LECTURE NOTES OF

ENVIRONMENTAL STUDIES

3RD SEMESTER ETC

PREPARED BY- LINCOLN MOHANTY

GOVERNMENT POLYTECHNIC DHENKANAL

DEPARTMENT OF ELCTRONICS AND TELECOMMUNICATION ENGINEERING

Syllabus

Unit 1: The Multidisciplinary nature of environmental studies

Definition, scope and importance, Need for public awareness.

Unit 2: Natural Resources

Renewable and non-renewable resources:

a. Natural resources and associated problems.

- Forest resources: Use and over-exploitation, deforestation, case studies, Timber extraction mining, dams and their effects on forests and tribal people.
- Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dam's benefits and problems.
- Mineral Resources: Use and exploitation, environmental effects of extracting and using mineral resources.
- Food Resources: World food problems, changes caused by agriculture and over grazing, effects of modern agriculture, fertilizers- pesticides problems, water logging, and salinity.
- Energy Resources: Growing energy need, renewable and non-renewable energy sources, use of alternate energy sources, case studies.
- Land Resources: Land as a resource, land degradation, man induces landslides, soil erosion, and desertification.

b. Role of individual in conservation of natural resources.

c. Equitable use of resources for sustainable life styles.

Unit 3: Systems

- Concept of an ecosystem.
- Structure and function of an ecosystem.
- Producers, consumers, decomposers.
- Energy flow in the ecosystems.
- Ecological succession.
- Food chains, food webs and ecological pyramids.

- Introduction, types, characteristic features, structure and function of the following ecosystem:
  - Forest ecosystem.
  - Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries).

Unit 4: Biodiversity and its Conservation

- Introduction-Definition: genetics, species and ecosystem diversity.
- Biogeographically classification of India.
- Value of biodiversity: consumptive use, productive use, social ethical, aesthetic and optin values.
- Biodiversity at global, national and local level.
- Threats to biodiversity: Habitats loss, poaching of wild life, man wildlife conflicts.

Unit 5: Environmental Pollution.

Definition, Causes, effects and control measures of:

a) Air pollution.
b) Water pollution.
c) Soil pollution.
d) Marine pollution
e) Noise pollution.
f) Thermal pollution
g) Nuclear hazards.

Solid waste Management: Causes, effects and control measures of urban and industrial wastes.

Role of an individual in prevention of pollution.

Disaster management: Floods, earth quake, cyclone and landslides.

Unit 6: Social issues and the Environment

- Form unsustainable to sustainable development.
- Urban problems related to energy.

- Water conservation, rain water harvesting, water shed management.
- Resettlement and rehabilitation of people; its problems and concern.
- Environmental ethics: issue and possible solutions.
- Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust, case studies.
- Air (prevention and control of pollution) Act.
- Water (prevention and control of pollution) Act.
- Public awareness.

Unit 7: Human population and the environment

- Population growth and variation among nations.
- Population explosion- family welfare program.
- Environment and human health.
- Human rights.
- Value education
- Role of information technology in environment and human health.

Syllabus upto 1st internal was unit 1, 2, and 3.

1	Textbook of Environmental studies	Erach Bharucha	# UGC
2	Fundamental concepts in Environmental Studies	D.D. Mishra	S.Chand & Co-Ltd
3	Text book of Environmental Studies	K.Raghavan Nambiar	SCITECH Publication Pvt. Ltd

4	Environmental Engineering	V.M.Domkundwar	Dhanpat Rai & Co

IMPORTANT DAYS OF ENVIRONMENTAL SIGNIFICANCE

1. World Environment Day 5th June
2. World Nature Day 3rd October
3. World Population Day 11th July
4. World Forest Day 21st March
5. World Health Day 7th April
6. National Science Day 28th February
7. Earth Day 22nd April
8. Anti-Tobacco Day 31st May
9. World Food Day 16th October
10. Wild Life Week 1-7th October
11. National Environmental
12. Awareness Month 19th Nov.-18th Dec.
13. United National Day 24th October
14. Ozone Day 16th September

Notes

Unit 1: The Multidisciplinary nature of environmental studies

Definition, scope and importance, Need for public awareness.

Definition

The term Environment has been derived from a French word 'environner' which means to encircle or to surround (Junaid). The term 'environment' means surroundings, in which the organisms live (JP Sharma). It has two components: abiotic (non-living) and biotic (living) components.

Different components of the environment are interlinked and interdependent.

Environment creates favourable conditions for the existence and development of living organisms.

United Nations Environment Programme (UNEP) defines environment as "the whole outer physical and biological system in which man and other organisms live".

P. Gisbert says, "Environment is anything immediately surrounding an object and exerting a direct influence on it".

According to **E. J. Ross**, "environment is an external force which influences us".

As per **Environment (Protection) Act of 1986**, environment refers to the "sum total of air, water and land and the interrelationships among themselves and also with the human beings, other living organisms or property."

Types of Environment

On the basis of proximity or nearness and the nature of the influences exerted on the organisms by the environment it can be of following types

a. Micro-environment: It refers to the immediate local surroundings of an organism.

b. Macro-environment: It refers to all the physical and biotic conditions that surround the organism externally.

Similarly on the basis of the composition or nature of the environmental components following types of environment can be enumerated.

a. Terrestrial environment where a major components of environment is land

b. Aquatic environment where water forms the major portion of an individual's environment

c. Aerial environment where air is the dominant environmental factor

Components of environment

a. Physical Environment or Physical component of environment - all abiotic factors or conditions like soil, minerals, temperature, light, rainfall, etc.

b. Biological environment or Biological component of environment - includes all biotic factors or living forms like plants, animals and micro-organisms.

c. Social environment or Social component of environment - includes an individual's social, economic and political condition wherein he lives.

Physical Environment

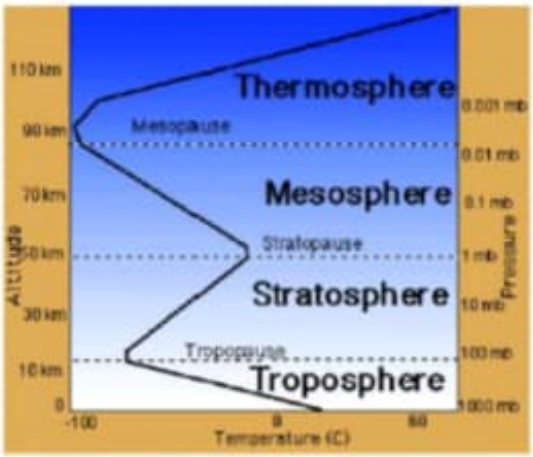
The main physical components of the environment are:

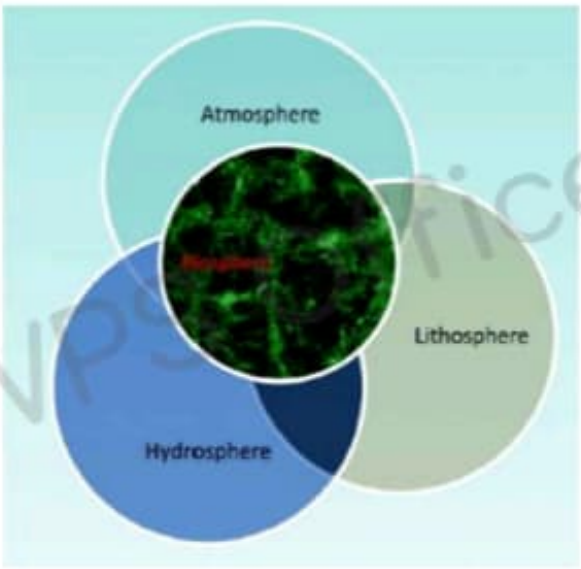
a. The Atmosphere or the air

b. The Hydrosphere or the water

c. The Lithosphere or the rocks and the soil

d. The Biosphere or the living communities taken together. This component is sometimes studied as a separate type of environment and is known as Biotic environment.





Scope of Environmental Science (junaid)

- Environmental Sciences is concerned with human welfare. Its main objectives are sustainability and better future.
- It attempts to understand the global environmental problems and suggest corrective measures at local and global levels.
- It deals with every general problem that mankind confronts and thus covers entire domain of human activities. Its scope, therefore, encompasses the whole humanity.
- The scope of environmental studies is that, the current trend of environmental degradation can be reversed if people of educated communities are organized and empowered.

Importance of Environmental Science

- Environment provides us a life support system i.e. from the environment that we get food to eat, water to drink, air to breathe and all necessities of day to day life.
- Our life heavily depends on components of environment like air, water, earth and biodiversity. Any disturbance to any of these components will badly affect our healthy life.
- To increase the knowledge about global warming, depletion of ozone layer etc. which are going to affect the mankind.
- To protect the environment from various problems like river or lake pollution, soil erosion, water logging and salinization of soil, arsenic pollution of groundwater etc.
- Environmental studies is very important since it deals with the individual issues like safe and clean drinking water, hygienic living conditions, clean and fresh air, fertile land, healthy food and sustainable development.
- Environment studies greatly influences the sustainable development.
- It need for wise planning of development

Need for public awareness

- With the advancement in technology, explosive increase in human population, scarcity of space and food, deterioration of hygienic conditions, depletion of natural resources one needs extensive and exhaustive study of the environment, particularly in relation to human survival and benefit.
- Public awareness was needed as the earth's natural resources are dwindling and our environment is being increasingly degraded by human activities.
- The goals of sustainable development cannot be achieved by any government alone until public participation. It is possible only when the public is aware about the ecological and environmental issues.
- The public has to be educated about the fact that if we are degrading our environment we are actually harming our own selves.
- Public awareness has most important to save the environment from massive degradation.

