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Natural Resources and Their Management

LAND RESOURCES: LAND RESOURCE AND LAND USE CHANGE, LAND DEGRADATION, MAN- INDUCED LANDSLIDES, SOIL EROSION AND DESERTIFICATION

Resource

A Resource is a source of supply, support, or aid, especially one that can be readily drawn upon when needed. Usually these are materials, energy, services, knowledge or other assets etc. from which benefits are drawn. Resources are classified in various ways such as biotic and abiotic, renewable and non-renewable etc.

Land Resource

Land is an important resource which is basic for sustenance of life. A detailed definition of land resource is given by FAO/UNEP (1997) who defined land and land resources as an area of the Earth's terrestrial surface, encompassing all attributes of the biosphere immediately above or below this surface, including those of the near-surface climate, the soil and terrain forms, the surface hydrology (including shallow lakes, rivers, marshes, and swamps), the near-surface sedimentary layers and associated groundwater and geohydrological reserve, the plant and animal populations, the human settlement pattern and physical results of past and present human activity (terracing, water storage or drainage structures, roads, buildings, etc.).
According to the FAO and UNEP (1999), the basic functions of land in supporting human and other terrestrial ecosystems can be summarized as follows:

a. Land is a store of wealth for individuals, groups, or a community.
b. Land provides food, fibre, fuel, or other biotic materials for human use.
c. Land provides habitats for plants, animals, and microorganisms.
d. Land is a co determinant in global energy balance and the global hydrological cycle, which is both a source and a sink for greenhouse gases.
e. Land plays an important role in regulation of the storage and flow of surface water and groundwater.
f. Land is a storehouse of minerals and raw materials for human use.
g. Land is a buffer, filter, or modifier for chemical pollutants.
h. Land provides physical space for settlements, industry, and recreation.
i. Land holds and protects evidence from the historical or prehistorical record (fossils, evidence of past climate, archaeological remains, etc.).
j. Land is a significant factor in distribution by enabling or hindering the movement of animals, plants, and people from one area to another.

Land Use Change:

Landuse is the function of land i.e. what it is used for. Land use is determined by physical factors such as topography, climate, soil type and human factors as well i.e. population density, technological capability, culture and traditions etc. In rural areas, land use can include forestry and farming. In urban areas, land use could be housing or industry. Broadly speaking, Land use is the functions that humans apply to the land available to them.

There are many types of land use:

a. Agricultural i.e. farmland.
b. Residential i.e. housing.
c. Commercial i.e. shopping centers, business houses, factories etc.
d. Recreational i.e. amusement parks etc.
e. Transport i.e. roads, railways, and airports.

Land Use in India: Details of various types of land uses in india as per land Use Statistics data of 2012-13 is given below:

- Forest Area: 70 mha (21.30%)
- Non-Agricultural uses: 26.5 mha (8.05%)
- Barren and uncultivable: 17.3 mha (5.26%)
- Culturable Waste: 12.6 mha (3.83%)
- Permanent pastures: 10.2 mha (3.12%)
- Miscellaneous tree crops: 3.2 mha (0.96%)
- Fallow land: 26.3 mha (8%)
- Agricultural land: 181.95 mha (55.3%)
- Net Sown Area: 139.9 mha (42.57%)

Source: Land Use Statistics (2012-13), Ministry of Agriculture & Family Welfare

Land Use Change is the change or variation in the use of the land e.g. forests clearance, coming up of cities, converting agricultural land into residential areas. i.e. putting land into a new use. Over period of time there has been shifting in land use pattern across the world. In india also there has been change in land use.

Table 3.1: Land Use Pattern in India in 1950-51 and 2006-07

Land Use Pattern in India in 1950-51 and 2006-07 (Percentage of land area calculated from Total reported land area under use i.e. 304 mhac)		
Land use	**1950-51**	**2006-7**
Net sown area	43.77	48
Not available for cultivation	14.92	13.5
Forests	14.23	19
Fallow land	9.89	6
Other Uncultivated land	17.39	9.5

LAND DEGRADATION

Land degradation is the process of deterioration in the characteristic and quality of soil which adversely affects its fertility or its optimum use.

In Broader terms, Land degradation means:

- Loss of natural fertility of soil because of loss of nutrients.
- Changes in the characteristic of soil.
- Soil texture and structure are deteriorated.
- Loss of soil fertility due to loss of valuable nutrients.
- Increase in water logging, salinity, alkalinity and acidity problems
- Loss at a social, economic and biodiversity level

Causes of Land Degradation:

(a)**Deforestation:** Deforestation is taking place at a faster rate due to increasing demands of timber, fuel and forest products which results into degradation of land resources and water resources as well.

(b) **Overgrazing:** Overgrazing refers to excessive eating of grasses and other green plants by cattle. It results into reduced growth of vegetation, reduced diversity of plant species, excessive growth of unwanted plant species, soil erosion, and degradation of land due to cattle movement.

(c) **Intensive and wrong Agricultural practices**: The modern agricultural practices, excessive use of fertilizers and pesticides have adversely degraded the natural quality and fertility of the cultivation land. Over irrigation may lead to problem of water logging and salinity.

(d) **Industrialization and Pollution:** Development of industries for the unsustainable economic growth of the country leads to excessive deforestation and utilization of land in such as way that it has lost its natural up gradation quality. Water-logging, soil erosion, salinity and contamination of the soil with industrial waste cause land degradation.

(e) **Urbanization:** Increasing growth of population and demand for more residential areas and commercial sectors is also one of the reasons for land degradation. Lack of proper sanitation amd waste management also leads to land degradation.

Prevention and Control Measures for Land Degradation: Following are some practices for controlling land degradation:

1. Degradation of top soil and erosion can be controlled by the following:

   a) Strip farming: It is & practice in which cultivated crops are sown in alternative strips to prevent water movement.
   b) Crop Rotation: It is one of the agricultural practice in which different crops are grown in same area following a rotation system which helps in replenishment of the soil.
   c) Ridge and Furrow Formation: Soil erosion is one of the factors responsible for lad degradation. It can be prevented by formation of ridge and furrow during irrigation which lessens run off.
   d) Construction of Dams: This usually checks or reduces the velocity of run off so that soil support vegetation.
   e) Contour Farming: This type of farming is usually practiced across the hill side and is useful in collecting and diverting the run off to avoid erosion.

2. Good agricultural practices involving minimal and need based use of chemical inputs and organic methods.

3. Proper management of wastes both solid and liquid, from industrial as well as domestic areas.

4. Proper land use planning and management.

MAN INDUCED LANDSLIDES

Landslides are the downward movement of a slope composed of earth materials such as rock, soil or artificial fills. Landslides are also called rock-slide, debris-slide, mud-slide, slump, earth-flow or soil-creep. These occur when soil or rock can no longer hold itself. When they are caused or accelerated due to human activities, they are termed as Man induced landslides.

During construction of roads and mining activities huge portions of mountainous fragile areas are cut down and thrown into adjacent areas and streams. These land masses weaken the already fragile mountain slopes leading to man-induced landslides.

Causes of landslides

1. Removal of vegetation - Deforestation in slopes creates soil erosion leading to landslides
2. Underground mining activities cause subsidence of the ground.
3. Movement of heavy vehicles in areas with unstable slopes causes landslides.
4. Construction activities such as road construction and widening, tunneling etc, involving blasting etc and addition of weight by construction on slopes causes landslides.
5. Over exploitation of groundwater also leads to landslides.

Effects of landslides

1. Landslides increase the turbidity of nearby streams, thereby reducing their productivity
2. Destruction of communicative links.
3. Loss of habitat and biodiversity
4. Loss of life, infrastructure and economic loss.

5. Changes in natural landscapes.

Prevention of man induced landslides:

1. Preventing soil erosion as much as possible by different means.
2. Protection slopes with vegetation crops and planting small shrubs.
3. Constructing different kinds of retaining walls depending on the geology of the area.
4. Grading of the slope i.e. reducing the gradient of the slope by increasing the base size where possible.

Land Slides Prone Himalayas in India: India has the highest mountain chain on earth, the Himalayas, which are formed due to collision of Indian and Eurasian plate, the northward movement of the Indian plate towards China causes continuous stress on the rocks rendering them friable, weak and prone to landslides and earthquakes. The slow motion of the Indian crust, about 5 cm/year accumulates stress to which natural disasters are attributed. Some landslides make unique, and unparalleled catastrophes. Landslides and avalanches are among the major hydro-geological hazards that affect large parts of India besides the Himalayas, the North-eastern hill ranges, the Western Ghats, the Nilgiris, the Eastern Ghats and the Vindhyas, in that order, covering about 15 % of the landmass. The Himalayas alone count for landslides of every fame, name and description- big and small, quick and creeping, ancient and new. The Northeastern region is badly affected by landslide problems of a bewildering variety. Landslides in the Darjeeling district of West Bengal as also those in Sikkim, Mizoram, Tripura, Meghalaya, Assam, Nagaland and Arunachal Pradesh pose chronic problems, causing recurring economic losses worth billions of rupees. A different variety of landslides, characterized by a lateritic cap, pose constant threat to the Western Ghats in the South, along the steep slopes overlooking the Konkan coast besides Nilgiris, which is highly landslide prone.

Fig. The Photograph of Okhimath landslide which formed a lake in Madhyamaheshwerganga, Rudraprayag district.

Some spectacular events of tragedies are reported as Varnavat landslide, Uttarkashi District, Malpha landslide Pithoragarh district, Okhimath landslide in Chamoli district, UK and Paglajhora in Darjeeling district as well as Sikkim, Aizawl sports complex, Mizoram.These are some of the more recent examples of landslides. The problem therefore needs to be tackled for mitigation and management for which hazard

zones have to be identified and specific slides to be stabilized and managed in addition to monitoring and early warning systems to be placed at selected sites.

SOIL EROSION

Soil erosion is a form of soil degradation. It is shifting of top layer of soil from one place to another. Soil erosion is a naturally occurring process on all land. The agents of soil erosion are water and wind, each contributing a significant amount of soil loss each year. Soil erosion may be a slow process that continues relatively unnoticed, or it may occur at an alarming rate causing serious loss of topsoil. The loss of soil from farmland may be reflected in reduced crop production potential, lower surface water quality and damaged drainage networks.

One of the major concerns regarding soil erosion is that it can permanently affect the land, which can be devastating for farmers or those with agricultural pursuits.

TYPES OF SOIL EROSION

1. **Normal erosion:** This is caused by the gradual removal of topsoil by natural processes. The rate of erosion is slow.
2. **Accelerated erosion:** This is caused by manmade activities. In this case, the rate of erosion is much faster than the rate of formation of soil.

Agents of Soil Erosion

1. **Water**: Water affects soil erosion in the form of rain, run-off, rapid flow or wave action. (In the form of Sheet erosion, Rill erosion, Gully erosion, Riparian erosion etc.)
2. **Wind**: Wind is an important climate agent that carries away the fine particles of soil thereby contributing to soil erosion. (e.g. saltation, suspension, surface creep)
3. **Biotic agents**: Overgrazing and human activities such as deforestation, construction etc. are the major biotic agents.

General Causes of Soil Erosion:

1. **Rain and rainwater runoff:** In a particular heavy rain, soil erosion is common. First of all, the water starts to break down the soil, dispersing the materials it is made of. Typically, rainwater runoff will impact lighter materials like silt, organic matter, and finer sand particles, but in heavy rainfall, this can also include the larger material components as well.
2. **Farming:** When land is worked through crops or other agricultural processes, it reduces the overall structure of the soil, in addition to reducing the levels of organic matter, making it more susceptible to the effects of rain and water. Tilling in particular, because it often breaks up and softens the structure of soil, can be a major contributor to erosion. Farming practices that reduce this activity tend to have far less issues with soil erosion.
3. **Slope of the land:** The physical characteristics of the land can also contribute to soil erosion. For example, land with a high hill slope will perpetuate the process of rainwater or runoff saturation in the area, particularly due to the faster movement of the water down a slope.
4. **Lack of vegetation:** Plants and crops help maintain the structure of soils, reducing the amount of soil erosion. Areas with less naturally-occurring flora may be a hint that the soil is prone to erosion.
5. **Wind:** Wind can be a major factor in reducing soil quality and promotion erosion, particularly if the soil's structure has already been loosened up. However, lighter winds will typically not cause

too much damage, if any. The most susceptible soil to this type of erosion is sandy or lighter soil that can easily be transported through the air.

Effects of Soil Erosion

1. **Loss of topsoil:** Obviously, this is the biggest effect of soil erosion. Because topsoil is so fertile, if it is removed, this can cause serious harm to farmer's crops or the ability to effectively work their land.
2. **Soil compaction:** When soil under the topsoil becomes compacted and stiff, it reduces the ability for water to infiltrate these deeper levels, keeping runoff at greater levels, which increases the risk of more serious erosion.
3. **Reduced organic and fertile matter:** As mentioned, removing topsoil that is heavy with organic matter will reduce the ability for the land to regenerate new flora or crops. When new crops or plants can't be placed successfully in the area, this perpetuates a cycle of reduced levels of organic nutrients.
4. **Poor drainage:** Sometimes too much compaction with sand can lead to an effective crust that seals in the surface layer, making it even harder for water to pass through to deeper layers. In some ways, this can help erosion because of the densely packed soil, but if it perpetuates greater levels of runoff from rainwater or flooding, it can negatively impact the crucial topsoil.
5. **Issues with plant reproduction:** When soil is eroded in an active cropland, wind in particular makes lighter soil properties such as new seeds and seedlings to be buried or destroyed. This, in turn, impacts future crop production.
6. **Soil acidity levels:** When the structure of the soil becomes compromised, and organic matter is greatly reduced, there is a higher chance of increased soil acidity, which will significantly impact the ability for plants and crops to grow.
7. **Long term erosion:** Unfortunately, if an area is prone to erosion or has a history of it, it becomes even harder to protect it in the future. The process has already reduced the soil structure and organic matter of the area, meaning that it will be harder to recover in the long run.
8. **Water pollution:** A major problem with runoff from soils – particularly those used for agricultural processes – is that there is a greater likelihood that sediment and contamination like the use of fertilizer or pesticide. This can have significant damage on fish and water quality.

