ghats

7. Environmental management
8. Media related to environment, renewable energy, desertification, mangroves, wildlife, Himalayan ecology, mining, etc.

The most important benefit of technology in the environment is probably remote sensing and GIS or geographic information systems.

Geographical information system (GIS)

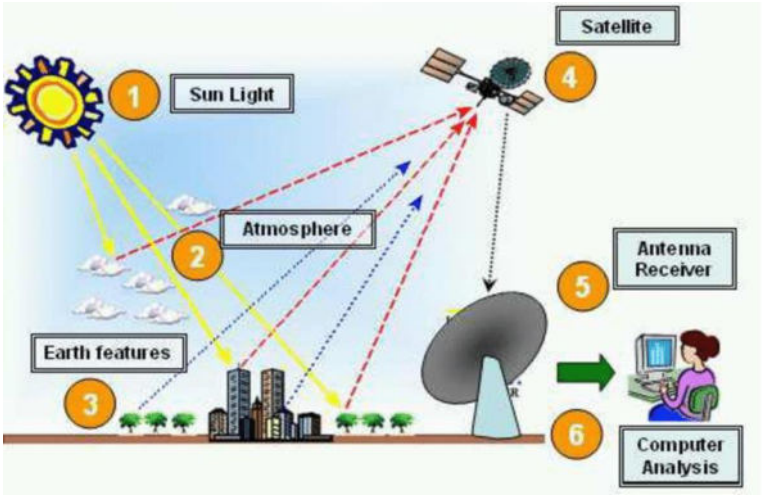
GIS is a computer-based tool for mapping and analyzing feature events on earth and is integrated with maps. Any location on the earth has massive amounts of data, including physical features, but political, economic and social data, as well. GIS facilitates the process by which we can visualize, analyze and understand this data. GIS is an effective tool for

a) Studying the environment
b) Reporting on environmental phenomena
c) Modeling how the environment responds to natural and man-made factors

GIS can be also be used to visualize data about natural resources, hazards, pollution emissions, health of ecosystems, climate change and so on. It is also very effective tool to analyze ecological footprints; improve watershed resource management; and respond to climate change, pollution, and much more. Now, let us look at remote sensing.

Remote Sensing

Remote sensing is one of the methods commonly used for collecting physical data to be integrated into GIS. Remote sensors collect data from objects on the earth without any direct contact. They do this by detecting energy reflected from the earth; these detectors are typically mounted on satellites or aircraft. Remote sensing technology has become much more prevalent, accurate and accessible in the recent years, and covers a wide range of engineering applications. For example, Satellite imageries provide us with real-time information about various physical and biological resources, water logging, desertification, deforestation, urban sprawl, river and canal network, mineral and energy reserves and so on. Digital information on a number of aspects like water resources, industrial growth, human settlements, road network, soil type, forest land, crop land or grassland can be accessed and analyzed. Data on monsoons, ozone layer depletion, smog can help in taking steps to deal with these issues effectively. Several softwares are also available that help along in this quest for the improvement of the environment.



Satellite Imaging

Anyone with an internet connection can now use Google Earth software to monitor or support scientific research on almost any place on the earth's surface. High-resolution satellite imagery is used to produce images using this software. Several ocean monitoring satellites have also been launched recently, which provide additional information required on various data such as a) Surface winds, ocean surface strata, b) Chlorophyll concentrations in ocean waters, c) Monitoring phytoplankton blooms, d) Atmospheric aerosols and suspended sediments in water. Several projects have been launched by the government of India, for the betterment of human health with the aid of technology. Health SAT is one such initiative by ISRO (Indian Space Research Organization).

HealthSAT

HealthSAT is a telemedicine system, housed in a small health centre. It consisting of a PC with customized medical software connected to a few medical diagnostic instruments, such as an ECG or X-ray scanner for scanning X-ray photos. Digitized versions of patients' medical images and diagnostic details (such as X-ray and blood reports) are dispatched to specialist doctors through the satellite-based communication link. The information, is in turn, received at the specialist centre where experienced doctors examine these reports, diagnose, interact with the patients (along with local doctors), and suggest appropriate treatment through video-conferencing.

Kiosk

The Information Kiosk, on the other hand, is an IT based facility available in rural areas. It provides information on groundwater use and cropping system changes. This technology can also be made use of in the conservation of wildlife and for the protection of endangered species. The Kiosk software is a touch screen driven setup with (no physical keyboard) with large icons displaying limited but focused data supported by graphics and animation. Local language is for ease of understanding, though it can be accessed in multiple languages, with simple and clear navigational paths.

Software Monitoring of Wildlife

In a bid to save the endangered big cats or tigers, the Centre has introduced M-Stripes, a software monitoring system to strengthen effectiveness of surveillance and anti-poaching measures in all the 39 tiger reserves across the country. This program has been reported to have achieved tremendous success and has witnessed a decline in poaching of these big cats.