Unit 2: Natural Resources

Renewable and non-renewable resources:

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Natural Resources

- Any material which is naturally available and can be used or transformed to be used for wellbeing is called a Natural Resource.
- Natural resource is anything that we can use & which cmes from nature.
- Air, water, sun, wood, oil, iron, and coal etc are all examples of natural resources.
- Natural resources must be

1. naturally occurring on the earth.
2. Useful to human being directly or indirectly.
3. Accessible to man.

Classification of Natural Resources

- On the basis of **origin,** natural resources are

1. Biotic such as forest, food, etc
2. Abiotic such as water, air, land, minerals, etc

- On the basis of **nature**

1. Organic such as fruits, fibres, etc
2. Inorganic such as coal, mica, gold, etc

- On the basis of **renewability**

1. Renewable resources:- Resources which can be renewed along with their utilization & are available for use. Eg: forest, solar energy, wind energy, water, wood, etc.
2. Non-renewable resources:- The formation of some resources like ore, coal, mineral, oil, etc. has taken several thousannd years. Once they used they cannot be easily replaced. These resources are known as Non-renewable resources. These resource takes very long time to come back.

Forest Resources

- Forests are one of the most important natural resources on the earth.
- A forest is a large area on land dominantly covered by trees or other woody vegetation.
- It provides material goods as well as environmental services which are essential.
- According to the United Nations Food and Agriculture Organization forests cover about 30% of world's land area.
- In India, forests covers about 27% area.

Forests can be broadly be classified as:

- Boreal forests: These are forests in subarctic region and are generally evergreen and coniferous.
- Temperate zone forests: They include both broadleaved deciduous forests and evergreen coniferous forests.
- Tropical and subtropical forests: They include tropical and subtropical moist, dry and coniferous forests.

Uses of Forests

Some of the major uses of forest resources are summarised as below

1. Economic uses:
    - Forests provide us a large number of commercial goods which include timber, firewood, pulpwood, food items, gum, resins, non-edible oils, rubber, fibres, lac, bamboo canes, fodder, medicine, drugs and many more items.
    - Half of the timber cut each year is used as fuel for heating and cooking.
    - One third of the wood harvest is used for building materials as lumber, plywood and hardwood, particle board and chipboard.
    - One sixth of the wood harvest is converted into pulp and used in paper industry.

2. Ecological uses:

The ecological services provided by our forests may be summed up as follows:

- Production of oxygen: The trees produce oxygen by photosynthesis which is vital for life on this earth. They are rightly called as earth's lungs.
- Reducing global warming: The main greenhouse gas carbon dioxide (CO_2) is absorbed by the forests as a raw material for photosynthesis. Thus it helps to huge reduction of CO_2 & due to this reason it helps to reducing the problem of global warming.
- Wildlife habitat: Forests are the homes of millions of wild animals and plants. About 7 million species are found in the tropical forests alone.
- Regulation of hydrological cycle: Forests absorbs the rainfall, slows down the runoff and slowly releasing the water for recharge of springs. About 50–80 % of the moisture in the air above tropical forests comes from their transpiration which helps in bringing rains.
- Soil conservation: Forests bind the soil particles tightly in their roots and prevent soil erosion.
- Wind erosion: They also act as wind-breaks. In deserts, trees reduce wind erosion.
- Maintains Ecological Balance: The forest check pollution of air through increasing oxygen content of the air.
- Control Floods: The floods are controlled because forests dry up rainwater like sponge.
- Environment Quality: The forest enchance the quality of environment by influencing the life supporting system.
- Pollution moderators: Forests can absorb many toxic gases and can help in keeping the air pure. They have also absorb noise and thus help in preventing air and noise pollution.

Over-exploitation of Forests

- Humans heavily depend on forests for food, medicine, shelter, wood and fuel.
- With growing civilization and increasing population the demands for raw materials like timber, pulp, minerals, fuel wood etc. has increased. This results in large scale logging, mining, road-building and clearing of forests.

- Excessive use of fuel wood and charcoal, expansion of urban, agricultural and industrial areas, etc. have together led to over- exploitation of our forests resources leading to rapid degradation.
- Our forests contribute substantially to the national economy. The international timber trade alone is worth over US $ 40 billion per year.

Deforestation

- Large scale degradation of forest cover also known as Deforestation.

  Or
- Deforestation is the process of felling or removal of trees from the forest.
- Over-exploitation of forest resources leading to deforestation.

Causes of Deforestation

- According to the United Nations Framework Convention on Climate Change (UNFCCC) secretariat, Subsistence farming is responsible for 48% of deforestation; commercial agriculture is responsible for 32% of deforestation; logging is responsible for 14% of deforestation and fuel wood removals make up 5% of deforestation.
- Deforestation occurs for many reasons like trees are cut down to be used or sold as fuel (sometimes in the form of charcoal) or timber, while cleared land is used as plantations of commodities and settlements, etc.
- Main causes responsible for deforestation are as under:
  I. Felling of trees to meet the ever increasing demand of the cities.
  II. Grazing by the local cattle, goats, sheep etc. They not only destroy the vegetation but also pull out the roots of plants.
  III. Shifting cultivation: (Jhum) As this cultivation takes short period like six years only (in some districts, even 2-3 years only), which does not provide enough time for natural repair of damaged ecosystem.
  IV. A major cause of deforestation has been the construction of hill roads. Road construction damaged the protective vegetation cover both above and below roads.
  V. Fuel requirements: Increasing demands for fuel wood by the growing population in India increases pressure on forests.

VI. Raw materials for industrial use: Wood for making boxes, furniture, railway-sleepers, plywood, match-boxes, pulp for paper industry etc. have exerted tremendous pressure on forests.

VII. Development projects: Massive destruction of forests occurs for various development projects like hydroelectric projects, big dams, road construction, mining etc.

VIII. Growing food needs: In developing countries this is the main reason for deforestation. To meet the demands of rapidly growing population, agricultural lands and settlements are created permanently by clearing forests.

IX. Commercial logging: It includes removal of forest wood for commercial purposes i.e for supplying constructional and timber wood to the local and world market.

X. Agriculture: Forest lands have been converted to agricultural farms in order to meet the food requirements of increasing population.

XI. Urbanization and industrialization: with increasing urbanisation and industrialization requirements for land are increasing. To meet this demand forests are cleared felled for settlements and for installation of industrial units.

XII. Forest fires: Natural and manmade forest fires are very common happenings in certain areas. These fires, cause huge damages to the forests world over.

Consequences of Deforestation

- Deforestation has far reaching consequences, both environmental as well as economic. Some of the major consequences are outlined as below:

I. Loss of wildlife: There are millions of animal and plant species living in forests. It threatens the existence of many wild life species due to destruction of their natural habitat.

II. Biodiversity loss: This is the most serious consequence of deforestation. Deforestation simply means the destruction and extinction of many plants and animal species.

III. Displacement of indigenous communities: Many indigenous groups of people live in and around forests. They draw all of their needs and necessities from nearby forests. It threatens their survival.

IV. Climate change: Deforestation can cause the climate to become extreme in nature. It increases CO_2 concentration in atmosphere and contributes to global warming.

V. Economic losses: Forests helps in tackling of flood and drought problems. When there are no forests, the economic losses due to floods and droughts become a huge burden on a nation's economy.

VI. Hydrological cycle gets affected, thereby influencing rainfall.

VII. Soil degradation: Due to loss of forest cover soil erosion increases and its fertility declines.

VIII. Landslides: In hilly areas deforestation leads to many local problems. It increases the occurrence of landslides and floods.

CASE STUDIES

1. Desertification in hilly regions of the Himalayas

- Deforestation in Himalayas, involving clearance of natural forests and plantation of monocultures like Pinus roxburghi, Eucalyptus camadulensis etc. have upset the ecosystem by changing various soil and biological properties.
- Nutrient cycling has become poor, original rich germplasm is lost. These areas are unable to recover and are losing their fertility.
- The entire west Khasi hill district of Meghalaya in North-east Himalayas, Ladakh and parts of Kumaon and Garhwal are now facing the serious problem of desertification.

2. Waning Rainfall in Udhagamandalam (Ooty)

- The sub normal rainfall during 1965-84 at Ooty in Nilgiri mountains has been found to be closely associated with declining forest cover in this region in the past 20 years.
- The rainfall pattern was found to fluctuate with wooded land area in the hills.
- When the Nilgiri mountains had luxuriant forest cover annual rainfall used to be much higher.