Prevention of Soil Erosion

1. **Conservational till farming or no-till farming**: Traditionally, land is ploughed to make a planting surface. This disturbs the soil and makes it susceptible to erosion. The no-till farming method makes minimum disturbance to the top soil by making slits in the unploughed soil. Seeds, fertilizers and water are injected in these slits.
2. **Contour farming**: In this method, crops are planted in rows along contours of gently sloped land. Each row acts as a small dam to hold soil thereby slowing water runoff.
3. **Terracing**: In this method, steep slopes are converted into a series of broad terraces that run across the contour. This retains water for crops and reduces soil erosion by controlling runoff.
4. **Alley cropping or Agro forestry**: This method involves planting crops in strips or alleys between rows of trees or shrubs that provide fruits and fuel wood. Hence, when the crop is harvested, the soil will not be eroded as the trees and shrubs remain on ground holding the soil particles.

5. **Wind breaks or shelter belts**: In this technique, trees are planted in long rows along the boundary of cultivated land which block the wind and reduce soil erosion. Wind breaks help in retaining soil moisture, supply wood for fuel and provide habitat for birds.

DESERTIFICATION

Desertification is defined as a process of land degradation in arid, semi-arid and sub-humid areas typically losing its bodies of water as well as vegetation and wildlife. due to various factors including climatic variations and human activities. Desertification is a significant global ecological and environmental problem. Almost 80% of the productive land in the arid and semi-arid regions is converted into desert. Approximately 600 million people are threatened by desertification.

Causes of Desertification

1. **Overgrazing:** Animal grazing is a huge problem for many areas that are starting to become desert biomes. If there are too many animals that are overgrazing in certain spots, it makes it difficult for the plants to grow back, which hurts the biome and makes it lose its former green glory.
2. **Deforestation:** When people are looking to move into an area, or they need trees in order to make houses and do other tasks, then they are contributing to the problems related to desertification. Without the plants (especially the trees) around, the rest of the biome cannot thrive.
3. **Farming Practices:** Some farmers do not know how to use the land effectively. They may essentially strip the land of everything that it has before moving on to another plot of land. By stripping the soil of its nutrients, desertification becomes more and more of a reality for the area that is being used for farming.
4. **Urbanization and other types of land development.** As mentioned above, development can cause people to go through and kill the plant life. It can also cause issues with the soil due to chemicals and other things that may harm the ground. As areas become more urbanized, there are less places for plants to grow, thus causing desertification.
5. **Climate Change:** Climate change plays a huge role in desertification. As the days get warmer and periods of drought become more frequent, desertification becomes more and more eminent. Unless climate change is slowed down, huge areas of land will become desert; some of those areas may even become uninhabitable as time goes on.
6. **Stripping the land of resources.** If an area of land has natural resources like natural gas, oil, or minerals, people will come in and mine it or take it out. This usually strips the soil of nutrients, which in turn kills the plant life, which in turn starts the process toward becoming a desert biome as time goes on.
7. **Natural Disasters:** There are some cases where the land gets damaged because of natural disasters, including drought. In those cases, there isn't a lot that people can do except work to try and help rehabilitate the land after it has already been damaged by nature.

Effects of Desertification

1. **Farming becomes next to impossible.** If an area becomes a desert, then it's almost impossible to grow substantial crops there without special technologies. This can cost a lot of money to try and do, so many farmers will have to sell their land and leave the desert areas.
2. **Hunger:** Without farms in these areas, the food that those farms produce will become much scarcer, and the people who live in those local areas will be a lot more likely to try and deal with hunger problems. Animals will also go hungry, which will cause even more of a food shortage.
3. **Flooding:** Without the plant life in an area, flooding is a lot more eminent. Not all deserts are dry; those that are wet could experience a lot of flooding because there is nothing to stop the water from gathering and going all over the place. Flooding can also negatively affect the water supply, which we will discuss next.
4. **Poor Water Quality:** If an area becomes a desert, the water quality is going to become a lot worse than it would have been otherwise. This is because the plant life plays a significant role in keeping the water clean and clear; without its presence, it becomes a lot more difficult for you to be able to do that.
5. **Overpopulation:** When areas start to become desert, animals and people will go to other areas where they can actually thrive. This causes crowding and overpopulation, which will, in the long run, end up continuing the cycle of desertification that started this whole thing anyway.
6. **Poverty:** All of the issues that we've talked about above (related to the problem of desertification) can lead to poverty if it is not kept in check. Without food and water, it becomes harder for people to thrive, and they take a lot of time to try and get the things that they need.

Prevention of Desertification

1. **Policy Changes Related to Farming**: How often people can farm and how much they can farm on certain areas could be put into place to help reduce the problems that are often associated with farming and desertification.
2. **Policy Changes to Other Types of Land Use:** If people are using land to get natural resources or they are developing it for people to live on, then the policies that govern them should be ones that will help the land to thrive instead of allowing them to harm the land further. The policy changes could be sweeping or they could be depending on the type of land use at hand.
3. **Education: E**ducation is an important tool that needs to be utilized in order to help people to understand the best way to use the land By educating them on sustainable practices, more land will be saved from becoming desert.
4. **Technology Advances.** In some cases, it's difficult to try and prevent desertification from happening. In those cases, there needs to be research and advancements in technology that could help us find more ways to prevent the issue from becoming epidemic.
5. **Putting Together Rehabilitation Efforts**. There are some ways that we can go back and rehabilitate the land that we've already pushed into desertification. That way we can also prevent the issue from becoming even more widespread in the areas that have already been affected.
6. **Sustainable practices**: There are plenty of sustainable practices that can be applied to those acts that may be causing desertification. By following these practices we can prevent desertification spreading further.

FOREST RESOURCES: USES OF FORESTS, CAUSES OF OVER-EXPLOITATION, CAUSES AND IMPACTS DUE TO MINING, DAM BUILDING ON ENVIRONMENT, FORESTS, BIODIVERSITY AND TRIBAL POPULATIONS

Forest Resources

The word 'forest' is derived from the Latin word 'Foris' means 'Outside' (may be the reference was to a village boundary or fence separating the village and the forest land). Forests are one of important natural resources on earth. A forest is a natural, self-sustaining biotic community predominantly of trees, shrubs and other woody vegetation, usually with a closed canopy. The difference between forests and woodlands is that whereas in a forest the crowns of individual trees touch to form a single canopy, in woodland, trees stow far apart, so that the canopy is open.

World forest cover as per Forest Resource Assessment 2010 is 31% of the earth's land surface. The World Resources Institute regards deforestation as one of the world's most pressing land-use problems.

According to India's State of Forest Report 2017, total forests cover of India is 7,08,273 sq. km, which is 21.54 percent of the total geographic area against the required coverage of 33 percent. Forest cover combined with tree cover is 24.39% of the total geographic area, even though it accounts for 2.4% of the world surface area it sustains the needs of 17% of human and 18% of livestock population.

Uses of forests:

Forests are of significant importance to humans and the ecological balance. For humans, they have many economic, cultural, historical, aesthetic, recreational and religious values.

This invaluable natural resource is beneficial to man in many ways.

1. **Local Consumptive use:** Local consumptive use of forests include:
   a. **Food:** Fruits, leaves, roots, mushrooms and tubers of plants and meat of forest animals form the food of forest tribes and others in the vicinity.
   b. **Fodder for livestock.**
   c. **Fuel Wood:** used as a source of energy for cooking purpose and for keeping warm.
   d. **Timber:** forests provides us timber used for making furniture, tool-handles etc
   e. **Bamboos and Fiber:** used for making houses, matting, flooring, baskets, ropes, rafts, cots etc.
   f. **Medicinal uses:** traditionally used for treating common diseases

2. **Productive Use**: It is also called as Market Use and include:
   a. **Timber:** Wood used for commercial purposes such as making furniture, bridges, etc.
   b. **Forest Products**: Fruits, spices, waxes, honey etc.
   c. **Paper:** Wood and Bamboo pulp are used for manufacturing paper (News-print, stationery, packing paper, sanitary paper)
   d. **Rayon:** Bamboo and wood are used in the manufacture of rayon (yarns, artificial silk-fibers).
   e. **Raw material for other industries** such as sport goods, railway sleepers, match boxes, tannins, gums, drugs, insecticides etc.

3. **Ecosystem services:**

a. **Habitat to Wildlife:** Mosses, ferns, insects, birds, reptiles, mammals and micro-organisms are provided shelter by forests.
b. **Conservation of Soil:** Forests prevent soil erosion by binding the soil with the network of roots of the different plants and reduce the velocity of wind and rain, which are the chief agents causing erosion.
c. **Soil-improvement:** The fertility of the soil increases due to the humus which is formed by the decay of forest litter.
d. **Reduction of atmospheric pollution and global warming:** Forests acts as natural absorbers of atmospheric pollutants, radiations, noise etc. By using up carbon dioxide and giving off oxygen during the process of photosynthesis, forests acts as sink for Co_2 and reduce global warming.
e. **Regulation of hydrological cycle/climate:** Transpiration of plants increases the atmospheric humidity which affects rainfall and cools the atmosphere.
f. **Regulation of water flow/water shed:** In the forests, the thick layer of humus acts like a big sponge and soaks rain water preventing run-off, thereby preventing flash-floods. Humus prevents quick evaporation of water, thereby ensuring a perennial supply of water to streams, springs and wells.

3. **Other Uses**: Forests are the treasure for research, education apart from their aesthetic, recreational and cultural values.

Overexploitation of Forests

Human are indisputably a part of most forests. With the exception of extremely inaccessible forestlands, all forests present on Earth today have been influenced by human being for tens of thousands of years. In many cases, forest communities have never been without the influence of human activities.

At the beginning of 20^{th} century about 30% of land in India was covered with forests but by the end of 20^{th} century, the forest cover was reduced to about 20%. Same goes true for the forests of the world due to overexploitation of forest resources. Excessive harvesting of forest resources affects the environment of the forest, which leads to the changes in climate, or other elements of the environment. Rapid increase in the deforestation and fossil fuel combustion has been considered to affect largely the forest resources. The major issues of global warming, acid rains and other forms of atmospheric pollution have become the target problems of the global level for it mere survival of the living beings.

Causes of over exploitation of forests:

1. Growing demand of Timber due to Population Explosion:

Major forest products consist of timber small wood and fuel wood. Indian forests produce about 5,000 species of wood, of which about 450 are commercially valuable. Hard woods include important species such as teak, ironwood, mahogany etc. These woods are used for constructional purposes.

Population explosion had its tremendous pressure on demand for timber and other wood. Consumption of wood for industrial uses is growing day by day.

2. **Raw materials for wood based industries:** Forest wealth suffers loss to meet the demand of raw materials for various industries such as paper and pulp, railway sleepers, match boxes, gums, resins, pharmaceuticals and many more.
3. **Increasing demand for firewood:** Pressure on forests is also increasing due to increasing demand for firewood especially local demand.

3. Deforestation to reclaim forest land fr infrastructural development : Large scale felling of trees and clearing of forest areas is called as Deforestation. Man has mercilessly cleared large areas of forests to reclaim land for housing, agriculture, factories, roads and rail tracks.

4. **Mining and Quarrying:** Large scale mining and quarrying activities in forest areas have taken a toll on the forest resources and ecology.

5. Overgrazing: Grazing animals first eat or trample the young plants, then destroy the leaves on the lower branches of tall trees, and finally damage their trunks and roots. It also results in soil erosion and may ultimately lead to desertification.

6. Dams.: Barriers constructed across the streams to form water reservoirs for generating power or preventing floods submerge and kill large tracts of forests.

7. Jhum / Shifting Cultivation: it is a traditional agro forestry system prevalent in certain parts of India, particularly North East India, in which there is felling and burning of forests followed by cultivation of crops for few years on the cleared land. Over period of time after using resources from the adjoining forest area also, same process is shifted to some other forest patch. Jhum cultivation has been responsible for destruction of huge forest area.

Apart from above mentioned causes forest are being subjected to damage due to:

a. **Fires:** Fire is the worst enemy of the forests. It destroys the full-grown trees, young trees of future forests, seeds and even humus. Animal life is also lost and there is a danger to human life too in a forest fire.

b. **Pests:** Many kinds of insects are forest pests destroy trees by eating up leaves, boring into shoots and spreading diseases. It is difficult to spray on extensive forest, but biological control is possible.

c. **Natural causes:** floods, storms, heavy snow, wind and lightening are some of the natural forces responsible for destroying forests.

Overexploitation of forest resources and large scale deforestation has many adverse effects. Some of the **effects of deforestation** are:

- Soil erosion and loss of fertile soil.
- Less Rainfall.
- Desertification.
- Disruption of carbon balance ie Global warming
- Loss of habitat for wild life
- Loss of biodiversity.
- Lowering of water table.
- Economic loss.
- Loss of Watershed areas
- Climatic Changes etc.

Impact of Mining on Environment, Forests, Biodiversity and Tribal Populations:

Mining: Mining is the extraction of valuable minerals or other geological materials from the earth, usually from an ore body, vein or (coal) seam. Materials recovered by mining include base metals, precious metals, iron, uranium, coal, diamonds, limestone, oil shale, rock salt and potash. Any material that cannot be grown through agricultural processes or created artificially in a laboratory or factory, is usually mined. Mining in a wider sense comprises extraction of any non-renewable resource e.g., petroleum, natural gas, or even

water. Minerals are the natural resources which play an important role in the economic development of the country.