3. Disappearing Tea gardens in Chhota Nagpur

This hilly region used to be a good forested area towards tea plantations. Following the destruction of forests, rainfall declined in Chhota Nagpur to such an extent that tea - gardens also disappeared from the region.

Major Activities in Forests and Their Effects on Forests and People

1. Timber Extraction:

- There has been unlimited exploitation of timber for commercial use.

- Due to increased industrial demand; timber extraction has significant effect on forest and tribal people.
- Main reason for timber extraction is logging. Logging for valuable timber, such as teak and Mahogany not only involves a few large trees per hectare but about a dozen more trees since they are strongly interlocked with each other by vines etc.
- Poor logging results in degraded forest and may lead to soil erosion especially on slopes.
- New logging roads permit shifting cultivators and fuel wood gatherers.
- Loss of long term forest productivity.
- Species of plants and animals may be eliminated.
- Exploitation of tribal people by contractor.

2. Mining:

- Mining operations for extracting minerals and fossil fuels like coal involves vast forest areas.
- Mining from shallow deposits is done by surface mining while that from deep deposits is done by sub-surface mining.

Major effects of mining operations on forest and tribal people are:

- More than 80,000 ha of land of the country is presently under the stress of mining activities.
- Mining and its associated activities require removal of vegetation along with underlying soil mantle and overlying rock masses. This results in defacing the topography and destruction of the landscape in the area.
- In Mussorie and Dehradun valley due to mining of various minerals over a length of about 40 Km, the forested area has declined at an average rate of 33% leading to landslides.
- Coal mining in Jharia, Raniganj and Singrauli areas have caused extensive deforestation in Jharkhand.
- Mining of magnesite and soap- stones have destroyed 14 ha of forest in the hill slopes at Khirakot, Kosi valley, Almora.
- Mining of radioactive minerals in Kerala, Tamilnadu and Karnataka are posing similar threats of deforestation.

- The rich forests of Western Ghats are also facing the same threat due to mining projects for excavation of copper, chromite, bauxite and magnetite.

3. Dams

- For building big dams, large scale devastation of forests takes place which breaks the natural ecological balance of the region. Floods, droughts and landslides become more prevalent in such areas.1
- The impacts caused by construction of dams and reservoir include the following effects and consequences:
  - The various change in the microclimate.
  - The loss of vegetal cover.
  - Soil erosion.
  - Variation in water table.
  - Enhanced seismic activities due to pressure of water.
- Big dams and river valley projects have multi-purpose uses and have been referred to as Temples of modern India. However, these dams are also responsible for the destruction of vast areas of forests.
- India has more than 1550 large dams, the maximum being in the state of Maharashtra (more then 600), followed by Gujarat (more then 250) and Madhya Pradesh (130).
- By constructing Sardar Sarovar (SS) Project
  - About 245 villages will be submerged, of which about 193 in M.P. alone.
  - Over 75,000 (nearly 50,000 in M.P. alone) people will be evicted.
  - Additional displacements is likely to be caused during social and environment rehabilitation work undertaken to repair the dislocation and damages caused by the project.
- By constructing Narmada Valley Project (NVP)
  - It would displace over one million people, mostly tribals.
  - It would submerge 56,000 ha fertile agriculture land.
  - Total forest areas nearly 60,000 ha. will be destroyed.
  - Nearly 25 species of birds will be deprived of their habitats.
- By constructing Bodhghat Project

- The project will destroy teak and sal forests.
- It will spell doom for the last surviving wild buffaloes.

- By constructing Tehri Dam
  - This Dam will displace over 85,000 people.
  - It will totally immerse the Tehri town and completely or partly submerge nearly 100 villages.
  - The site of the Dam is prone to intense seismic activity.
  - The 3,200 million ton of water that the Dam would impound, could cause a major earth tempor.
  - In the event of a disaster, the entire religious townships of Deoprayag, Hardwar and Rishikesh would be devastated.
  - Thousand of hectares of rich, agriculture land will be drowned.

Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dam's benefits and problems.

Water resources

- Life on the earth could originate because of the presence of water.
- About 97% of earth's surface is covered by water.
- Water is essential for maintenance of life.
- Most of the animals and plants have 60–65% water in their bodies.
- Due to its unique properties water is of multiple uses for all living organisms.
- Uptake of nutrients, their distribution in the body, regulation of temperature, and removal of wastes are all mediated through water.
- Human beings depend on water for almost every developmental activity.
- Water is used for drinking, irrigation, transportation, washing and waste disposal for industries and used as a coolant for thermal power plants.
- Water shapes the earth's surface and regulates our climate.

Surface water

- Surface water is water in a river, lake or fresh water wetland.
- Surface water is naturally replenished by precipitation and naturally lost through discharge to the oceans, evaporation, evapotranspiration and groundwater recharge.

- Although the only natural input to any surface water system is precipitation within its watershed.
- The total quantity of water is also depends on many other factors such as storage capacity in lakes, wetlands and artificial reservoirs, the permeability of the soil beneath these storage bodies, the runoff characteristics of the land in the watershed, the timing of the precipitation and local evaporation rates.
- Brazil is the country estimated to have the largest supply of fresh water in the world, followed by Russia and Canada.

Ground water

- Groundwater is fresh water located in the subsurface pore space of soil and rocks.
- It is also water that is flowing within aquifers below the water table.
- About 9.86% of the total fresh water resources are in the form of groundwater and it is about 35-50 times that of surface water supplies.

Uses of Water

1. Irrigational use:

- It is estimated that 70% of worldwide water is used for irrigation.
- It takes around 2,000 - 3,000 litres of water to produce enough food to satisfy one person's daily dietary need.
- This is a considerable amount, when compared to that required for drinking, which is between two and five litres.
- It is observed that Agriculture sector is the major user of water.

2. Industrial use:

- It is estimated that 22% of worldwide water is used in industry.
- Major industrial users include hydroelectric dams, ore and oil refineries, which use water in chemical processes, and manufacturing plants which use water as a solvent.

3. Household uses:

- It is estimated that 8% of worldwide water use is for household purposes.
- These include drinking water, bathing, cooking, toilet flushing, cleaning, laundry and gardening.

- Drinking water is water that is of sufficiently high quality so that it can be consumed or used without risk of immediate or long term harm. Such water is commonly called potable water.

4. Institutional uses:

- Water is also used in the institution such as schools, colleges, etc. for different purpose like drinking, toilet flushing, cleaning etc.
- About 5 to 10% of water used for institutional purpose.

5. Fire uses:

   About 1% of water used for fire purpose.

6. Public uses:

   Water is also used for public places for drinking, gardening etc.

Over-exploitation of Water Resources

- Water is a precious natural resource.
- It requires judicious use as its availability varies from place to place and from time to time.
- Overexploitation of surface as well as ground water has harmful effects on its future availability and on local environment.
- Excess extraction of ground water results in various types of geological and ecological complications which are detrimental to life.
- When groundwater withdrawal is more than its recharge rate, the sediments in the aquifer get compacted, a phenomenon known as ground subsidence. Here sediment also tends to come out with water leads to failure of ground.
- Mining of groundwater done in arid and semi-arid regions for irrigating crop fields may cause a sharp decline in future agricultural production, due to lowering of water table.
- With increasing human population and rapid development, the world water withdrawal demands have increased.

Rain Water Harvesting

- It is a water conservation practice that involves capturing of rain where it falls or capturing of the runoff water after or during a rainfall.
- In general, water harvesting is the activity of direct collection of rainwater.

- The rainwater collected can be stored for direct use or can be recharged into the groundwater.
- Rain is the first form of water that we know in the hydrological cycle, hence is a primary source of water for us.
- Rivers, lakes and groundwater are all secondary sources of water. In present times, we depend entirely on such secondary sources of water but rain is the ultimate source that feeds all these secondary sources.
- Water harvesting means to understand the value of rain, and to make optimum use of the rainwater at the place where it falls.
- Therefore, water harvesting can be undertaken through a variety of ways such as:

1. Capturing runoff from rooftops
2. Capturing runoff from local catchments
3. Capturing seasonal floodwaters from local streams
4. Conserving water through watershed management

- The rain water harvesting can serve the following purposes:
  I. Provide drinking water
  II. Provide irrigation water
  III. Increase groundwater recharge
  IV. Reduce urban floods and overloading of sewage treatment plants
  V. Reduce seawater ingress in coastal areas.

FLOODS

- In some countries like India and Bangladesh rainfall does not occur throughout the year, rather, 90% of it is concentrated into a few months (June-September).
- Heavy rainfall often causes floods in the low-lying coastal areas. Prolonged downpour can also cause the over-flowing of lakes and rivers resulting into floods.
- Deforestation, overgrazing, mining, rapid industrialization, global warming etc. have also contributed largely to a sharp rise in the incidence of floods.
- Floods have been regular features of some parts of India and Bangladesh causing huge economic loss as well as loss of life.
- People of Bangladesh are familiar to moderate flooding during monsoon and they utilize the flood water for raising paddy.

- Networking of rivers is being proposed at national level to deal with the problems of floods.

DROUGHTS

- There are about 80 countries in the world, lying in the arid and semiarid regions that experience frequent spells of droughts.
- When annual rainfall is below normal and less than evaporation, drought conditions are created.
- Drought is a meteorological phenomenon, but due to several anthropogenic causes like overgrazing, deforestation, mining etc. there is spreading of the deserts tending to convert more areas to drought affected areas.
- In the last twenty years, India has experienced more and more desertification, thereby increasing the vulnerability of larger parts of the country to droughts.
- In Maharashtra there has been no recovery from drought for the last 30 years due to over-exploitation of water by sugarcane crop which has high water demands.
- Carefully selected mixed cropping help optimize production and minimize the risks of crop failures.
- Social Forestry and Wasteland development can prove quite effective to fight the problem, but it should be based on proper understanding of ecological requirements and natural process.
- The Kolar district of Karnataka is one of the leaders in Social Forestry.

Conflicts over water

- Indispensability of water and its unequal distribution has often led to inter-state or international disputes.
- Issues related to sharing of river water have been largely affecting our farmers and also shaking our governments.
- Some major water conflicts are discussed here:

1. Water conflict in the Middle East:

- Three river basins, namely the Jordan, the Tigris-Euphrates and the Nile are the shared water resources for Middle East countries.
- Ethiopia controls the head waters of 80% of Nile's flow and plans to increase it.

- Sudan too is trying to divert more water.
- This would badly affect Egypt, which is a desert, except for a thin strip of irrigated cropland along the river Nile and its delta.
- The population of Egypt is likely to double in the next 20 years, thereby increasing its water crisis.
- Likewise there is a fierce battle for water among Jordan, Syria and Israel for the Jordan River water share.
- Turkey has abundant water and plans to build 22 dams on Tigris-Euphrates for Hydroelectric power generation.

2. The Indus Water Treaty:

- The Indus, one of the mightiest rivers is dying a slow death due to dams and barrages that have been built higher up on the river.
- The Sukkur barrage (1932), Ghulam Mohamad Barrage at Kotri (1958) and Tarbela and Chasma Dams on Jhelum, a tributary of Indus have resulted in severe shrinking of the Indus delta.
- In 1960, the Indus water treaty was established vide which Indus, the Jhelum and the Chenab were allocated to Pakistan and the Satluj, the Ravi and the Beas were allocated to India.
- Being the riparian state, India has pre-emptive right to construct barrages across all these rivers in Indian territory.
- However, the treaty requires that the three rivers allocated to Pakistan may be used for non-consumptive purposes by India i.e. without changing its flow and quality.
- With improving political relations between the two countries it is desirable to work out techno-economic details and go for an integrated development of the river basin in a sustainable manner.

3. The Cauvery water dispute:

- Out of India's 18 major rivers, 17 are shared between different states.
- In all these cases, there are intense conflicts over these resources which hardly seem to resolve.
- The Cauvery river water is a bone of contention between Tamilnadu and Karnataka and the fighting is almost hundred years old.

- Tamilnadu, occupying the downstream region of the river wants water-use regulated in the upstream.
- Whereas, the upstream state Karnataka refuses to do so and claims its primacy over the river as upstream user.
- The river water is almost fully utilized and both the states have increasing demands for agriculture and industry.
- The consumption is more in Tamilnadu than Karnataka where the catchment area is more rocky.
- In 1991-92 due to good monsoon, there was no dispute due to good stock of water in Mettur, but in 1995, the situation turned into a crisis due to delayed rains and an expert Committee was set up to look into the matter which found that there was a complex cropping pattern in Cauvery basin.
- Sambra paddy in winter, Kurvai paddy in summer and some cash crops demanded intensive water, thus aggravating the water crisis.
- Proper selection of crop varieties, optimum use of water, better rationing, rational sharing patterns, and pricing of water are suggested as some measures to solve the problem.

4. The Satluj-Yamuna link (SYL) canal dispute:

- The issue of sharing the Ravi-Beas waters and SYL issue between Punjab and Haryana is being discussed time and again and the case is in the Supreme Court.
- The Supreme Court on January 15, 2002 directed Punjab to complete and commission the SYL within a year, failing which the Center was told to complete it.
- However, two years have passed, but neither the SYL has been completed nor the conflict over sharing of Ravi Beas water is resolved.
- The conflict revolving around sharing of river water needs to be tackled with greater understanding and objectivity.

Big Dams- Benefits and Problems

- Benefits River valley projects with big dams have usually been considered to play a key role in the development process due to their multiple uses.
- India has the distinction of having the largest number of river-valley projects.
- These dams are often regarded as a symbol of national development.

- The tribals living in the area pin big hopes on these projects as they aim at providing employment and raising the standard and quality of life.
- The dams have tremendous potential for economic upliftment and growth.
- They can help in checking floods, generate electricity and reduce water and power shortage, provide irrigation water to lower areas, provide drinking water in remote areas and promote navigation, fishery etc.
- The environmental impacts of big-dams are also too many due to which very often the big dams become a subject of controversy. The impacts can be at the upstream as well as downstream levels.
- The upstream problems include the following:
    i. Displacement of tribal people
    ii. Loss of forests, flora and fauna
    iii. Changes in fisheries and the spawning grounds
    iv. Siltation and sedimentation of reservoirs
    v. Loss of non-forest land
    vi. Stagnation and water logging near reservoir
    vii. Breeding of vectors and spread of vector-borne diseases
    viii. Reservoir induced seismicity (RIS) causing earthquakes
    ix. Growth of aquatic weeds.
    x. Microclimatic changes.
- The downstream impacts include the following:
    i. Water logging and salinity due to over irrigation
    ii. Micro-climatic changes
    iii. Reduced water flow and silt deposition in river
    iv. Flash floods
    v. Salt water intrusion at river mouth
    vi. Loss of land fertility along the river since the sediments carrying nutrients get deposited in the reservoir
    vii. Outbreak of vector-borne diseases like malaria

- Thus, although dams are built to serve the society with multiple uses, but it has several serious side-effects. That is why now there is a shift towards construction of small dams or mini-hydel projects.

Mineral Resources: Use and exploitation, environmental effects of extracting and using mineral resources.

Mineral Resources

- Minerals are naturally occurring, inorganic, crystalline solids having a definite chemical physical properties.
- There are thousands of minerals occurring in different parts of the world. However, most of the rocks, we see everyday are just composed of a few common minerals like quartz, feldspar, biotite, dolomite, calcite, laterite etc.
- The economic development also depends on the minerals like mica, copper, lead and zinc are of vast economic importance. Thorium and uranium are atomic energy minerals.
- Based on their properties, minerals are basically of two types:
    1. Non-metallic minerals e.g. graphite, diamond, quartz, feldspar.
    2. Metallic minerals e.g. bauxite, laterite, haematite etc.
- Some Major Minerals of India:
    a) Energy generating minerals Coal and lignite: West Bengal, Jharkhand, Orissa, M.P., A.P. Uranium (Pitchblende or Uranite ore): Jharkhand, Andhra Pradesh (Nellore, Nalgonda), Meghalaya, Rajasthan (Ajmer).
    b) Other commercially used minerals Aluminium (Bauxite ore): Jharkhand, West Bengal, Maharashtra, M.P., Tamilnadu. Iron (haematite and magnetite ore): Jharkhand, Orissa, M.P., A.P., Tamilnadu, Karnataka, Maharashtra and Goa. Copper (Copper Pyrites): Rajasthan (Khetri), Bihar, Jharkhand, Karnataka, M.P., West Bengal, and Andhra Pradesh.

Uses of Mineral Resources

- The main uses of minerals are as follows:
    a. Development of industrial plants and machinery. e.g. iron, coal, aluminium, lead chromium, nickel, mercury, cadmium etc.
    b. Generation of energy e.g. coal, lignite, uranium.
    c. Construction, housing, settlements, e.g. iron, aluminium, silicate, limestone.

d. Defence equipments (weapons, armaments) e.g. copper, chromium, cobalt, manganese, iron, lead.
e. Transportation means e.g. iron, lead, aluminium, platinum.
f. Communication (telephone wires, cables, electronic devices) e.g. copper, lead, nickel.
g. Medicinal system (particularly in Ayurvedic system) e.g. gold, silver, iron.
h. Formation of alloys for various purposes e.g. steel alloys.
i. Agriculture (as fertilizers, seed dressings and fungicides) e.g. zineb containing zinc, maneb containing manganese etc.
j. Jewellery e.g. gold, silver, platinum, diamond.