Area Under Mining: It is pertinent to note that out of the total land area of the country (3.29 million sq. kms.), the area leased out of mining, as on 1.9.94, was 7126.13 sq. kms. Comprising about 9,213 mining leases excluding atomic minerals, minor minerals, petroleum and natural gas this constitutes only about 0.25 per cent of the geographic area of the country and that including atomic minerals and minor minerals it may be around 0.28 per cent of the total area. Although the area occupied for mining activity is small yet the damage to the environment on account of mining is causing grave concern.

Impacts of Mining: Mining from shallow deposits is done by surface mining while that from deep deposits is done by sub-surface mining. It leads to degradation of lands and loss of top soil. It is estimated that about eighty thousands hectare land is under stress of mining activities in India. Mining activities has badly affected the biodiversity, like soil cover, animals, birds, plant species etc. Unsustainable mining of natural resources have been a key factor for degradation of biodiversity. Vegetation in the forest areas have been under constant threat because of the unsustainable exploitation of the minerals.

Impacts of mining can be discussed as follows:

1. **Air pollution:** Pollution with dust and gases due to drilling, blasting, mine haulage and transportation by road, and also from waste heaps. It leads to the emission of dust, suspended particle and gases causing air pollution which may retard the growth of some of the plant species in surrounding areas and fauna dependent on these plants.

2. **Surface Water Pollution:** Release of harmful trace element e.g., CO, Pb, Cd etc. leads to the contamination of surface water. Sub-surface mining often progresses below the water table, so water must be constantly pumped out of the mine in order to prevent flooding. When a mine is abandoned, the pumping ceases, and water floods the mine. This introduction of water is the initial step in most acid rock drainage situations.

   Acid rock drainage occurs naturally within some environments as part of the rock weathering process but is exacerbated by large-scale earth disturbances characteristic of mining and other large construction activities, usually within rocks containing an abundance of sulfide minerals. Areas where the earth has been disturbed (e.g. construction sites, subdivisions, and transportation corridors) may create acid rock drainage. In many localities, the liquid that drains from coal stocks, coal handling facilities, coal washeries, and coal waste tips can be highly acidic, and in such cases it is treated as acid mine drainage (AMD).

   Biomagnification plays an important role in polluted habitats and even concentration levels of contaminant that are not high enough to directly kill exposed organisms, may have greater impact on the species on top of the food chain because of this phenomenon.

3. **Ground Water Pollution:** Underground water is also contaminated due to seepage and infiltration of leached drainage. Also modifies water regimes such as surface flow, groundwater availability and lowering down of water table. Mining can have adverse effects on surrounding surface and groundwater if protective measures are not taken. The result can be unnaturally high concentrations of some chemicals, such as arsenic, sulfuric acid, and mercury over a significant area of surface or subsurface. Runoff of mere soil or rock debris -although non-toxic- also devastates the surrounding vegetation.

4. **Land Pollution:** Mining leads to the degradation of soil quality, fertility, soil modification with dust, salts and other toxic elements. Also results in soil erosion and alteration of landforms. Soils' texture and water content can be greatly modified in mine areas, leading to plants communities

changes in the area. Most of the plants have a low concentration tolerance for metals in the soil, but sensitivity differs among species. Grass diversity and total cover is less affected by high contaminant concentration than forbs and shrubs. Animals can be poisoned directly by mine products and residuals. Bioaccumulation in the plants or the smaller organisms they eat can also lead to poisoning: horses, goats and sheep are exposed in certain areas to potentially toxic concentration of copper and lead in grass

5. **Noise pollution:** Drilling, blasting, crushing units and transportation of minerals adds to noise pollution and vibration problem in the mine and adjoining areas. Noise and vibrations due to blasting, operation of the machines and transportation have driven away small animals including wild animals and birds from nearby forests

7. **Deforestation:** The major consequence of mining is the deforestation which results in loss of flora and fauna. Removal of vegetation has created pressure on fauna to leave the area required for mining and other purposes. With open cast mining the overburden, which may be covered in forest, must be removed before the mining can commence. Although the deforestation due to mining may be small compared to the total amount it may lead to species extinction if there is a high level of local endemism.

8. **Loss of habitat:** Clearing of forest area results in loss of habitat, which is primary reason for loss of biodiversity. Endemic species are especially sensitive, since they need very specific environmental conditions. Destruction or slight modification of their habitat puts them at the risk of extinction. Habitats can be damaged when there is not enough terrestrial product as well as by non-chemicals products, such as large rocks from the mines that are discarded in the surrounding landscape with no concern for impacts on natural habitat.

9. **Subsidence:** Sand mining and gravel mining creates large pits and fissures in the earth's surface. At times, mining also extend so deeply that it affects ground water, springs, underground wells, and the water table. This may lead to the process of land subsidence.

10. **Loss of Aesthetic value:** Mining activity results in **s**poiling aesthetics of the area with untreated waste dumps. It directly results in loss of landscape and beauty of the surroundings.

11. **Ecological Imbalance:** All the environmental effects of mining discussed above directly affect the ecosystem and its stability as many species are killed due to toxicity of water and soil and loss of habitat.

12. **Loss of Land:** Mining results in wastage of land as it neither remain suitable for industrial use nor for agricultural purposes.

13. **Economic Upliftment of the locals/tribes**: Mining industry being site-specific and located in tribal and interior areas provides employment to local people directly in mines. In fact mining activity can be a vehicle in the uplift of socio-economic status of the local people.

14. **Socio-Cultural disturbance to the tribes:** Mining can negatively affect tribes, by forcing them out from their homes and land and their by disrupting their social and cultural fabric. Mostly lack of proper compensation, disputes over land use, lack of sufficient consultation and local engagement and accurate information on mining impacts becomes a reason for social conflict.

15. **Health Impacts:** Miners as well as the locals are always on the high risk of respiratory problems due to high levels of dust and other chemical particulates present in deep coal mines and other type of mining activities.

Impacts of Dam building on Environment, Forests, Biodiversity and Tribal Population:

Dam: Water is a precious resource that is becoming an increasingly scarce commodity worldwide. To reduce scarcity, there is a growing pressure to harness and utilize surface water sources like rivers by building dams over them. A Dam is a barrier that stops or restricts the flow of water. The potential use could be for irrigation, hydroelectricity, water transport etc.

Dams Across World: The first ever dam was built in 1890, but by 1950 the world had 5,000 large dams. As per the World Commission on Dam Report – 2000, there are 45,000 large dams (in 140 countries) in the world. Of these 22,000 are in China, USA – 6390, India – 4291 (i.e. 9% of the world's total), Spain – 1000 and Japan – 1200. According to an estimate, 160-320 new large dams are built every year worldwide to trap run off with dams and storage reservoirs so as to impound huge amount of rain water.

Dams in India: India has more than 1550 large dams, the maximum being in the state of Maharashtra (more than 600), followed by Gujarat (more than 250) and Madhya Pradesh (130).

The highest one is Tehri dam, on river Bhagirathi in Uttaranchal and the largest in terms of capacity is Bhakra dam on river Satluj in Himachal Pradesh.

Impacts of Dams: Big dams have been in sharp focus of various environmental groups all over the world, which is mainly because of several ecological problems including deforestation and socio-economic problems related to tribal or native people associated with them.

e.g. The Silent valley hydroelectric project was one of the first such projects situated in the tropical rain forest area of Western Ghats which attracted much concern of the people. The crusade against the ecological damage and deforestation caused due to Tehri dam was led by Shri. Sunder Lal Bahaguna, the leader of Chipko Movement. The cause of Sardar Sarovar Dam related issues have been taken up by the environmental activitist Medha Patkar, joined by Arundhati Ray and Baba Amte. For building big dams, large scale devastation of forests takes place which breaks the natural ecological balance of the region.

Various Impacts of Dams can be discussed as:

1. Submergence of forests/ other ecosystems: Right from the construction stage which may require large patches of land areas to be cleared to the stage when impoundment starts, when the reservoir submerges large tracts of forests and other ecosystems, including grasslands and wetlands. Around 400,000 km^2 of land worldwide has been submerged due to the construction of dams.

2. Impacts of mining and quarrying for construction materials: The soil, stones and sand required for the construction of dams and canals are often mined and quarried from around the dam or canal site. Such extraction can also have adverse environmental impacts, especially by aggravating dust pollution, disturbing wildlife and destroying vegetation. The scars and pits that such mining and quarrying leave (sometimes called borrow pits) remain as ecological sores and can also have an adverse impact on the dam and the canals.

3. Impacts of backwater build-up: When a free-flowing river meets the relatively static reservoir, there is a build-up of back-pressure and a resultant backwater. This can destroy the upstream ecology and cause damage to property. Backwaters can also build up due to the deposition of sediments and silt upstream of the reservoir as 'backwater deposits'.

4. Impacts on aquatic ecosystems: Construction activities, including the diversion of the river through a tunnel, have major adverse impacts on the aquatic ecosystem. Vulnerable species, with either limited distribution or low tolerance, could become extinct even before the dam is completed.

The blocking of a river and the formation of a lake significantly alters the ecological conditions of the river, adversely impacting species and the ecosystem. There are changes in pressure, temperature, oxygen levels and even in the chemical and physical characteristics of the water.

Besides, by interrupting the flow of water, ecological continuity is broken. This is most obvious in the case of those species of fish whose passage up to their breeding grounds is blocked by the dam. However, many other species get affected, though not as dramatically.

5. Impact on terrestrial biodiversity: The disturbance caused by construction activities, including noise and movement, building of roads, extraction of stone and soil, construction of buildings, etc. also negatively impact the fauna and flora at the dam site.

Also, it is impossible to replace a natural forest by a plantation. Therefore, even if there is formal 'compensation' for the forests lost in terms of forest area, the actual ecological and biodiversity losses that the destruction of natural forests causes cannot be compensated.

6. Wildlife losses: Apart from forests, the reservoir and the dam also affect other ecosystems and various fauna and flora species. Unfortunately, till recently, there was little effort to assess the impact on flora and fauna and on non-forest ecosystems. Even where studies were conducted, there was a tendency to consider only large mammals as 'wildlife'. Recommended mitigation included the creation of bridges for the movement of elephants (Dalma-Subernarekha Project) and the creation of sanctuaries (Sardar Sarovar). In some cases it was suggested that there would be no impact on wildlife as they would migrate to neighboring forests.

7. Impacts on cultivated biodiversity: Reservoirs also submerge productive agricultural land in the valley. This not only has a social and economic cost but also adversely affects cultivated biodiversity and a host of birds, insects, mammals and reptiles that have adapted to agricultural ecosystems. In many cases, traditional crop varieties and methods of cultivation disappear because of dams.

8. Impacts of reservoir-induced seismicity (RIS): The weight of the reservoir, by itself or in conjunction with other reservoirs in the region, can create the sorts of pressures that could result in an earthquake. The weight of the reservoir can also force water down cracks and faults till it catalyzes an earthquake. The occurrence of reservoir-induced seismicity is now a well-accepted fact. RIS has occurred in various dams across the world. 17 of the 75 cases of RIS reported worldwide have been reported from India.

9. Water logging and salinity: Canals themselves can directly contribute to water logging. If not properly lined, or maintained, significant amounts of water can seep out of canals and inundate the lands around. Also, when subsidiary canals are not well maintained, when the releases of water are not properly monitored, or when drainage is not assured, waterlogging results. Waterlogging not only reduces the anticipated agricultural benefits from irrigation projects but sometimes reduces them to levels below those prior to irrigation. A well known and documented case is that of the Tawa dam in Madhya Pradesh.

Waterlogging can also be one of the causes of salinity and provide a conducive habitat for vector breeding. It destroys natural vegetation, damages houses, buildings and roads.

Impacts of canals on natural drainage

Canals also interfere with natural drainage across a slope and thereby lead to waterlogging on the up-slope of the canal where the water collects, and aridity on the down-slope.

10.Impacts of power lines: Very often corridors have to be cut through forests and other natural ecosystems to accommodate power lines. This adversely affects the terrestrial ecosystems. These corridors also have to be maintained in order to allow repair and upgradation work on power lines, causing a long-term impact.

In the Uri project, for example, 98.54 ha. of forestland was given clearance for transmission lines in Jammu and Kashmir. Power lines, especially high-tension lines, are also known to produce high levels of radiation, affecting ecosystems and human beings. High-tension power lines can also cause fires and be hazardous to birds and animals.

11. Impacts on biodiversity downstream: By interfering with river flows, dams adversely affect downstream flora and fauna. There is a popular misconception that as dams supplement dry season flows and only partially curtail rainy season flows, their impact downstream is negligible or even, sometimes, positive.

-In fact, riverine ecology needs heavy rainy season flows as it is during this time that many fish species breed. By curtailing the rainy season flow, the dam inhibits the ability of the ecosystem to regenerate itself. Heavy monsoon flow also acts as a flush for the riverbed and river mouth, clearing them of accumulated silt, garbage and stale water. The absence of such a flow creates significant problems downstream and decreases the capacity of the riverbed to accommodate peak flows, leading to larger floods in the case of cloudbursts or sudden releases of water.

-In many irrigation projects, a significant amount of water is diverted from the river and transported out by canals. This results in significant shortfalls in the natural flow and in the net flow of water in the river. There are, again, serious ecological implications of this.

-A large proportion of the nutrients that flow down the river and form an essential part of the food-chain of the river's ecosystem get trapped by the dam thereby starving the ecosystem.

-Certain species of fish must travel upstream to breed. The recent tendency to set up breeding centers for such fish might ensure the availability of these fish downstream but does not compensate for the ecological roles that these fish species played in the riverine ecosystem upstream of the dam.

12. Impacts of water flow variation downstream: The variation and reduction in water flow in the river adversely affects water availability downstream, both from surface sources and because of inadequate recharging of groundwater. Diversion of water into canals also results in less water downstream, affecting ground and surface water resources.

-Pollution: Reduction and variation in the flow of the river also results in the increased concentration of pollutants downstream, during dry seasons.

-Saltwater ingress: Where the quantity and force of water reaching the river mouth and flowing to the sea is reduced, there is a danger of saltwater ingress. Such ingress can not only destroy riverine and terrestrial ecosystems but can also contaminate groundwater resources.