Environmental Impacts of Mineral Extraction

- More important environmental concern arises from the impacts of extraction and processing of these minerals during mining, smelting etc.
- Indian Scenario: India is the producer of 84 minerals the annual value of which is about Rs. 50,000 crore.
- At least six major mines need to mention here which are known for causing severe problems:
  i. Jaduguda Uranium Mine, Jharkhand exposing local people to radioactive hazards.
  ii. Jharia coal mines, Jharkhand underground fire leading to land subsidence and forced displacement of people.
  iii. Sukinda chromite mines, Orissa seeping of hexavalent chromium into river posing serious health hazard, Cr6+ being highly toxic and carcinogenic.
  iv. Kudremukh iron ore mine, Karnataka causing river pollution and threat to biodiversity.
  v. North-Eastern Coal Fields, Assam Very high sulphur contamination of groundwater.
- The environmental damage caused by mining activities are as follows:
  i. Devegetation and defacing of landscape:
    - The top soil as well as the vegetation are removed from the mining area to get access to the deposit.
    - While large scale deforestation or devegetation leads to several ecological losses, loss of habitat, loss of endemic species, and the landscape also gets badly affected.

ii. Subsidence of land:

- This is mainly associated with underground mining.
- Subsidence of mining areas often results in tilting of buildings, cracks in houses, buckling of roads, bending of rail tracks and leaking of gas from cracked pipelines leading to serious disasters.

iii. Groundwater contamination:

- Mining disturbs the natural hydrological processes and also pollutes the groundwater.
- Sulphur, usually present as an impurity in many ores is known to get converted into sulphuric acid through microbial action, thereby making the water acidic.
- Some heavy metals also get leached into the groundwater and contaminate it posing health hazards.

iv. Surface water pollution:

- The acid mine drainage often contaminates the nearby streams and lakes.
- The acidic water is detrimental to many forms of aquatic life.
- Sometimes radioactive substances like uranium also contaminate the water bodies through mine wastes and kill aquatic animals.
- Heavy metal pollution of water bodies near the mining areas is a common feature creating health hazards.

v. Air pollution:

- In order to separate and purify the metal from other impurities in the ore, smelting is done which emits enormous quantities of air pollutants damaging the vegetation nearby and has serious environmental health impacts.
- The suspended particulate matter (SPM), SOx, soot, arsenic particles, cadmium, lead etc. shoot up in the atmosphere near the smelters and the public suffers from several health problems.

vi. Occupational Health Hazards:

- Most of the miners suffer from various respiratory and skin diseases due to constant exposure to the suspended particulate matter and toxic substances.
- Miners working in different types of mines suffer from asbestosis, silicosis, black lung disease etc.

Process of Mining:

- Extraction of minerals from earth crust is mining.
- Mining is done to extract minerals (or fossil fuels) from deep deposits in soil by using sub-surface mining or from shallow deposits by surface mining.
- Surface mining can make use of any of the following three types:
    a. Open-pit mining in which machines dig holes and remove the ores (e.g. copper, iron, gravel, limestone, sandstone, marble, granite).
    b. Dredging in which chained buckets and draglines are used which scrap up the minerals from under-water mineral deposits.
    c. Strip mining in which the ore is stripped off by using bulldozers, power shovels and stripping wheels (e.g. phosphate rocks).

Food Resources: World food problems, changes caused by agriculture and over grazing, effects of modern agriculture, fertilizers- pesticides problems, water logging, and salinity.

Food Resources

- We have thousands of edible plants and animals over the world out of which only about three dozen types constitute the major food of humans.
- The main food resources include wheat, rice, maize, potato, barley, oats, cassava, sweet potato, sugarcane, pulses, sorghum, millet, about twenty or so common fruits and vegetables, milk, meat, fish and seafood.
- Amongst these rice, wheat and maize are the major grains, about 1500 million metric tons of which are grown each year, which is about half of all the agricultural crops.
- About 4 billion people in the developing countries have wheat and rice as their staple food.
- Meat and milk are mainly consumed by more developed nations of North America, Europe and Japan who consume about 80% of the total.
- Fish and sea-food contribute about 70 million metric tons of high quality protein to the world's diet.
- The Food and Agriculture Organization (FAO) of United Nations estimated that on an average the minimum caloric intake on a global scale is 2,500 calories/day.

World Food Problems

- During the last 50 years world grain production has increased almost three times, thereby increasing per capita production by about 50%.
- But, at the same time population growth increased at such a rate in LDCs (Less developed countries) that it outstripped food production.
- Every year 40 million people (fifty percent of which are young children between 1 to 5 years) die of undernourishment and malnutrition.
- This means that every year our food problem is killing as many people as were killed by the atomic bomb dropped on Hiroshima during World War II. Now its important to increase our food production, equitably distribute it and also to control population growth.
- Indian Scenario: Although India is the third largest producer of staple crops, an estimated 300 million Indians are still undernourished. Our food problems are directly related to population.

Impacts of Overgrazing and Agriculture

Impacts of Overgrazing

Impact of Overgrazing are listed below

I. Land Degradation:

- Overgrazing removes the vegetal cover over the soil and the exposed soil gets compacted due to which the effective soil depth declines.
- So the roots cannot go much deep into the soil and adequate soil moisture is not available.
- The humus content of the soil decreases and overgrazing leads to organically poor, dry, compacted soil.
- Due to trampling by cattle the soil loses infiltration capacity, which reduces percolation of water into the soil which result in loss of water due to surface run off.
- Thus overgrazing leads to multiple actions resulting in loss of soil structure, hydraulic conductivity and soil fertility.

II. Soil Erosion:

- Due to overgrazing by cattle, the cover of vegetation almost gets removed from the land.

- The soil becomes exposed and gets eroded by the action of strong wind, rainfall etc.
- The grass roots are very good binders of soil. When the grasses are removed, the soil becomes loose and susceptible to the action of wind and water.

III. Loss of useful species:

- Overgrazing adversely affects the composition of plant population and their regeneration capacity.
- The original grassland consists of good quality grasses and forbs with high nutritive value.
- When the livestock graze upon them heavily, even the root stocks which carry the reserve food for regeneration get destroyed.
- Now some other species appear in their place. These secondary species are hardier and are less nutritive in nature.
- Some livestock keep on overgrazing on these species also.
- These species do not have a good capacity of binding the soil particles and, therefore, the soil becomes more prone to soil erosion.

Impacts of Agriculture

- Agriculture exists on the earth from early years, Some 10,000 to 12,000 years ago, agriculture done by cultivating plants of our own choice.
- Type of agriculture practiced these days is very different from the traditional ones and their outputs in terms of yield as well as their impacts on the environment.

Traditional agriculture and its impacts:

- It usually involves a small plot, simple tools, naturally available water, organic fertilizer and a mix of crops.
- It is more near to natural conditions and usually it results in low production.
- It is still practiced by about half the global population.

The main impacts of this type of agriculture are as follows:

I. Deforestation:

The slash and burn of trees in forests to clear the land for cultivation and frequent shifting result in loss of forest cover.

II. Soil erosion:

Clearing of forest cover exposes the soil to wind, rain and storms, thereby resulting in loss of top fertile layer of soil.

III. Depletion of nutrients:

- During slash and burn the organic matter in the soil gets destroyed and most of the nutrients are taken up by the crops within a short period, thus making the soil nutrient poor which makes the cultivators shift to another area.

Modern Agriculture and its impacts:

- It makes use of hybrid seeds of selected and single crop variety, high-tech equipments and lots of energy subsidies in the form of fertilizers, pesticides and irrigation water.
- The food production has increased tremendously, evidenced by green revolution.
- However, it also gave rise to several problems.

The main impacts of this type of agriculture are as follows:

I. Impacts related to high yielding varieties (HYV):

- The uses of HYVs encourage monoculture i.e. the same genotype is grown over vast areas.
- In case of an attack by some pathogen, there is total devastation of the crop by the disease due to exactly uniform conditions, which help in rapid spread of the disease.

II. Fertilizer related problems:

a) Micronutrient imbalance:

- Most of the chemical fertilizers used in modern agriculture have nitrogen, phosphorus and potassium (N, P, K) which are essential macronutrients.
- Farmers usually use these fertilizers indiscriminately to boost up crop growth.
- Excessive use of fertilizers cause micronutrient imbalance. For example, excessive fertilizer use in Punjab and Haryana has caused deficiency of the micronutrient zinc in the soils, which is affecting productivity of the soil.

b) Nitrate Pollution:

- Nitrogenous fertilizers applied in the fields often leach deep into the soil and ultimately contaminate the ground water.

- The nitrates get concentrated in the water and when their concentration exceeds 25 mg/L, they become the cause of a serious health hazard called Blue Baby Syndrome or methaemoglobinemia.
- This disease affects infants to the maximum extent causing even death.
- In Denmark, England, France, Germany and Netherlands this problem is quite prevalent.
- In India also, problem of nitrate pollution exists in many areas.

c) Eutrophication:

- Excessive use of N and P fertilizers in the agricultural fields leads to another problem, which is not related to the soil, but relates to water bodies like lakes.
- A large proportion of nitrogen and phosphorus used in crop fields is washed and meet water bodies causing over nourishment of the lakes, a process known as Eutrophication (eu=more, trophic=nutrition).
- Due to eutrophication the lakes get invaded by algal blooms.
- These algal species grow very fast by rapidly using up the nutrients. They are often toxic and badly affect the food chain.
- The algal species quickly complete their life cycle and die thereby adding a lot of dead organic matter.
- The fishes are also killed and there is a lot of dead matter that starts getting decomposed.
- Oxygen is consumed in the process of decomposition and very soon the water gets depleted of dissolved oxygen.
- This further affects aquatic fauna and ultimately anaerobic conditions are created where only pathogenic anaerobic bacteria can survive.
- Thus, due to excessive use of fertilizers in the agricultural fields the lake ecosystem gets degraded.

III. Pesticide related problems:

- Thousands of types of pesticides are used in agriculture.
- The first generation pesticides include chemicals like sulphur, arsenic, lead or mercury to kill the pests.

- DDT (Dichlorobdiphenyl trichloroethane) whose insecticidal properties were discovered by Paul Mueller in 1939 belongs to the second generation pesticides.
- After 1940, a large number of synthetic pesticides came into use.
- Although these pesticides have gone a long way in protecting our crops from huge losses occurring due to pests, yet they have a number of side-effects, as discussed below:

a) Creating resistance in pests and producing new pests:

- Some individuals of the pest species usually survive even after pesticide spray.
- The survivors give rise to highly resistant generations.
- About 20 species of pests are now known which have become immune to all types of pesticides and are known as Super pests.

b) Death of non-target organisms:

- Many insecticides are broad spectrum poisons which not only kill the target species but also several non-target species that are useful to us.

c) Biological magnification:

- Many of the pesticides are non-biodegradable and keep on accumulating in the food chain, a process called biological magnification.
- Since human beings occupy a high trophic level in the food chain, hence they get the pesticides in a bio-magnified form which is very harmful.

IV. Water Logging:

- Over irrigation of croplands by farmers for good growth of their crop usually leads to waterlogging.
- Inadequate drainage causes excess water to accumulate underground and gradually forms a continuous column with the water table.
- Under water-logged conditions, pore-spaces in the soil get fully drenched with water and the soil-air gets depleted.
- The water table rises while the roots of plants do not get adequate air for respiration.
- Mechanical strength of the soil declines, the crop plants get lodged and crop yield falls.

- In Punjab and Haryana, extensive areas have become water-logged where adequate canal water supply or tube-well water encouraged the farmers to use it over- enthusiastically leading to water-logging problem.
- Preventing excessive irrigation, sub-surface drainage technology and bio-drainage with trees like Eucalyptus are some of the remedial measures to prevent water-logging.

V. Salinity problem:

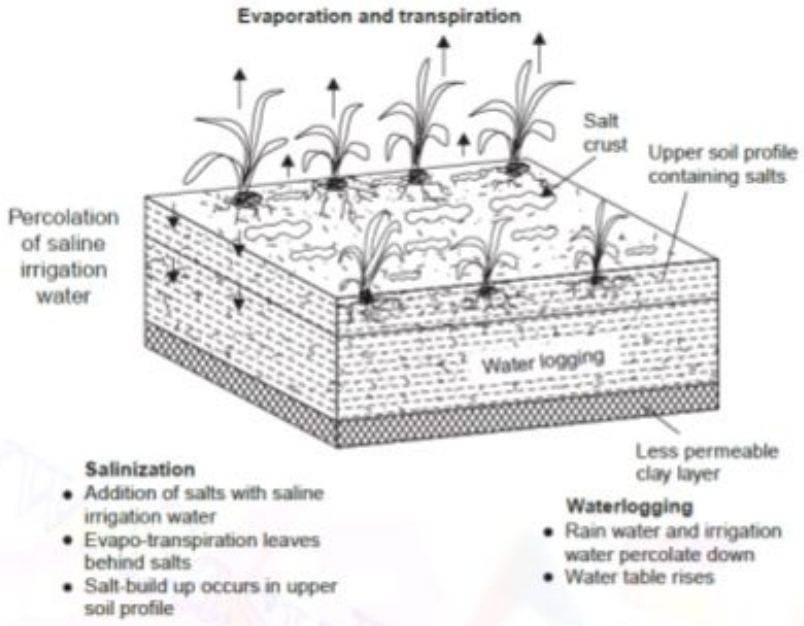
- At present one third of the total cultivable land area of the world is affected by salts.
- In India about seven million hectares of land are estimated to be salt affected which may be saline or sodic.
- Saline soils are characterized by the accumulation of soluble salts like sodium chloride, sodium sulphate, calcium chloride, magnesium chloride etc.
- Their electrical conductivity is more than 4 dS/m.
- Sodic soils have carbonates and bicarbonates of sodium, the pH usually exceeds 8.0 and the exchangeable sodium percentage (ESP) is more than 15%.

Causes:

- A Major cause of salinization of soil is excessive irrigation.
- About 20% of the world's croplands receive irrigation with canal water or ground water which unlike rainwater often contains dissolved salts.
- Under dry climates, the water evaporates leaving behind salts in the upper soil.
- Thousands of hectares of land area in Haryana and Punjab are affected by soil salinity and alkalinity.
- Most of the crops cannot tolerate high salinity.

Remedy:

- The most common method for getting rid of salts is to flush them out by applying more good quality water to such soils.
- Another method is laying underground network of perforated drainage pipes for flushing out the salts slowly.
- This sub-surface drainage system has been tried in the experimental station of CSSRI at Sampla, Haryana.



Stalinization and water logging

Energy Resources: Growing energy need, renewable and non-renewable energy sources, use of alternate energy sources, case studies.

Energy Resources

- Energy consumption of a nation is usually considered as an index of its development.
- This is because almost all the developmental activities are directly or indirectly dependent upon energy.
- The first form of energy technology probably was the fire, which produced heat and the early man used it for cooking and heating purposes.
- Wind and hydropower have also been in use for the last 10,000 years.
- The invention of steam engines replaced the burning of wood by coal and coal was later replaced to a great extent by oil.

Growing Energy Needs

- Development in different sectors relies largely upon energy.
- Agriculture, industry, mining, transportation, lighting, cooling and heating in buildings all need energy.
- With the demands of growing population the world is facing further energy deficit.

- The fossil fuels like coal, oil and natural gas which at present are supplying 95% of the commercial energy of the world resources and are not going to last for many more years.
- If you just look at the number of electric gadgets in your homes and the number of private cars and scooters in your locality, you will realize that in the last few years they have multiplied many folds and all of them consume energy.
- Developed countries like U.S.A. and Canada constitute about 5% of the world's population but consume one fourth of global energy resources.
- An average person consumes 300 GJ (Giga Joules, equal to 60 barrels of oils) per year. By contrast, an average man in a poor country like Bhutan, Nepal or Ethiopia consumes less than 1 GJ in a year.
- So a person in a rich country consumes almost as much energy in a single day as one person does in a whole year in a poor country.
- This clearly shows that our life-style and standard of living are closely related to energy needs.

Renewable and Non-Renewable Energy Sources

- A source of energy is one that can provide adequate amount of energy in a usable form over a long period of time.
- These sources can be of two types:

1. Renewable Resources
    - Which can be generated continuously in nature and are inexhaustible e.g. wood, solar energy, wind energy, tidal energy, hydropower, biomass energy, bio-fuels, geo-thermal energy and hydrogen.
    - They are also known as non-conventional sources of energy and they can be used again and again in an endless manner.
2. Non-renewable Resources
    - Which have accumulated in nature over a long span of time and cannot be quickly replenished when exhausted e.g. coal, petroleum, natural gas and nuclear fuels like uranium and thorium.
    - Wood is a renewable resource as we can get new wood by growing a sapling into a tree within 15-20 years but it has taken millions of years for the formation of coal from trees and cannot be regenerated in our life time, hence coal is not renewable.

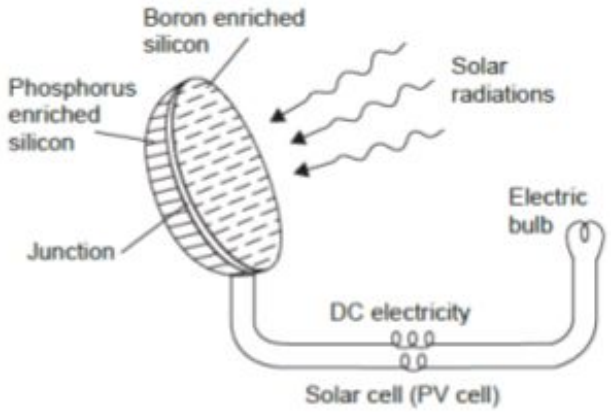
- We will now discuss various forms of renewable and non-renewable energy resource.

Renewable Energy Resources

1. Solar energy:
   - Sun is the ultimate source of energy, directly or indirectly for all other forms of energy.
   - The nuclear fusion reactions occurring inside the sun release enormous quantities of energy in the form of heat and light.
   - The solar energy received by the near earth space is approximately 1.4 kilojoules/second/m^2 known as solar constant.
   - Traditionally, we have been using solar energy for drying clothes and food-grains, preservation of eatables and for obtaining salt from sea-water.
   - Now we have several techniques for harnessing solar energy.
   - Some important solar energy harvesting devices are discussed here.

   I. Solar heat collectors:
      - These can be passive or active in nature.
      - Passive solar heat collectors are natural materials like stones, bricks etc. or material like glass which absorb heat during the day time and release it slowly at night.
      - Active solar collectors pump a heat absorbing medium (air or water) through a small collector which is normally placed on the top of the building.