13. Impacts of sudden release of water or of dam failure: Degraded catchments, excessive rainfall or over-filling of reservoirs, may make it necessary to suddenly release large quantities of water from the reservoir in order to protect the dam structure. Such sudden releases can be disastrous for people living downstream, for their crops and for entire ecosystems. There are many causes of dam failure. It can be due to faulty design or construction, use of substandard materials, overtopping due to surplus water, deliberate sabotage or bombing or because of severe earthquakes.

In some cases, whereas the dam structure might remain intact, the neighboring hillsides crumble having the same effect as the dam collapsing.

14. Impacts on tribes/ displacement and rehabilitation activities: Often dams cause displacement of large local populations. And mostly sites for rehabilitation are carved out of forest areas or from other ecologically valuable areas. Also, when large human populations are shifted to new locations, there is often serious adverse impact on the neighboring environment. This is accentuated if adequate resources have not been planned for and made available to meet the water, land, fuelwood and fodder needs of these populations. Forests and other natural resources are also sometimes degraded because a lack of other livelihood options force the affected people to earn their living by extracting firewood and fodder at an unsustainable rate.

15. Impacts on health: For reservoirs in the tropical regions of the world, especially those that are below 1,000 m. elevation, there is a significant threat of vector breeding. Mosquitoes, which are carriers of malaria, filaria, dengue and other diseases breed in small pools of water created on the edges of the reservoir due to the lowering and raising of the water level of the reservoir.

16. **Socio-economic and cultural impact on tribes/local populations:** Dams can negatively affect tribes, by forcing them out from their homes and land and their by disrupting their social and cultural fabric. Mostly lack of proper compensation, disputes over land use, lack of sufficient consultation and local engagement and accurate information on mining impacts becomes a reason for social conflict.

Positive impacts/Benefits of Dams:

(a) Hydroelectric power generation.

(b) Transfer of water using canals from areas of excess to areas of deficit water.

(c) Irrigation during dry period.

(d) Flood control and soil protection.

(e) Ensuring year-round water supply.

(f) Multipurpose river valley projects also provide for inland water navigation.

(g) Economic upliftment of the Area.

FOREST CONSERVATION ACT, 1980

Conservation of forests in pre-Independence India, was legally covered under Forest Act 1927. But Parliament of India enacted a new legal framework covering wide aspects of forests thereby providing for effective conservation measures on 25th of October, 1980 i.e. Forest Conservation Act, 1980. This act extends over all over India, except J&K. The Act covers under it all types of forests including reserved forests, protected forests or any forested land irrespective of its ownership.

Main Objectives of the Act:

1. Protection and Conservation of the Forests.
2. Restricting the use of forest land for non forest purposes.
3. Preventing de-reservation of forests that were reserved under Forest Act 1927.

This Act was amended in 1988 to further include more provisions mainly

4. To restrict private leasing of forest land.
5. To prevent clear felling of naturally grown trees.

1n 2002, Forest (Conservation) Rules 2003 have been added to this act with further amendments in 2004.

Important Definitions in the Act:

1. **Forest:** Forest means 'a biotic community composed predominantly of trees, shrubs and woody climbers.
2. **Forest Produce:** It includes 'timber, wood bark, charcoal, oil, resin, catechu, natural varnish, lac, mahua seeds , etc. whether brought from or found in a forest.
3. **Non-forest purpose**: It means the breaking up or clearing any forest land or portion thereof for:

(a) the cultivation of tea, coffee, spices, rubber, palms, oil-bearing plants, horticultural crops or medicinal plants;

(b) any purpose other than re-afforestation, but does not include any work relating or ancillary to conservation, development and management of forests and wildlife, namely, the establishment of check-posts, fire lines, wireless communications and construction of fencing, bridges and culverts, dams, waterholes, trench marks, boundary marks, pipelines or other like purposes.

Salient Features/ Important provisions

Important salient features of the Act are as follows:

(i) State to seek Permission from Central Government: The State Govt. has been empowered under this Act to use the forests only for forestry purposes. If at all it wants to use it in any other way, it has to take prior approval of central Government, after which it can pass orders for declaring some part of reserve forest for non-forest purposes or for clearing some naturally growing trees and replacing them by economically important trees (reforestation).

- For Mining, a non-forestry activity, prior approval of Central Govt. is mandatory. The Supreme Court in a case T.N. Godavarman Thirumulkpad Vs. Union of India (1997) directed all on-going mining activity to be ceased immediately in any forest area of India if it had not got prior approval of Central government

- Wildlife sanctuaries, National Parks etc. are totally prohibited for any exploration or survey under this Act without prior approval of Central Govt. even if no tree-felling is involved.

(ii) **Constitution of Advisory committee:** It makes provision for conservation of all types of forests and for this purpose there is an Advisory committee with Director General of Forests, MoEF as chairperson, which recommends funding for it to the Central Government.

(iii) **Diversion of Forest land for other purposes is prohibited:**

-The reserved forests shall not be diverted or de-reserved without prior permission of the central government. The land that has been notified or registered for forest land may not be used for non-forest purposes.

-Forest departments are forbidden to assign any forest land for re-afforestation.

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

-Diversion of forest land for non-forest uses is a cognizable offence and the violator is punishable under law.

(iv) **Immediate closure of non-forest activities:** Any illegal non-forest activity, as mentioned in definition, within a forest area can be immediately stopped under this Act.

(v) **Special provisions for some non forest activities:** The Act made provisions for allowing some non-forest activities in forests, without cutting trees or limited cutting with prior approval of Central Govt. These activities are setting of transmission lines, seismic surveys, exploration, drilling and hydroelectric projects. The last activity involves large scale destruction of forest, for which prior approval of the Centre is necessary.

More activities have been brought under 'non-forest activity' in subsequent amendments for effective conservation such as under:

- Cultivation of tea, coffee, spices, rubber and plants which are cash-crops, are included under non-forestry activity and not allowed in reserve forests.
- Even cultivation of fruit-bearing trees, oil-yielding plants or plants of medicinal value in forest area need to be first approved by the Central Govt. This is because newly introduced species in the forest area may cause an imbalance in the ecology of the forest. If the species to be planted is a native species, then no prior clearance is required.
- Tusser cultivation (a type of silk-yielding insect) in forest areas by tribals as a means of their livelihood is treated as a forestry activity as long as it does not involve some specific host treelike Asan or Arjun. This is done in order to discourage monoculture practices in the forests which are otherwise rich in biodiversity.

- Plantation of mulberry for rearing silkworm is considered a non-forest activity. The reason is same as described above.
- Removal of stones, bajri, boulder etc from river-beds located within the forest area fall under non-forest activity.

Any proposal sent to central govt. for non-forest activity must have a cost-benefit analysis and Environmental Impact Statement (EIS) of the proposed activity with reference to its eco-logical and socio-economic impacts.

Penalties: Penalty for contravention of the provisions of the Act whoever contravenes or abets the provisions of the Act, shall be punishable with simple imprisonment for a period of 15 days extended to six months or more and a fine of Rs 500 or more.

WATER: USE AND OVER-EXPLOITATION OF SURFACE AND GROUND WATER, WATER CONSERVATION, FLOODS, DROUGHTS, CONFLICTS OVER WATER (INTERNATIONAL & INTER-STATE)

Water an essential resource: Water is an essential natural resource basic to existence of life and is very useful in all aspects of human life. Water is a physical substance that is unique in all aspects; it can exist in all three states of matter such as solid, liquid and gaseous state and at a specific temperature found at the surface of the earth. Water is a universal solvent; it is stored in various parts of the world, starting from the atmosphere through the river channel up to ground water.

Water Resources: Water resources include all the; things are derived from water bodies and are of great benefits to man and his environment. Water resources are also referred to sources of water that are useful or potentially useful. Some sources of water include, rain, sea, stream, lake, pond, bore hole and well.

Water possess important economic, legal and political aspects as well as it is not uniformly distributed all over the surface of the earth, however the knowledge of the physical distribution of water is basic to the understanding of the social, economic and political problems that surround water resources management.

Distribution of water : (refer to unit-I)

Water Resources of India:

India has only about 4 per cent of the world's water resources. The main sources of water are: **precipitation, surface water and groundwater.**

The total water received from precipitation is not available for use, as much of it is lost by evaporation and a good deal of it goes as run-off to rivers, lakes and ponds. A small amount seeps through the soil to form groundwater.

Surface Water: The surface water is available to us in the form of rivers, lakes, ponds and other water bodies. Rivers are the most important source of surface water in our country. The mean annual flow of Indian rivers is about 1900 billion cubic meters.

The total flow of all rivers of India is about 6 per cent of the discharge of all rivers in the world. The effective storage capacity of surface water in India is only about 150 billion cubic meters, which is only 8 per cent of the total flow of all the rivers. Thus, about 92 per cent of the surface water flows into the sea.

Ground water and Aquifers: Water that is available in the deeper layers of the earth is known as Groundwater. This water has been trapped inside the earth's crust for several centuries. The water that is lying under the ground has the capacity to move in general direction of its slope with a very small velocity.

The bodies that contain such water are known as Aquifers. Water from these aquifers can be drawn by digging wells and pumping water from these wells. The groundwater potential in India is about 450 billion cubic meters. Water percolates easily in the alluvial soils. Thus, the potential of groundwater development is high in the Northern Plains of India. Of the total groundwater resources, about 25 per cent is used for domestic, industrial and related purpose, while 75 per cent is used for irrigation.

Uses of Surface and Ground water: uses of water can be categorized into two types:

A, Consumptive use: In such uses, water is completely utilized and cannot be reused e.g. Drinking.

B. Non-consumptive use: In such uses, water is not completely utilized and is reused e.g. Hydropower plant

General Uses of water are as under:

1. **Domestic Use:** Globally, household or personal water use is estimated to account for 15% of worldwide water use; since water is one of the most important necessities of life, it is highly needed in our homes for various uses. Domestic water use is water used for indoor and outdoor household purpose for instance for drinking, preparing food, bathing, washing of clothes and dishes, brushing of teeth, watering of yard and garden.
2. **Industrial use:** A large quantity of water is required by large industries like hydroelectric dams, thermoelectric power plants for cooling and generation of power. Large industries like ore and oil refineries use water in chemical processes and manufacturing plants also use water as a solvent. Other example include various breweries, Iron smelting companies which use water for washing and processing of their raw materials. 20-30% of water is used for industrial operations by refineries, iron & steel industries, paper & pulp industries, etc.
3. **Agricultural use:** Some of the world's farmers still farm without irrigation by choosing crops that match the amount of rain that falls in their area. However, some years are wet and others are extremely dry, in this case, farmer use water for irrigation to produce crops all year round. Almost 60-70% of fresh water is used for irrigation
4. **Fishing:** Fishing is a major activity which is common among the riverine people through which they earn their living. This activity is usually carried out all year round as to supply fish to various locations locally and internationally.
5. **Source of Food for Man:** Edible foods such as seaweeds and microalgae are widely eaten as seafood by different humans around the world. However, shellfish like Squid, crab, octopus, oyster, shrimp, and lobster are harvested from saltwater environments.
6. **Transportation:** Water in the rivers, lakes, and oceans are often used as a means of transport for conveying people and goods from one place to another for example Atlantic Ocean, river Niger and river Benue.
7. **Hydroelectric Power:** These various sources of water presents on the surface of the earth are demanded for the production of electricity.
8. **Mineral Deposit:** Water bodies serve a source of mineral deposits for example, salt, Placer Gold, Tin, crude oil, Titanium, and Diamonds, Limestone and Gypsum are extracted from large water bodies. Read more on mineral resources.
9. **Employment:** The various water bodies such as lakes, rivers and oceans provide employment opportunities for people in various locations of the world. Ship builders, sailors, mariners and fishermen are examples of such people.
10. **Recreation and Tourism:** Various water bodies also provide excellent facilities for swimming fishing and picnicking, boating, rafting skiing. Even activities such as golf, where there may not be

any standing water, require plenty of water to make the grass on the course green. A larger water body like oceans provides beautiful scenery which attracts tourists.

Over-Exploitation of Surface and Ground Water: The rapid increase in population and industrial growth led to severe demand on water resources. After using all available surface water resources to the maximum, human beings began using groundwater to meet their needs. The over utilization of ground and surface water has not only lead to scarcity of water but also some other serious consequences. Some of the major impacts are summarized below:

1. **Depletion of water resources and biodiversity:** Overharvesting and exploitation causes water depletion, collapse of fisheries and production of food. Quality and quantity of water gets badly affected by these depletions of living resources and biodiversity. Over-utilization of groundwater leads to drying-up of dug wells as well as bore wells.
2. **Risk to ecosystem functions:** Increasing population and rising consumption increases water abstraction and acquisition of cultivated land. Virtually all ecosystem functions including habitat, production and regulation functions are at risk.
3. **Loss of integrity of freshwater ecosystems:** Human activities for infrastructure development like creation of dams, land conversion, etc. are responsible for this loss of integrity of freshwater ecosystems. Water quality and quantity, fisheries, habitats, etc. are at risk due to this loss of integrity.
4. **Pollution of Water:** Due to excess use of fertilizers and irrigation water for agricultural fields, agricultural water that contains nitrogen as a fertilizer percolates rapidly and pollutes the groundwater with excessive nitrates thereby rendering the water unfit for potable use by infants.

Release of pollutants to land, air or water alters chemistry and ecology of water bodies. Greenhouse gas emissions produce significant changes in runoff and rainfall patterns. Because of water pollution, water supply, habitat, water quality, food production, climate change, etc. are at risk. Sewage is the most common source of groundwater pollution. Landfills, underground storage tanks, and hazardous waste disposal sites are other sources of contamination. Surface sources of pollution can affect groundwater where the ground is very permeable or where conduits to the water table are present. Pollution spreads with the flow of groundwater. Cleanup of contaminated groundwater is extremely difficult and expensive.