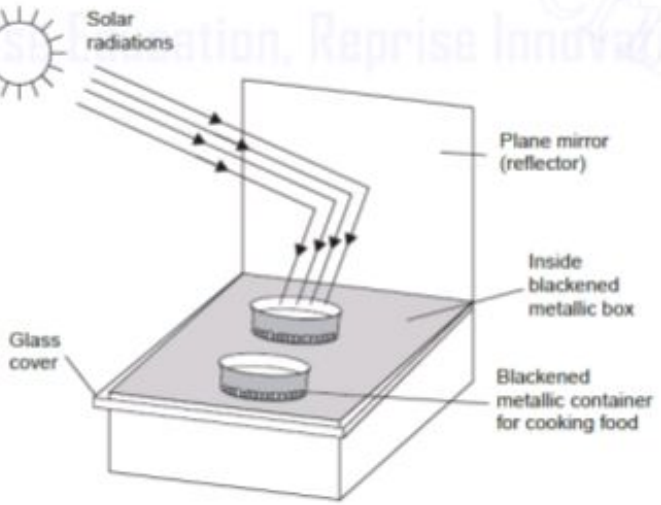
   II. Solar cells:
      - They are also known as photovoltaic cells or PV cells.
      - Solar cells are made of thin wafers of semi conductor materials like silicon and gallium.
      - When solar radiations fall on them, a potential difference is produced which causes flow of electrons and produces electricity.
      - By using gallium arsenide, cadmium sulphide or boron, efficiency of the PV cells can be improved.
      - The potential difference produced by a single PV cell of 4 cm^2 size is about 0.4-0.5 volts and produces a current of 60 milli amperes.



- A group of solar cells joined together in a definite pattern form a solar panel which can control a large amount of solar energy and can produce electricity enough to run street-light, irrigation water pump etc.
- Solar cells are widely used in calculators, electronic watches, street lighting, traffic signals, water pumps etc. Solar cells are used for running radio and television also.
- They are also used in artificial satellites for electricity generation.
- They are more in use in remote areas where conventional electricity supply is a problem.

III. Solar cooker:

- Solar cookers make use of solar heat by reflecting the solar radiations using a mirror directly on to a glass sheet which covers the black insulated box within which the raw food is kept as shown in Fig.



- The food cooked in solar cookers is more nutritious due to slow heating.
- However it has the limitation that it cannot be used at night or on cloudy days.
- Moreover, the direction of the cooker has to be adjusted according to the direction of the sun rays.

IV. Solar water heater:

- It consists of an insulated box painted black from inside and having a glass lid to receive and store solar heat.

V. Solar furnace:

- Here thousands of small plane mirrors are arranged in concave reflectors, all of which collect the solar heat and produce as high a temperature as 3000°C.

VI. Solar power plant:

- Solar energy is harnessed on a large scale by using concave reflectors which cause boiling of water to produce steam.
- The steam turbine drives a generator to produce electricity.
- A solar power plant (50 K Watt capacity) has been installed at Gurgaon, Haryana.

2. Wind Energy

- The high speed winds have a lot of energy in them as kinetic energy due to their motion.
- The wind energy is harnessed by making use of wind mills.
- The blades of the wind mill keep on rotating continuously due to the force of the striking wind.
- The rotational motion of the blades drives a number of machines like water pumps, flour mills and electric generators.
- A large number of wind mills are installed in clusters called wind farms, which feed power to the utility grid and produce a large amount of electricity.
- These farms are ideally located in coastal regions, open grasslands or hilly regions, particularly mountain passes and ridges where the winds are strong and steady.
- The minimum wind speed required for satisfactory working of a wind generator is 15 km/hr.

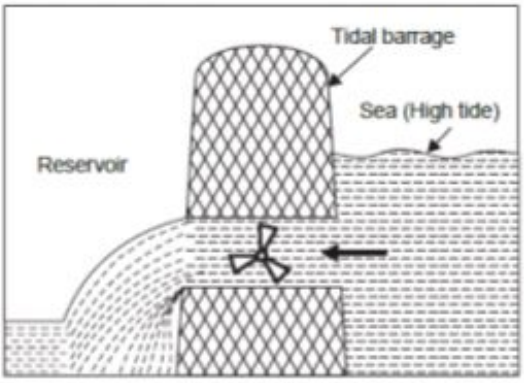
- The wind power potential of our country is estimated to be about 20,000 MW, while at present we are generating about 1020 MW.
- The largest wind farm of our country is near Kanyakumari in Tamil Nadu generating 380 MW electricity.
- Wind energy is very useful as it does not cause any air pollution.

3. HYDROPOWER

- The water flowing in a river is collected by constructing a big dam where the water is stored and allowed to fall from a height.
- The blades of the turbine located at the bottom of the dam move with the fast moving water which in turn rotate the generator and produces electricity.
- We can also construct mini or micro hydro power plants on the rivers in hilly regions for harnessing the hydro energy on a small scale, but the minimum height of the water falls should be 10 metres.
- The hydropower potential of India is estimated to be about 4×1011 KW-hours.
- Till now we have utilized only a little more than 11% of this potential.
- Hydropower does not cause any pollution, it is renewable and normally the hydro power projects are multi-purpose projects helping in controlling floods, used for irrigation, navigation etc.
- However, big dams are often associated with a number of environmental impacts.

4. Tidal Energy

- Ocean tides produced by gravitational forces of sun and moon contain enormous amounts of energy.
- The 'high tide' and 'low tide' refer to the rise and fall of water in the oceans.
- A difference of several meters is required between the height of high and low tide to spin the turbines.
- The tidal energy can be harnessed by constructing a tidal barrage.
- During high tide, the sea-water flows into the reservoir of the barrage and turns the turbine, which in turn produces electricity by rotating the generators.
- During low tide, when the sea-level is low, the sea water stored in the barrage reservoir flows out into the sea and again turns the turbines as shown in figure.



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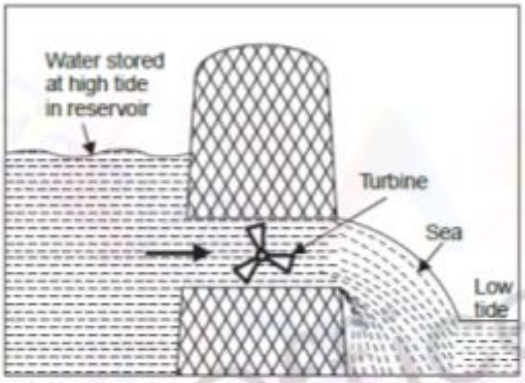


(b)

- There are only a few sites in the world where tidal energy can be suitably harnessed.
- The bay of Fundy Canada having 17-18 m high tides has a potential of 5,000 MW of power generation.
- The tidal mill at La Rance, France is one of the first modern tidal power mill.
- In India Gulf of Cambay, Gulf of Kutch and the Sunder bans deltas are the tidal power sites.

5. Ocean Thermal Energy (OTE)

- The energy available due to the difference in temperature of water at the surface of the tropical oceans and at deeper levels is called Ocean Thermal Energy.
- A difference of 20°C or more is required between surface water and deeper water of ocean for operating OTEC (Ocean Thermal Energy Conversion) power plants.
- The warm surface water of ocean is used to boil a liquid like ammonia.
- The high pressure vapours of the liquid formed by boiling are then used to turn the turbine of a generator and produce electricity.

- The colder water from the deeper oceans is pumped to cool and condense the vapours into liquid. Thus the process keeps on going continuously for 24 hours a day.

6. Geothermal Energy

- The energy harnessed from the hot rocks present inside the earth is called geothermal energy.
- High temperature, high pressure steam fields exist below the earth's surface in many places.
- This heat comes from the fission of radioactive material naturally present in the rocks.
- In some places, the steam or the hot water comes out of the ground naturally through cracks in the form of natural geysers as in Manikaran, Kullu and Sohana, Haryana.
- Sometimes the steam or boiling water underneath the earth do not find any place to come out.
- We can artificially drill a hole up to the hot rocks and by putting a pipe in it make the steam or hot water gush out through the pipe at high pressure which turns the turbine of a generator to produce electricty.
- In USA and New Zealand, there are several geothermal plants working successfully.

7. Biomass Energy

- Biomass is the organic matter produced by the plants or animals which include wood, crop residues, cattle dung, manure, sewage, agricultural wastes etc.
- Biomass energy is of the following types :

I. Energy Plantations:

- Solar energy is trapped by green plants through photosynthesis and converted into biomass energy.
- Fast growing trees like cottonwood, poplar and Leucaena, non-woody herbaceous grasses, crop plants like sugarcane, sweet sorghum and sugar beet, aquatic weeds like water hyacinth and sea-weeds and carbohydrate rich potato, cereal etc. are some of the important energy plantations.

- They may produce energy either by burning directly or by getting converted into burnable gas or may be converted into fuels by fermentation.