5. **Subsidence:** When groundwater withdrawal is more than its recharge rate, the sediments in the aquifer get compacted, the phenomenon known as ground subsidence. Ground subsidence at the surface can be regarded as ground movement which takes place due to the intensive extraction of groundwater. This may leads to structural damage in buildings, fracture in pipes and reverses the flow of canals leading to flooding.
6. **Lowering of Water Table**: Lowering of water table occurs where groundwater is withdrawn faster than it can be recharged. It can also cause wells to dry up. It is not advisable to do excessive mining as it would cause a sharp decline in future agricultural production, due to lowering of water table.
7. **Water logging:** Another problem associated with over utilization of water is excessive irrigation particularly on poorly drained soils, which causes water logging. This occurs in poorly drained soils where water can't penetrate deeply. For example, there may be an impermeable clay layer below the soil. It also occurs on areas that are topographically poorly drained. When soils are water logged, air spaces in the soil are filled with water, and plant roots essentially suffocate lack oxygen. Water logging also damages soil structure. Worldwide, about 10% of all irrigated land suffers from water logging.
8. **Saltwater Incursion:** Saltwater incursion involves contamination of freshwater aquifers with saltwater. Fresh water floats as a lens on denser salt water. If fresh water is removed

in large amount, a cone of depression is created in the fresh water lens. Lowering of the water table by 1 foot results in raising the level of salt water by 40 feet. This situation occurs primarily in island or coastal areas.

FLOODS

Floods occur when land that is usually dry is submerged by large amounts of water. Sudden submergence or inundation of land area with water is called as flood. The occurrence of floods can be due to both natural and human causes.

Anthropogenic causes of floods include:

1. **Clearing of forests:** Lack of vegetation cover to hold the soil together on slopes causes erosion and deposition in river beds making them shallow, flooding occurs when these rivers overflow. Also bare slopes increase surface runoff and volume of water flowing into the rivers.
2. **Urban development:** The clearing of land for development of residential, commercial and industrial complexes have rapidly increased built-up areas. These concrete pavements and roads prevent infiltration of rainwater into the ground coupled with lack of vegetation cover to intercept the rain water results in increased runoff flowing into the rivers resulting in flooding.
3. **Improper farming and other land use practices:** The combination of absence of forest cover on one hand, and inappropriate farming and land-use practices on the other have aggravated the flood devastation. There are hardly any forests left in the catchment area of the rivers. It is well known fact that the forest areas are characterized by high infiltration capacity.
4. **Enhanced Green house effect:** Various human activities resulting in increased green house effect and causing global warming are leading to various climate changes such as higher rainfall in short duration, melting of more ice etc. All these have lead to increased incidences of floods.

Natural causes of floods:

1. **Excessive rainfall:** Floods occur when rainwater is unable to seep into the ground quickly enough or rivers overflow their banks because river channels cannot contain excess water. It is common in tropical areas.
2. **Storm Surges:** It occurs when strong winds raise the waves in the ocean to exceptionally high levels, causing them to crash into the coast and flood the land. It is common in coastal areas with low-lying relief.
3. **Melting Snow:** Melting of snow in spring releases large amount of water into the rivers, causing them to overflow their banks. It is common in places with cool temperate climate.
4. **Global Atmospheric processes:** Abnormal weather phenomenon such as El Nino (warming of surface ocean waters at Southeastern part of Pacific Ocean).
5. **Earthquakes:** Earthquakes can bring about landslides or trigger tsunamis. When landslides occur, loosened soil, rocks, mud debris etc. may be deposited in rivers causing overflowing of these rivers. Tsunamis triggered by strong undersea earthquakes can flood and devastate coastal settlements.

Impact of floods:

1. **Loss of life**: Floods mostly strike people unprepared, leading to loss of lives in drowning. Along with livestock and other life forms. Impact is higher in flood plain areas which are densly populated,
2. **Damage to infrastructure and property:** Flood cause huge losses to homes, roads, power supply and other infrastructure.
3. **Spread of Diseases:** After flood water recedes, shallow stagnant water may cover areas over a considerable period of times. This may result in outbreak of water borne diseases. Moreover homeless flood victims are housed in temporary shelters which are mostly overcrowded and with poor sanitation conditions which may turn situation worse.

4. **Loss of natural habitat:** Trees, vegetation and other natural habitats may get destroyed leading to loss of biodiversity.

Mitigation of floods

Floods can be mitigated by structural, water control and non-structural measures such as:

Structural methods include building dams, reservoirs, and retarding basins, channel management and embankments.

Water control methods: include increasing forest and vegetation cover, watershed management, flood proofing and catchment modifications. Schemes of drainage and flood protection,

Non-structural methods: flood forecasting, flood warning and emergency preparedness systems, flood insurance, public information and education, and flood relief

Drought

Drought is lack or insufficiency of rain for an extended period that causes considerable hydrologic imbalances and consequently water shortages, stream flow reductions and depletion of groundwater levels and soil moisture.

Drought is the most serious physical hazard to agriculture in nearly every part of the world. Drought can simply be defined as extended periods of precipitation shortage, normally for a season or more resulting in water deficiency for some human activities or environmental sustainability.

Human activities such as farming, irrigation, or domestic uses of water are normally highly impacted during droughts.

Causes of Drought

Natural causes:

1. **Rainfall or Precipitation Deficiency:** less rainfall may lead to the following conditions:

-Meteorological Drought: Whenever there is prolonged periods of rainfall deficiency for a season or more and usually when there is a lack of anticipated rainfall or precipitation.

-Hydrological Drought: When a region goes for long periods without any rain, especially for more than a season, then the situation leads to dry conditions and water deficiency.

-Agricultural Drought: Farmers, for instance, plant in expectation of rain and so when it doesn't rain as expected, drought conditions are experienced and there is huge decline in food production.

2. Drying out of Surface Water Flow

Lakes, rivers, and streams are the primary suppliers of downstream surface waters in various geographical regions around the globe. In extremely hot seasons, these surface water flows may dry out downstream contributing to drought – meaning the demands for water supply become higher than the available water.

3. Global Atmospheric processes: Abnormal weather phenomenon such as El Nino (warming of surface ocean waters at Southeastern part of Pacific Ocean). It causes droughts in Australia, Indonesia etc.

Anthropogenic Causes: Human activities play a relatively significant role in the management of the water cycle such as:

1. Deforestation: Cutting of forests for construction, and agriculture negatively impact the water cycle. Trees and vegetation cover are essential for the water cycle as it helps to limit evaporation, stores water, and attracts rainfall.

In this sense, deforestation – clearing vegetation cover and cutting down trees increases evaporation and lessens the ability of the soil to hold water leading to increased susceptibility of desertification. Deforestation can also influence the occurrence of dry conditions since it reduces forest's watershed potential. Construction and agricultural activities may as well reduce the overall supply quantity of water, resulting in dry spells.

2. Faulty Irrigation systems and hydro-electric dams are some of the human activities that can significantly diminish the amount of water flowing downstream to other areas causing drought conditions..

3. Global Warming: Human actions have contributed to more and more emissions of greenhouse gasses into the atmosphere thus resulting in the continued rise of the earth's average temperatures. Consequently, evaporation and evapo-transpiration levels have risen, and the higher temperatures have led to wildfires and extended dry spell periods. The global warming situation tends to exacerbate the drought conditions. Some of the worst droughts witnessed in sub-Saharan Africa have been associated with global warming and climate change

Effects of Drought

Drought not only leads to serious economic consequences but also leaves behind untold human misery. Among all the natural disasters, drought affects largest number of people in the world. Shortage of water for even the basic needs is the main problem in the drought areas. The effects of drought are widespread and have devastating effects on the environment and the society as a whole. The effects can therefore generally be categorized as environmental, economic, and social.

1. Environmental Impacts of Droughts

- **Drying out of water bodies**

Surface waters such as lakes, rivers, ponds, creeks, streams and lagoons dry out during extended dry conditions which destroy natural habitats.

- **Reduction in soil quality**

Soil moisture, essential for soil microbial activities, is reduced in drought conditions resulting in minimized organic activity and continued dry spell which kills soil organisms. The end result is dry and cracked soil and it even becomes easier for decertification to occur.

- **Desertifiaction as conditions unfavourable for plants and other vegetation and forest fires**

Drought conditions make it unsuitable for plants and vegetation cover to survive. Besides, fertile lands are lost as a result of drought, and in consequence, desertification sets in. Desertification is whereby the lands become infertile and bare, frequently as a result of overgrazing and is exacerbated by drought which makes it difficult for such lands to recover. Prolonged period of dryness also increase incidences of forest fires.

- **Migration and even death of Animals and loss of biodiversity**

Animals and wildlife are forced to migrate in drought conditions since they have to move for long distances to get water and food. When the wildlife and animals migrate, they end up in new locations where they can be vulnerable, endangered because of new threats. This leads to loss of biodiversity and disruption of the natural ecosystems.

2. Economic Impacts of Droughts

- **Increased budgetary spending by farmers**

During droughts, farmers spend more money on crop irrigation so as maintain crop yields

•Reduced crop yields

Often, low crop yields are experienced during drought periods. Therefore, farmers usually undergo major economic losses because of low crop yields. They pay for lots of inputs and labor, but the outcomes are less.

- **Industrial and governmental losses**

Industries and businesses in farm equipment manufacturing and merchandising respectively suffer huge loss when farmers lack the money to buy their resources. Governments, on the other hand, have to allocate more money and spend even more for drought mitigation.

- **Higher energy cost for economies dependent on hydro-power**

Extended dry spells can translate to lowered water levels in rivers and dams used to generate hydro-power. This means higher costs of energy for businesses because the hydro-energy companies are driven to operate below capacity.

3. Social Impacts of Droughts: Social implications are possibly the most felt effects of drought. They are the direct effects to people and communities. They include

- **Outbreak of waterborne diseases**

Due to non availability of clean water for drinking and water for sanitation and cleaning level of impurities in surface waters rises. As a result, managing and preventing waterborne diseases such as typhoid and cholera becomes increasingly difficult, especially in poor regions.

- **Hunger, anemia, malnutrition, and deaths**

Hunger, anemia, malnutrition and deaths of people are often witnessed in drought-stricken areas. Often, it is as a result of lack of sufficient food nutrition due to low food production that directly contributes to diseases and health vulnerability.

- **Migration of people and anxiety**

People are forced to shift to other places in search for better living conditions during droughts. This contributes to loss of livelihoods and people undergo lots of stress and anxiety. Women, children, and the elderly are the most affected.

Mitigation of Droughts: Adapting certain practices can mitigate droughts or reduce their impacts such as

1. **Management of Watershed and other Water conservation practices**: Watershed management along with other water conservation practices must be adapted. (detail in next section-water conservation)

2. **Using better Agricultural and irrigation methods:** Crops that are resistant to droughts can be planted. Proper irrigation minimizes water loss and helps conserve water.

3. **Increasing vegetation Cover in Drought Prone/ affected areas:** Efforts must be put into increase vegetation cover in drought affected or prone areas so as to prevent desertification.

WATER CONSERVATION

Water conservation includes all the policies, strategies and activities to sustainably manage the natural resource of fresh water, to protect the hydrosphere, and to meet the current and future human demand. Population, household size, and growth and affluence all affect how much water is used. Factors such as climate change have increased pressures on natural water resources especially in manufacturing and agricultural irrigation.

Objectives: The goals of water conservation efforts include:

- **Ensuring availability** of water for future generations. This requires that the withdrawal of fresh water from an ecosystem does not exceed its natural replacement rate.

- **Energy conservation.** Water pumping, delivery and waste water treatment facilities consume a significant amount of energy. In some regions of the world over 15% of total electricity consumption is devoted to water management.
- **Habitat conservation**. Minimizing human water use helps to preserve freshwater habitats for local wildlife and migrating waterfowl, as well as reducing the need to build new dams and other water diversion infrastructures.

Strategies: In implementing water conservation principles, there are a number of key activities mainly:

1. Any beneficial **reduction in water loss**, use and waste of resources.
2. Avoiding any damage to **water quality**.
3. Improving **water management practices** that reduce or enhance the beneficial use of water.

Water-saving technology for the home includes:

1. Low-flow shower heads sometimes called energy-efficient shower heads as they also use less energy.
2. Low-flush toilets and composting toilets. These have a dramatic impact in the developed world, as conventional Western toilets use large volumes of water.
3. Dual flush toilets created by C aroma includes two buttons or handles to flush different levels of water. Dual flush toilets use up to 67% less water than conventional toilets.
4. Faucet aerators, which break water flow into fine droplets to maintain "wetting effectiveness" while using less water. An additional benefit is that they reduce splashing while washing hands and dishes.
5. Raw water flushing where toilets use sea water or non-purified water.
6. Waste water reuse or recycling systems, allowing.
   • Reuse of graywater for flushing toilets or watering gardens.
   • Recycling of wastewater through purification at a water treatment plant.
7. Rainwater harvesting.
8. High-efficiency clothes washers.
9. Weather-based irrigation controllers.
10. Garden hose nozzles that shut off water when it is not being used, instead of letting a hose run.
11. Low flow taps in wash basins.
12. Swimming pool covers that reduce evaporation and can warm pool water to reduce water, energy and chemical costs.
13. Automatic faucet is a water conservation faucet that eliminates water waste at the faucet. It automates the use of faucets without the use of hands.

Rain water Harvesting

Rainwater harvesting is the collection and storage of rainwater for reuse on-site, rather than allowing it to run off. Rain water harvesting includes storage of rainwater into natural reservoirs or tanks, or the infiltration of surface water into subsurface aquifers (before it is lost as surface runoff). These stored waters are used for various purposes such as gardening, irrigation etc.

Methods of Rainwater Harvesting

Broadly there are two ways of harvesting rainwater

1. Surface runoff harvesting
2. Roof top rainwater harvesting

1. Surface runoff harvesting: In urban area rainwater flows away as surface runoff. This runoff could be caught and used for recharging aquifers by adopting appropriate methods.

2. Rooftop rainwater harvesting: It is a system of catching rainwater where it falls. In rooftop harvesting, the roof becomes the catchments, and the rainwater is collected from the roof of the house/building. It can either be stored in a tank or diverted to artificial recharge system. This method is less expensive and very effective and if implemented properly helps in augmenting the groundwater level of the area.

Rooftop Rainwater Harvesting System

Components of the Rooftop Rainwater Harvesting: The system mainly constitutes of following sub components:

a. Catchments: The surface that receives rainfall directly is the catchment of rainwater harvesting system. It may be terrace, courtyard, or paved or unpaved open ground. The terrace may be flat RCC/stone roof or sloping roof. Therefore the catchment is the area, which actually contributes rainwater to the harvesting system.

b. Transportation: Rainwater from rooftop should be carried through down take water pipes or drains to storage/harvesting system. Water pipes should be UV resistant (ISI HDPE/PVC pipes) of required capacity. Water from sloping roofs could be caught through gutters and down take pipe. At terraces, mouth of the each drain should have wire mesh to restrict floating material.

c. First Flush: First flush is a device used to flush off the water received in first shower. The first shower of rains needs to be flushed-off to avoid contaminating storable/rechargeable water by the probable contaminants of the atmosphere and the catchment roof. It will also helpful in cleaning of silt and other material deposited on roof during dry seasons Provisions of first rain separator should be made at outlet of each drainpipe.

d. Filter: Filters are used for treatment of water to effectively remove turbidity, colour and microorganisms. After first flushing of rainfall, water should pass through filters. A gravel, sand and 'netlon' mesh filter is designed and placed on top of the storage tank. This filter is very important in keeping the rainwater in the storage tank clean. It removes silt, dust, leaves and other organic matter from entering the storage tank.

The filter media should be cleaned daily after every rainfall event. Clogged filters prevent rainwater from easily entering the storage tank and the filter may overflow. The sand or gravel media should be taken out and washed before it is replaced in the filter.

The advantages of Rain Water Harvesting are:

- It provides self-sufficiency to water supply.
- It reduces the cost for pumping of ground water.
- It provides high quality water, soft and low in minerals.
- It improves the quality of ground water through dilution when recharged.
- It redces soil erosion & flooding in urban areas.
- The rooftop rain water harvesting is less expensive and easy to construct, operate and maintain.
- In deserts, RWH is the only relief.
- In saline or coastal areas & Islands, rain water provides good quality water.

Tamilnadu is the first Indian state to make rainwater harvesting mandatory. On 30 May 2014, the state government announced that it will set up 50,000 rainwater harvesting structures at various parts of the capital city of Chennai.

Watershed Management

Watershed: Every body of water (e.g., rivers, lakes, ponds, streams, and estuaries) has a watershed. The watershed is the area of land that drains or sheds water into a specific receiving water body, such as a lake or a river. As rainwater or melted snow runs downhill in the watershed, it collects and transports sediment and other materials and deposits them into the receiving water body.

Watershed is that land area which drains or contributes runoff to a common outlet. Watershed is defined as a geo-hydrological unit draining to a common point by a system of drains. All lands on earth are part of one watershed or other. Watershed is thus the land and water area, which contributes runoff to a common point.

Watershed management: Watershed management is a term used to describe the process of implementing land use practices and water management practices to protect and improve the quality of the water and other natural resources within a watershed by managing the use of those land and water resources in a comprehensive manner.

Objectives:

The main aim of Watershed Management is to implant the sustainable management of natural resources to improve the quality of living for the population is to be accomplished by the following objectives:

1. Improvement and restoration of soil quality and thus, raising productivity rates.
2. Supply and securing of clean and sufficient drinking water for the population.
3. Improvement of infrastructure for storage, transport and agricultural marketing.
4. To manage the watershed for beneficial developmental activities like domestic water supply, irrigation, hydropower generation etc.
5. To minimize the risks of floods, droughts and landslides.
6. To develop rural areas in the region with clear plans for improving the economy of the regions.

To summarize Watershed management practices aims for three main purposes:

i. To increase infiltration of water.
ii. To increase water holding capacity of the soil.
iii. To prevent soil erosion.

• Methods used in Watershed management: Briefly these methods can be categorized as under:

1. Vegetative measures or Agronomical measures: These include Strip cropping, Pasture cropping, Grass land farming, Wood lands etc

2. Engineering measures or Structural practices: Contour bunding, Contour trenching, Terracing, Construction of earthen embankment, Construction of check dams, Construction of farm ponds, Construction of diversion, Gully controlling structure, Rock dam, Establishment of permanent grass and vegetation, Providing vegetative and stone barriers, Construction of silt tanks distension etc.

Benefits of a Healthy Watershed: Water is essential for our future. The goal of watershed management is to properly balance and manage this resource. A healthy watershed provides the triple benefits of human, ecological and economic health.

1. Ecological Health

A healthy watershed functions as a complete ecological system promoting the health of all living organisms and landscapes within the watershed. A healthy, intact watershed minimizes the impacts of flooding and erosion and serves to filter sediments and contaminants so they do not reach our streams, lakes, and groundwater.

2. Economic Health

An abundant supply of clean water is essential for a vibrant economy. Homes, farms, municipalities and businesses all need an ample supply of clean water to operate effectively. Clean water allows municipalities, businesses, agricultural producers, and industries to operate more cost effectively, saving money for taxpayers and consumers. Healthy rivers, lakes, wetlands and natural spaces are foundations for recreation and tourism.

3. Human Health

Life requires a safe daily supply of water. But water is far more than that: clean surface and ground water is essential to support our high quality of life and the social aspects of our communities. Clean rivers, lakes and streams provide many healthy recreational opportunities including swimming, boating, and fishing.

Watershed management programmes in India:

(i) Drought Prone Area Programme (DPAP): Year of start: 1970-71

Objectives: Area development programme through restoration of ecological balance and optimum utilization of land, water, livestock and human resources to mitigate the effect of drought.

(ii) Desert Development Programme (DDP): Year of start: 1977-78

Objectives: Mitigate the effect of drought in the desert area and restore ecological balance.

(iii) National Watershed Development Programme for Rainfed Agriculture (NWDPRA): Year of start: 1986-87

Objectives: To conserve and utilize rain water from both arable and non arable lands on watershed basis. To increase the productivity of crops and to increase the fuel, fodder and fruit resources through appropriate alternate land use system.

(iv) Control of Shifting Cultivation: Year of start: 1986-87

Objectives: Restoring ecological balance in hilly areas and improving socio-economic conditions.

(v) World Bank Assisted Integrated Watershed Development Project: Year of start: 1990

Neeranchal Watershed Program

Neeranchal, World Bank assisted National Watershed Management Project. Neeranchal is designed to further strengthen and provide technical assistance to the Watershed Component of PMKSY (Prime Minister Krishi Sinchai Yojna). The program is being implemented in nine participating states - Andhra Pradesh, Chattisgarh, Gujarat, Jharkhand, Madhya Pradesh, Maharashtra, Odisha, Rajasthan and Telangana.

CONFLICTS OVER WATER

Water is essential for our existence and is fast becoming scarce. Today, water is considered as the heart of an economy of any country and all economic activities depend on it. However at the national as well as international level, river water disputes are being created because of continuously increasing demand for water, its decreasing availability, and its deteriorating quality. Rivers flow in their natural form according to geomorphic condi-tions. They are not controlled by political units. Flow of water is distributed according to the relief and size of the watershed area. Rapidly increasing population and limited water resources give rise to conflicts over water. Unequal distribution of water leads to inter-state or international disputes.

Inter-State / National conflicts: in India, Perhaps the longest standing and contentious inter-state issue has been the sharing of river waters. Most of the Indian rivers are inter-state, i.e., they flow through more than one state. Due to increase in demand for water, a number of inter-state disputes over sharing river waters have surfaced.

e.g.

(i) Cauvery water dispute: This conflict began with the construction of dam in Mysore state by Tipu Sultan in 17th century. In 1916, an agreement was made with the help of a British Engineer and Krishna Sagar dam was built. When the demand of water increased, the states of Tamilnadu and Kamataka claimed more water. Kerla and Pondichery also made their claim on the water of Kaveri. The dispute is still under consideration. The government of India formed the Kaveri water dispute commission on June 2, 1990, But the issue still remain unresolved.

(ii) Narmada Water Dispute: Narmada originates in Amarkantak (Madhya Pradesh). Its length is 1,300 kilometer and has a catchment area of 98,796 square km. Gujarat, Madhya Pradesh and Rajasthan are the three states involved in the dispute over the use of Narmada waters. Under Section 4 of the Inter-state Water Dispute Act, 1956, the Union government set up a Narmada water dispute tribunal under Justice V. Ramaswami. The tribunal announced its award on December 7, 1979. Under the award, Gujarat was allowed to utilise 90 lakh acre feet of water, while Madhya Pradesh and Maharashtra were allowed 182.5 lakh acre feet and 2.5 lakh acre feet respectively.

(iii) Son-Rihand Water Dispute: The Son-Rihand water dispute involves three states—Bihar, Uttar Pradesh and Madhya Pradesh. The origin of the dispute may be traced in the Banasagar Agreement of 1973. Bihar has been opposed to this agreement right from the beginning. In the year 1992, administrative necessities regarding the distribution of the water among all the three states were implemented. But the agreement has not been reached yet.

It may be mentioned here that under the agreement, the entire Rihand waters had been allocated to Bihar, but the Singarauli-based National Thermal Power Corporation (NTPC) plant and the Uttar Pradesh government have been utilising water in the Rihand reservoir. Bihar resents this practice. The state contends that the Banasagar agreement violated the state's 100 years right on Son waters in Inderpuri barrage.

(iv) Yamuna Water Dispute: The dispute relating to the distribution of Yamuna waters is an old one. Five states of the country—Haryana, Uttar Pradesh, Rajasthan, Delhi and Himachal Pradesh—are involved in this dispute. The first agreement on Yamuna water was reached between Haryana and Uttar Pradesh in 1954 followed by others but efforts to resolve the conflict remain unfruitful. An agreement was reached between Haryana and Delhi in 1993. Under the agreement, the two parties decided to construct an additional water carrier system. An agreement on Yamuna waters involving all the five states concerned was reached in May 1994. Delhi is the biggest beneficiary of the 1994 accord, while Haryana the greatest looser. Section 7(3) of the agreement says that in case water in Yamuna is less than anticipated, Delhi's requirement of potable water would be met first.

This provision is being resented by other states, particularly Haryana. But Delhi is not satisfied with the amount of Yamuna waters it is getting. It is demanding more, saying it uses only 40 per cent of its share of water, remaining 60 per cent goes back to Yamuna, benefiting Haryana and Uttar Pradesh. The dispute remains unsettled.

International conflicts over water:

1. **Indus water Treaty- Water conflict between India and Pakistan :** The Indus Water Treaty (IWT) is a water-distribution treaty between India and Pakistan signed on September 19, 1960. The treaty was signed by the then Prime Minister Sh Jawaharlal Nehru and Pakistan's President Ayub Khan. It was brokered by the World Bank (International Bank for Reconstruction and Development) he Indus Waters Treaty (IWT) deals with river Indus and its five tributaries, which are classified in 2 categories: Eastern rivers: Sutlej, Beas, Ravi and Western rivers: Jhelum, Chenab and Indus.

According to treaty, all the water of Eastern rivers shall be available for unrestricted use in India. India should let unrestricted flow of water from western rivers to Pakistan. It doesn't mean that India can't use Western River's water. The treaty says that India can use the water in Western rivers in "non-consumptive" needs. Here non consumptive means we can use it for irrigation, storage and even for electricity production. (But India has not fully utilized this provision so far). The treaty allocates 80% of water from the six-river Indus water system to Pakistan. A Permanent Indus Commission was set up as a bilateral commission to implement and manage the Treaty. Though Indus originates from Tibet, China has been kept out of the Treaty.

Dispute between Indiaand Pakistan over Indus started right after Partition, as given under:

- **1948:** India cuts off supply in most canals that went to Pakistan. But restores it later.
- **1951:** Pakistan accuses India of cutting water to many of its villages.
- **1954:** Word Bank comes up with a water-sharing formula for two countries.
- **1960:** Indus Waters Treaty signed.
- **1970's:** India starts building hydropower projects in Kashmir. Pakistan raises concern.
- **1984:** Pakistan objects over India building Tulbul barrage on Jhelum. India stops it unilaterally.
- **2007:** Pakistan raises concern over Kishanganga hydroelectric plant.
- **2008:** Lashkar-e-Taiba starts campaign against India. Its chief Hafiz Saeed accuses India of water terrorism.
- **2010:** Pakistan accuses India of choking water supply consistently.
- **2016:** India reviews working of Indus Waters Treaty linking it with cross-border terrorism (Uri attack).

  Indus Water Treaty is considered to be one of the most successful water-sharing endeavours in the world today. For 56 years, both India and Pakistan are peacefully sharing the water of Indus and its tributaries, thanks to The Indus Water Treaty (IWT). Because of the confrontations between India and Pakistan over other issues, the water treaty naturally comes into picture. Recently, After the Uri cross-border attack by Pakistan in 2016, Indian Prime Minister Narendra Modi had said "**Blood and Water cannot flow simultaneously**."

  There are issues between India and Pakistan, but there has been no fight over water after the Treaty was ratified. Most disagreements and disputes have been settled via legal procedures, provided for within the framework of the treaty. India has never used our rights on the western rivers. Under the Indus Water Treaty, we can make use of the waters of the western rivers for irrigation, storage, and even for producing electricity, in the manner specified. If we just do what we are entitled to under the Treaty, it would be enough to send jitters through Pakistan. It would be a strong signal without doing anything drastic.

(ii) India-Bangladesh Dispute on River Ganga Water: Ganga water dispute is connected with the Kolkata port. The flow of water of river Ganga from the steep slope of Himalayas is very fast and within

the boundaries of Uttar Pradesh and Bihar, many companion rivers merge into it. After its entry into Bangladesh, flow of its water becomes slow and it divides into two rivers named Padma and Ganga.

Padma merges into the Brahmaputra and becomes Meghna in Bangadesh. It then falls in the Bay of Bengal. Ganges divides itself into many streams in the delta of Sunderban. In 1974, Farakka barrage was constructed on this flow of water in 1974 to make water available for Kolkata port, so that ships can sail up to the dock even during dry season and the dock remains free of silt.

Bangladesh had objections to this saying that (1) India diverts the whole water during dry season towards Kolkata port, which results in insufficient quantity of water in Meghna-Padma river, and (2) the gates of Farrakka barrage are opened during the rainy season, which results in flood in Bangladesh.

Opposition of Bangladesh: Maulana Abdul Hamid Khan Bhasni organized a long march to Farakka with three lakh persons on 16 May, 1976. Bangladesh raised this issue in the General Assembly of United Nations Organization on 15 November 1996. Begum Khalida Zia delivered a speech against India but no country supported her except China and Pakistan.

A treaty regarding distribution of water of Ganges-Farrakka was entered into force between India and Bangladesh on 5 November 1977. According to it, 34,500 cusec out of the distributable 55,000 cusec in Farrakka was allocated for Bangladesh. The remaining 20,500 cusec would remain for Kolkata. In the agreement it was also decided that out of the total water available in Farrakka barrage, 25 per cent would remain stored while 60 per cent would go to Bangladesh and 40 per cent to West Bengal. This treaty continued up to 31 May, 1988.

On 11 December, 1996 River water treaty was again signed. It is valid for 30 years having a clause for review after every five years. It can also be reviewed after one year on unilateral demand. Among the 12 clauses of the agreement, some important ones are as under:

1. Both the countries would distribute the water on equal basis if water in Farakka remains 70,000 cubic feet.

2. In case water remains between 70,000 to 75,000, Bangladesh would get 35,000, and the balance water would remain with India.

3. If the quantity of water exceeds 75,000, India would get 40,000 and the balance would go to Bangladesh.

(iii) **Mahakali River Dispute:**

This dispute regarding the water of river Mahakali (called Sharda in India) is between India and Nepal. The latest dispute relates to Ranakpur and Pancheshwar projects, but the dispute regarding water of Mahakali almost resolved after the Nepal visit of the then Foreign Minister of India, Sh Pranab Mukherji, in February 1996. In 1998, the Indo-Nepal Sub-Commission was established with the objective of taking action on all the aspects related with the development of water resources.

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

This act came into force on 23rd March, 1974. It is an act for the prevention, control and abatement of water pollution and maintaining or restoring of wholesomeness of water. This Act has 64 sections and 8 chapters – (I) Preliminary (II) The Central and State boards for the prevention and control of water pollution (III) Joint Boards (IV) Powers and functions of boards (V) Prevention and control of water pollution (VI) Funds, accounts and audit (VII) Penalties and Procedures (VIII) Miscellaneous.

(I) PRELIMINARY

This Act may be called the Water (Prevention and Control of Pollution) Act, 1974. It extends to the whole of India.

Definitions:

(a) *Board* means the Central Board or a State Board.

(b) *Central Board* means the Central Pollution Control Board.

(c) *State Board* means a State Pollution Control Board.

(c) *member* means a member of a Board and includes the chairman.

(d) *pollution* means such contamination of water or such alteration of the physical, chemical or biological properties of water or such discharge of any sewage or trade effluent or of any other liquid, gaseous or solid substance into water (whether directly or indirectly) as may, or is likely to, create a nuisance or render such water harmful or injurious to public health or safety, or to domestic, commercial, industrial, agricultural or other legitimate uses, or to the life and health of animals or plants or of aquatic organisms

(e) *sewage effluent* means effluent from any sewerage system or sewage disposal works and includes sullage from open drains.

(f) *stream* includes— river; water course; inland water; sub-terranean waters; sea or tidal waters

(g) *trade effluent* includes any liquid, gaseous or solid substance which is discharged from any premises used for industry, operation or process, or treatment and disposal system other than domestic sewage.

(II) THE CENTRAL AND STATE BOARDS FOR THE PREVENTION AND CONTROL OF WATER POLLUTION

The Central Board shall consist of the following members, namely:—

A full-time chairman; officials, not exceeding five to be nominated by the Central Government to represent that Government; officials, not exceeding five, to be nominated by the Central Government from amongst the members of the State Boards; non-officials, not exceeding three to be nominated by the Central Government, to represent the interests of agriculture, fishery or industry or trade; two persons to represent the companies or corporations; a full-time member-secretary.

The State Board shall consist of the following members, namely:—

(a) a chairman; officials, not exceeding five to be nominated by the State Government to represent that Government; officials, not exceeding five to be nominated by the State Government from amongst the members of the local authorities functioning within the State; non-officials, not exceeding three to be nominated by the Central Government, to represent the interests of agriculture, fishery or industry or trade; two persons to represent the companies or corporations; a full-time member-secretary.

(III) JOINT BOARDS

Constituted by two or more Governments of contiguous States, or by the Central Government (in respect of one or more Union territories) and one or more Governments of States contiguous to such Union territory or Union territories.

(IV) POWERS AND FUNCTIONS OF BOARDS

A. Functions of Central Board

(a) To advise the Central Government on any matter concerning the prevention, control or abatement of water pollution.

(b) To co-ordinate activities of state boards and resolve disputes among them.

(c) To plan and execute a nation-wide programme for the prevention, control or abatement of water pollution.

(d)To provide technical assistance and guidance to the State Boards, carry out and sponsor investigations and research relating to problems of water pollution and prevention, control or abatement of water pollution.

(e)To lay down, modify or annual, in consultation with state board the standards for stream or well.

(f)To collect, compile and publish data relating to water pollution and the measures devised for its effective prevention, control or abatement of water pollution.

Functions of State Boards

(a) To plan and execute comprehensive programme for the prevention, control or abatement of streams and wells.

(b) To advise the State Government on any matter concerning the prevention, control or abatement of water pollution.

(c) To collect and disseminate information relating to water pollution.

(d)To collaborate with the Central Board in organising the training for prevention, control or abatement of water pollution and to organise mass-education programme.

(e) To inspect and review plans, specifications or works for the purification and the system for the disposal of sewage or trade effluents.

(f) To lay down, modify or annul effluent standards for the sewage and trade effluents and for the quality of receiving waters.

(g) To evolve economical and reliable methods of treatment of sewage and trade effluents and utilisation of sewage and suitable trade effluents in agriculture.

(h) To lay down standards of treatment of sewage and trade effluents to be discharged into any particular stream.

(V) PREVENTION AND CONTROL OF WATER POLLUTION

(a)A State Board or any officer empowered by shall have power to take for the purpose of analysis samples of water from any stream or well or samples of any sewage or trade effluent.

(b)No person shall knowingly cause or permit any poisonous, noxious or polluting matter to enter into any stream or well or sewer or on land.

(d)Any person aggrieved by an order made by the State Board may, within thirty days from the date on which the order is communicated to him, shall made an appeal to the appellate authority.

(c)Where it appears to the State Board that any poisonous, noxious or polluting matter is present in any stream or well or has entered into it due to any accident, it shall issue orders immediately restraining or prohibiting the person concerned from discharging any poisonous, noxious or polluting matter and remedying or mitigating any pollution.

(d) No person without consent of the State Board can establish any industry, operation or any treatment and disposal system or an extension which is likely to discharge sewage or trade effluent into a stream or well sewer.

(VI) FUNDS, ACCOUNTS AND AUDIT

The Central Government in each financial year make contributions to the State Boards to enable the State Board to perform their functions under this Act. Every State Board shall also have its own fund for the purposes of this Act. The accounts of the Board shall be audited by a duly qualified auditor.

(VII) PENALTIES AND PROCEDURES

Whoever contravenes any of the provisions of this Act shall be punishable with imprisonment which may extend to three months or with fine which may extend to ten thousand rupees or with both, and in the case of a continuing contravention or failure, with an additional fine which may extend to five thousand rupees

for every day during which such contravention or failure continues after conviction for the first such contravention or failure.

(VIII) MISCELLANEOUS

(a) Establishment of Central Water Laboratory and State Water Laboratory

(b) Appointment of Analysts for the purpose of analysis of samples of water or of sewage or trade effluent.

(c) The Central government has the power to supersede the Central board or Joint board. State Government can also supersede the State board.

Amendments

This Act was amended in 1988 for the prevention and control of water pollution, and for the maintaining or restoring

ENERGY RESOURCES: GROWING ENERGY NEEDS, RENEWABLE & NON-RENEWABLE ENERGY SOURCES, USE OF ALTERNATE ENERGY RESOURCES

ENERGY RESOURCES

Most commonly, we define Energy as capacity to do work. Energy can be defined in a number of ways. In the broad sense, energy means the capacity of something – a person, an animal, or a physical system (machine) – to do work and produce change. It can be used to describe someone doing energetic things such as running, talking, and acting in a lively and vigorous way. It is used in science to do describe the part of the market where energy itself is harnessed and sold to consumers. The resources from which energy is derived or resources used to do work are called as energy resources.

Energy plays a key role in the process of economic growth of a nation. The industrial development of any country is dependent on the organised development of its power resources. Energy is also indispensable for agriculture, transport, business and domestic requirements. In fact, electricity has such a wide range of applications in modern economic development that its per capita consumption is, to a great extent, an index of the material advancement of the country.

Global Energy Consumption Pattern: About 24 percent of energy consumed globally, is used for transportation, 40 percent for industries, 30 percent for domestic and commercial purposes and the rest 6 percent for other uses including agriculture. There is a wide disparity in energy consumption in developed and industrialized countries and developing countries.

On the other hand, industrialized nations, with only 25 percent of global population, account for 70 percent of the commercial energy consumption. India, with 16 percent of world's population, accounts for just 3 percent of the total energy consumption.

Energy Consumption Pattern in India: India with 16 % of the world's population consumes only 1.5 % of the total energy produced in the world in comparison to U.S.A. which has 6.25% population of the world and utilizes 33% of the energy.
India's per capita consumption of commercial energy that is energy from coal, petroleum and hydroelectric energy is very low. It is only one eighth of the world average.

Indian industries claim a large share (about 38.5%) of the total energy followed by transportation (about 31.2%), domestic establishment (about 13.7%) and the rest in agriculture (about 17%).

Share of various energy sources in the commercial consumption of energy in India mostly comes from the coal (about 56%) and petroleum (about 32%). The other sources are hydroelectric, nuclear power, natural gas etc.

Growing Energy Needs in the World: The International Energy Agency (IEA) has released a central scenario showing a 37% increase in global primary energy demand by 2040. Two-thirds of this growth in demand will come from non-OECD countries, with China leading until the mid-2020s before India picks up the slack as from 2025. Meanwhile, demand for energy in sub-Saharan Africa is expected to rise 80% by 2040, fuelled in particular by strong demographic growth that will see the population double to almost 1.8 billion. Despite this strong growth, however, non-OECD countries will still consume far less energy per capita than their rich-world counterparts did in the 1970s (at comparable levels of GDP per capita).

According to latest findings published in the International Energy Agency's (IEA) newest resource, the Global Energy and CO2 Status Report, 2017, which provides an up-to-date snapshot of recent trends and developments across all fuels. Global energy demand rose by 2.1% in 2017, more than twice the previous year's rate, boosted by strong global economic growth, with oil, gas and coal meeting most of the increase in demand for energy, and renewables seeing impressive gains. Overall, renewables had the highest growth rate of any fuel last year. Accordingly, new findings show that over 70% of global energy demand growth was met by oil, natural gas and coal, while renewables accounted for almost all of the rest.

Growing Energy needs in India:

India, the second largest populated nation in the world with more than a billion people has an economy which is growing at nearly 8% over the last decade and about 6% on the average since her independence in 1947 and it is expected that India's economy will go more or less the same rate if not go higher even till 2050, which will naturally demand enormous amounts of energy.
Though India is presently the fourth largest electricity producing country in the world, her per capita energy consumption (500 kWh) is rather small, which is only about 1/2 of China, 1/4 of World average and about 1/13th of developed nations.
In India commercial energy accounts for a little over half of the total energy used in the country, the rest coming from non commercial sources. Share of agriculture in commercial energy consumption has risen rapidly over the past 4 decades. Industry consumes about 80% of the coal and 70% of the electrical energy in India. The transport sector accounts for 65% of the total oil consumption. The energy consumption of household sector has also increased due to air conditioners, refrigerators and other electrical appliances. India has to increase not only the indigenous availability but also aim at efficient utilization of energy.

RENEWABLE AND NON-RENEWABLE ENERGY SOURCES

Energy resources are classified in different types based on different parameters. Commonly, like other natural resources, energy resources are also classified as renewable and non-renewable.

A) **Renewable Energy Resources:**
Renewable energy resources are mostly biomass-based and are available in unlimited amount in nature since these can be renewed (i.e. regenerated in natural process) over relatively short period of time. Renewable energy sources are inexhaustible, i.e. they can be replaced after we use them and can produce energy again and again.
These include, firewood (or fuel wood) obtained from forest, petro plants, plant biomass (as agricultural wastes like bagasse), animal dung, solar energy, wind energy, water energy (hydro-electrical, ocean wave

and tidal energy), and geothermal energy etc. These can reproduce themselves in nature and can be harvested continuously through a sustained proper planning and management.

B) **Non-renewable (Exhaustible) Energy Resources:**

Non-renewable energy resources are available in limited amount and develop over a longer period of time. As a result of unlimited use, they are likely to be exhausted one day. These include various fossil fuels including petroleum products, coal and natural gas and nuclear energy. Nuclear energy is mainly obtained from the nuclear fission of the uranium and thorium. The global resources of fossil fuel and uranium and thorium are limited and will be eventually be depleted. Moreover, use of fossil fuels for energy has negative environmental consequences, such as air pollution, global warming, acid rains and oil spills. Thus, it has been become essential to minimize the use of fossil fuels and to replace them with renewable resources.

Energy sources are also classified as Conventional and Non-conventional sources.

A) **Conventional Sources of Energy:** The sources of energy which have been in use for a long time, e.g., coal, petroleum, natural gas and water power. They are exhaustible except water. They cause pollution when used, as they emit smoke, ash and other pollutant gases. They are very expensive to be maintained, stored and transmitted as they are carried over long distance through transmission grid and lines.

B) **Non-Conventional Sources of Energy:** The resources which are yet in the process of development over the past few years. It includes solar, wind, tidal, biogas, and biomass, geothermal. They are inexhaustible and are generally pollution free. They can also be called as Alternate sources of energy.

NON-RENEWABLE ENERGY SOURCES

1. **Coal:** Coal is a solid fossil fuel formed in several stages as buried remains of land plants that lived 300-400 million years ago and were subjected to intense heat and pressure over millions of years.The most thorough assessment was carried out in 2006, stating that coal resources suitable for energy production amount to 1.081 trillion tons. Although coal is considered a widely distributed deposit and found in all continents, extraction is economically grounded and concentrated only in **four major countries**: USA (27%), Russia (17%), China (13%) and India (10%). These countries provide ~65% of coal extraction in the world. Coal is ranked depending on how much "carbonization" it has gone through. Carbonization is the process that ancient organisms undergo to become coal. Peat is the lowest rank of coal. It has gone through the least amount of carbonization. Anthracite is the highest rank of coal with Carbon content of 90%, Carbon content of Bituminous coal, Lignite and Peat are 80%, 70% and 60% respectively.

   Advantages and Disadvantages
   Coal is a reliable source of energy and we can rely on it day and night, summer and winter, sunshine or rain, to provide fuel and electricity.
   When coal is burned, it releases many toxic gases and pollutants into the atmosphere. Mining for coal can also cause the ground to cave in and create underground fires that burn for decades at a time.

2. **Petroleum**

   Petroleum is a liquid fossil fuel. It is also called oil or crude oil. Most of the world's Petroleum is trapped by underground rock formations deep under the ground. We drill through the earth to access he oil. Some deposits are on land, and others are under the ocean floor. Once oil companies begin drilling with a "drill rig," they can extract petroleum 24 hours a day, seven days a week, 365 days a

year. Many successful oil sites produce oil for about 30 years. Sometimes they can produce oil for much longer.

When oil is under the ocean floor, companies drill offshore. They must build an oil platform. Oil platforms are some of the biggest manmade structures in the world. Once the oil has been drilled, it must be refined. Oil contains many chemicals besides carbon, and refining the oil takes some of these chemicals out. About half of the world's petroleum is converted into gasoline. The rest can be processed and used in liquid products such as nail polish and rubbing alcohol, or solid products such as water pipes, shoes, crayons, roofing, vitamin capsules, and thousands of other items.

Advantages and Disadvantages

There are advantages to drilling for oil as it is relatively inexpensive to extract. It is also a reliable and dependable source of energy and money for the local community.

Oil provides us with thousands of conveniences. In the form of gasoline, it is a portable source of energy that gives us the power to drive places. Petroleum is also an ingredient in many items that we depend on.

However, burning gasoline is harmful to the environment. It releases hazardous gases and fumes into the air that we breathe. There is also the possibility of an oil spill. If there is a problem with the drilling machinery, the oil can explode out of the well and spill into the ocean or surrounding land. Oil spills are environmental disasters, especially offshore spills. Oil floats on water, so it can take a toll on fishes, other aquatic life and ruin birds' feathers.

3. Natural Gas

Natural gas is another fossil fuel that is trapped underground in reservoirs. It is a mixture of 50-90% methane and small amounts of other hydrocarbons. Natural gas is formed by decomposition of dead plants and animals buried under oceans at high temperature and pressure for millions of years. Natural gas is found in deposits a few hundred meters underground. In order to get natural gas out of the ground, companies drill straight down. However, natural gas does not form in big open pockets. Natural gas is trapped in rock formations that can stretch for kilometers. It can be in two forms:

1. **Dry gas:** Natural gas containing low hydrocarbons like ethane, it is called dry gas.
2. **Wet gas:** Natural gas containing high hydrocarbons like propane and butane along with methane is called wet gas.

Natural gas can also be turned into a liquid form, called liquid natural gas (LNG). LNG is much cleaner than any other fossil fuels. Liquid natural gas takes up much less space than the gaseous form. The amount of natural gas that would fit into a big beach ball would fit into a ping-pong ball as a liquid. LNG can be easily stored and used for different purposes. LNG can even be a replacement for gasoline.

Advantages and Disadvantages

Natural gas is relatively inexpensive to extract, and is a "cleaner" fossil fuel than oil or coal. When natural gas is burned, it only releases carbon dioxide and water. This is healthier than burning coal.

However, extracting natural gas can cause environmental problems. Fracturing rocks can cause mini-earthquakes. The high-pressure water and chemicals that are forced underground can also leak to other sources of water. The water sources, used for drinking or bathing, can become contaminated and unsafe.

4. Liquified Petroleum Gas (LPG)

The petroleum gas obtained during crackling and fractional distillation can be easily converted into liquid under high pressure as LPG. LPG is a colourless, odourless gas to which mercaptans are added

to produce foul smell that aids in detection of LPG leaks. It can be easily stored, transported and is widely used for cooking in our country.

5. Nuclear Energy

Nuclear energy is usually considered another non-renewable energy source. Although nuclear energy itself is a renewable energy source, the material used in nuclear power plants is not. Nuclear energy harvests the powerful energy in the nucleus, or core, of an atom. Nuclear energy is released through nuclear fission, the process where the nucleus of an atom splits. Nuclear power plants are complex machines that can control nuclear fission to produce electricity.

The material most often used in nuclear power plants is the element uranium. Although uranium is found in rocks all over the world, nuclear power plants usually use a very rare type of uranium, U-235. Uranium is a non-renewable resource.

Nuclear energy is produced by two types of reactions:

(i) Nuclear fission: Nuclear fission is a nuclear chain reaction in which the heavy nucleus is split into lighter nuclei by fast moving neutrons thereby releasing a large amount of energy.

Example: Fission of Uranium 235

(ii) Nuclear fusion: Nuclear fusion is a nuclear chain reaction in which lighter nucleus is combined together at extremely high temperatures to form heavy nucleus thereby releasing large amount of energy.

Example: Fusion of Dueterium atoms to form helium with release of large amount of energy.

India has 10 nuclear reactors that produce 2% of India's electricity. Nuclear power plants have been established in India in Kaiga (Karnataka), Kakrapar (Gujarat), Kundankulam (T.N.), Tarapur (Maharashtra), Rana Pratap Sagar (Rajasthan),Kalpakkam (Tamil Nadu),Narora (Uttar Pradesh) etc

Advantages and disadvantages:

Nuclear energy is a popular way of generating electricity around the world. Nuclear power plants do not pollute the air or emit greenhouse gases. They can be built in rural or urban areas, and do not destroy the environment around them.

However, nuclear energy is difficult to harvest. Nuclear power plants are very complicated to build and run. Many communities do not have the scientists and engineers to develop a safe and reliable nuclear energy program.

Nuclear energy also produces radioactive material. Disposal of nuclear waste is an important concern. Radioactive waste can be extremely toxic, causing burns and increasing the risk for cancers, blood diseases, and bone decay among people who are exposed to it.

6. Petroleum: Petroleum or crude oil is a thick liquid consisting of more than 100 combustible hydrocarbons with small amounts of S, O and N as impurities. Fossil fuels are mainly formed by the decomposition of dead plants and animals that were buried under lakes and oceans at a high temperature and pressure for millions of years. From the crude petroleum oil, various hydrocarbons are separated by fractional distillation of crude petroleum oil. At the present rate of usage, the world's crude oil reserves are expected to get over in the next 30 years.

Alternate sources of energy: (Non-Conventional / Renewable Sources of Energy)

Typically, Alternative energy sources encompass all those energy options that do not consume fossil fuel. They are widely available and environment friendly and cause little or almost no pollution. There have been several alternative energy projects running in various countries to reduce our dependence on traditional fossil fuels. Important alternate sources of energy are discussed below:

1. SOLAR ENERGY

The energy that we get directly from the sun is called solar energy. Nuclear fusion occurring in the sun releases enormous amount of energy in the form of heat and light. Several techniques are available for collecting, converting and using solar energy.

Methods of harvesting solar energy

Various devices used to harvest solar energy are:

a. **Solar cells** or **Photovoltaic cells** or **PV cells**: Solar cells consist of a p-type semiconductor (Silicon doped with Boron) and n-type semiconductor (Silicon doped with Phosphorus) in close contact with each other. When solar rays fall on the top p-type semiconductor, the electrons from the valence band move to the conduction band and cross the p-type junction into the n-type semiconductor. A potential difference is created causing an electric current to flow. These cells are widely used in calculators, electronic watches, street lights, water pumps to radio and television.

b. **Solar battery**: When several solar cells are connected in series, it forms a solar battery. These solar batteries generate enough electricity to run water pumps, street lights, etc. They are mainly used in remote areas where electricity supply is a problem.

c. **Solar heat collectors**: Solar heat collectors consist of natural materials like stones, bricks, or materials like glass, which absorb heat during the day time and release it slowly in the night. It is generally used in cold places where houses are kept in hot condition using solar heat collectors.

d. **Solar water heaters:** It consists of an insulated box, in which is painted black on the inside. It is provided with a glass lid to receive and store solar heat. The box contains a copper coil painted in black through which cold water flows in, gets heated in the copper coil and flows into a storage tank. Finally, water from storage tanks is supplied.

Few other applications of solar energy are: Solar cooker, Solar dryer and Solar refrigerator etc.

2. WIND ENERGY

Wind is defined as moving air. Energy recovered from the force of wind is called wind energy. Wind energy is harnessed by the use of wind mills.

a. **Wind mills**: The force of blowing wind strikes the blades of the wind mill thereby causing it to rotate continuously. This rotational energy of the blades is used to drive several machines like water pump, flour mill and electric generators.

b. **Wind farms**: Several wind mills joined together in a definite pattern forms a wind farm. Wind farms generate large amounts of electricity.

Condition: The minimum speed required for satisfactory working of a wind generator is 15 kmph.

3. OCEAN ENERGY

Ocean can be used for generating electricity:

a.. **Tidal energy:** Ocean tides produced by virtue of gravitational force of sun and moon possess enormous amounts of energy. Tidal energy can be harnessed by constructing a tidal barrage. During high tide, sea-water is allowed to flow into reservoir of the barrage and rotate the turbine thereby producing electricity.

During low tide, when sea level is low, sea water stored in the barrage reservoir is allowed to flow into the sea thereby rotating the turbine again.

b. **Ocean thermal energy conversion (OTEC):** There is a large temperature difference between surface level and deep water level of tropical oceans. This temperature difference can be utilized to generate electricity. This energy is called ocean thermal energy. A necessary condition is that temperature difference of at least 20ºC is required between surface water and deep water. The technique used here is that the relatively hot surface temperature of the ocean is used to boil a low boiling liquid like ammonia. The high vapour pressure of the liquid formed by boiling is used to turn the blades in a turbine and generate electricity. The cool waters in the deep sea are used to cool and condense the vapor into liquid.

4. GEO-THERMAL ENERGY

Temperature of the earth increases at the rate of 20 -75ºC per km. Down below the earth's surface, high pressure and high temperature steam fields exist in many places. The energy harnessed from high temperature present inside the earth's surface is called geothermal energy.

a. Natural Geysers: In some places, steam comes out of ground through cracks naturally in the form of natural geysers.

b. Artificial Geysers: Sometimes, a hole is drilled up to the hot region and by sending a pipe in it, the steam is made to rush-out through the pipe with very high pressure.

The steam coming out of natural or artificial geysers is made to rotate the turbine of a generator to produce electricity.

5. BIOMASS ENERGY

Biomass is organic matter produced by plants or animals. It is used as a source of energy. Biomass is generally burnt for heating, cooling and industrial purposes.

Example: wood, crop residues, seeds, cattle dung, sewage, agricultural wastes, etc.

Biomass may be converted into energy in any of the following types:

1. **Biogas**: Biogas is a mixture of gases such as methane, carbon dioxide, hydrogen sulphide, etc. It contains about 65% of methane gas as a major constituent. Biogas is obtained by the anaerobic fermentation of animal dung or plant wastes in the presence of water.
2. **Biofuels**: Biofuels are the fuels, obtained by the fermentation of biomass. Examples are Ethanol, Methanol.
   (i) **Ethanol**: Ethanol can be produced by sugarcane. Its calorific value is less when compared to petrol and therefore produces much less heat than petrol.
   (ii) **Methanol**: Methanol can be easily obtained from ethanol or sugar containing plants. Its calorific value is also too low when compared to gasoline and petrol.
   (iii) **Gasohol**: Gasohol is a mixture of ethanol and gasoline.
3. **Hydrogen fuel**: Hydrogen produced by some algae and bacteria. E.g. Chlorella, *Citobacter freundii*.

Hydrogen can be produced by thermal dissociation or photolysis or electrolysis of water. It possesses high calorific value. It is non-polluting as the product of combustion is water.

Disadvantages of Hydrogen fuel

(i) Hydrogen is highly flammable and explosive in nature.
(ii) Safe handling is required
(iii) It is difficult to store and transport

CASE STUDIES

Wind energy India is generating 1200 MW electricity using wind energy. The largest wind farm is in Kanyakumari in Tamil Nadu, which generates 380 MW electricity.

Hydrogen-Fuel cell car General motor company of china invented experimental cars that run on electric motors fueled by hydrogen and oxygen. These cars produce no emission and the only waste products being water droplets and water vapour.