II. Petro-crops:

- Certain latex-containing plants like Euphorbias and oil palms are rich in hydrocarbons and can yield an oil like substance under high temperature and pressure.
- This oily material may be burned in diesel engines directly or may be refined to form gasoline. These plants are popularly known as petro-crops.

III. Agricultural and Urban Waste biomass:

- Crop residues, bagasse (sugarcane residues), coconut shells, peanut hulls, cotton stalks etc. are some of the common agricultural wastes which produce energy by burning.
- Animal dung, fishery and poultry waste and even human refuse are examples of biomass energy.
- In Brazil 30 % of electricity is obtained from burning bagasse.
- In rural India, animal dung cakes are burnt to produce heat.
- About 80 % of rural heat energy requirements are met by burning agricultural wastes, wood and animal dung cakes.
- In rural areas these forms of waste biomass are burned in open furnaces called 'Chulhas' to produce heat and cook food.

8. Biogas:

- Biogas is the burnable gas obtained from biomass in a particularly designed fermentation plant.
- It is a mixture of methane, carbon dioxide, hydrogen and hydrogen sulphide, the major constituent being methane.
- Biogas is produced by anaerobic degradation of animal and plant wastes in the presence of water.
- All wastes are directed to a dome shaped or other structure made for the purpose.
- After sometime microbial action on biomass wastes in presence of plenty of water produces biogas which can directly be used for cooking and heating purposes.

- Biogas is a non-polluting, clean and low cost fuel which is very useful for rural areas where a lot of animal waste and agricultural waste are available.
- The sludge left over after use of gas from plant is a rich fertilizer.

9. Biofuels

- Biomass can be fermented to alcohols like ethanol and methanol which can be used as fuels.
- Ethanol can be easily produced from carbohydrate rich substances like sugarcane.
- However, as compared to petrol its calorific value is less and therefore, produces much less heat than petrol.
- Gasohol is a common fuel used in Brazil and Zimbabwe for running cars and buses. In India too gasohol is planned to be used on trial basis in some parts of the country, to start with in Kanpur.
- Gasohol is a mixture of ethanol and gasoline.
- Methanol is very useful since it burns at a lower temperature than gasoline or diesel. Thus the bulky radiator may be substituted by sleek designs in our cars.
- Methanol too is a clean, non-polluting fuel.
- Methanol can be easily obtained from woody plants and ethanol from grain-based or sugar-containing plants.

Hydrogen as a Fuel

- As hydrogen burns in air, it combines with oxygen to form water and a large amount of energy (150 kilojoules per gram) is released.
- Due to its high, rather the highest calorific value, hydrogen can serve as an excellent fuel. Moreover, it is non-polluting and can be easily produced.
- Production of Hydrogen is possible by thermal dissociation, photolysis or electrolysis of water.
- By thermal dissociation of water (at 3000°K or above) hydrogen (H2) is produced.
- Thermochemically, hydrogen is produced by chemical reaction of water with some other chemicals in 2-3 cycles so that we do not need the high temperatures for the production of H_2.

- Electrolytic method dissociates water into hydrogen (H2) and oxygen by making a current flow through it.
- Photolysis of water involves breakdown of water in the presence of sun light to release hydrogen.
- Green plants also have photolysis of water during photosynthesis.
- However, hydrogen is highly inflammable and explosive in nature.
- Hence, safe handling is required for using H2 as a fuel. Also, it is difficult to store and transport.
- Presently, H2 is used in the form of liquid hydrogen as a fuel in spaceships.

Non Renewable Sources of Energy

- Fossil fuels like coal, petroleum and natural gas are the major sources of energy in the present world.
- They are used as fuels and are non renewable.
- These were formed by the decomposition of the remains of plants and animals buried under the earth millions of years ago.
- Nuclear energy is another form which is very effective but has also its own demerits.

1. Coal:
    - Coal is the most abundant fossil fuel in the world.
    - There are mainly three types of coal, namely anthracite (hard coal), bituminous (Soft coal) and lignite (brown coal).
    - Anthracite coal has maximum carbon (90%) and calorific value (8700 kcal/kg.), Bituminous, lignite and peat contain 80, 70 and 60% carbon, respectively.
    - India has about 5% of world's coal though Indian coal is not very good in terms of heat capacity.
    - Major coal fields in India are Raniganj, Jharia, Bokaro, Singrauli, and Godavari valley.
    - Anthracite coal occurs only J & K in India.
    - On burning coal causes serious environmental pollution including release of carbon dioxide a major green house gas.
2. Petroleum:

- It is the most important energy source in the world.
- There are 13 countries in the world having 67% of the petroleum reserves which together form the OPEC (Organization of Petroleum exporting countries).
- About 1/4th of the oil reserves are in Saudi Arabia.
- Crude petroleum is a complex mixture of alkane hydrocarbons.
- Hence it has to be purified and refined by the process of fractional distillation, during which process different constituents separate out at different temperatures and we get a large variety of products from this, namely, petroleum gas, kerosene, petrol, diesel, fuel oil, lubricating oil, paraffin wax, asphalt, plastic etc.
- LPG we use at home is a liquefied form of petroleum gas which mostly consists of Butane.
- In India in India oil fields are located at Digboi (Assam), Gujarat Plains and Bombay High, offshore areas in deltaic coasts of Gadavari, Krishna, Kaveri and Mahanadi.
- Petroleum also cause pollution on burning but it is cleaner than coal as it left no residue after burning.

3. Natural gas:

- It is also a fossil fuel.
- Natural gas deposits mostly accompany oil deposits because it has been formed by decomposing remains of dead animals and plants buried under the earth.
- It is mainly composed of methane (95%) with small amounts of propane and ethane.
- Natural gas is the cleanest fossil fuel.
- It can be easily transported through pipelines.
- It has a high calorific value of about 50KJ/G and burns without any smoke.
- Natural gas is used as a domestic and industrial fuel.
- It is used as a fuel in thermal power plants for generating electricity.
- Compressed natural gas (CNG) is used as an alternative to petrol and diesel for transport of vehicles.
- It is much cleaner and causes no or very little pollution.

- In Delhi all buses and auto rickshaws run on this new fuel.

4. Nuclear energy:

- Nuclear energy is the tremendous energy present in the nucleus of an atom.
- This energy can be harnessed from the atoms of some elements and can be utilised for fulfilling energy requirements at large scale.
- It can be generated by two types of reactions:

I. Nuclear Fission:

- It is the nuclear change in which nucleus of certain isotopes with large mass numbers are split into lighter nuclei on bombardment by neutrons and a large amount of energy is released through a chain reaction.
- As in the example below Uranium atom is bombarded with a neutron and it releases huge amount of energy and Uranium atoms gets converted to Krypton and Barium.

  $_{92}U^{235} + {}_{0}n^{1} \rightarrow {}_{36}Kr^{92} + {}_{56}Ba^{141} + 3\ {}_{0}n^{1} + \text{Energy}$
- Uranium-235 nuclei are most commonly used in nuclear reactors.

II. Nuclear fusion:

- Here two isotopes of a light element are forced together at extremely high temperatures until they fuse together to form a heavier nucleus.
- This reaction also releases enormous energy in the process. It releases more energy than nuclear fission.

  $_{1}H^{2} + {}_{1}H^{2} \rightarrow {}_{3}He^{2} + {}_{0}n^{1} + \text{Energy}$
- In the example shown above, two hydrogen (Deuterium) atoms fuse to form the nucleus of Helium at very high temperature.

- Nuclear energy has tremendous potential but very serious risks of leakage from nuclear reactor are associated with it.
- Disposal of the nuclear waste also poses a big problem.
- There are several nuclear power stations in India located at Tarapur (Maharashtra), Kota (Rajasthan), Kalpakkam (Tamil Nadu) and Narora (U.P.).
- India has uranium from mines in Bihar.
- There are deposits of thorium in Kerala and Tamil Nadu.

Alternate Sources of Energy

- Energy requirements are increasing day by day where as conventional sources of energy such as oil, coal and natural gas are very limited.
- This situation insists for use of non conventional sources of energy which can be renewed and thus be used again and again without fear of depleting them.
- The alternative non-conventional energy sources include all the renewable forms of energy.

Land Resources: Land as a resource, land degradation, man induces landslides, soil erosion, and desertification.

Land Resources:

Land as a resource

- Land is a finite and valuable resource upon which we depend for our food, fibre and fuel wood, the basic amenities of life.
- Soil, especially the top soil, is classified as a renewable resource because it is continuously regenerated by natural process though at a very slow rate.
- About 200-1000 years are needed for the formation of one inch or 2.5 cm soil, depending upon the climate and the soil type.
- But, when rate of erosion is faster than rate of renewal, then the soil becomes a non-renewable resource.

Land Degradation

- With increasing population growth the demands of land for producing food, fibre and fuel wood is also increasing.
- Hence there is more and more pressure on the limited land resources which are getting degraded due to over-exploitation.
- Soil degradation is a real cause of alarm because soil formation is an extremely slow process and the average annual erosion rate is 20-100 times more than the renewal rate.
- Soil erosion, water-logging, salinization and contamination of the soil with industrial wastes like fly-ash, press-mud or heavy metals all cause degradation of land.

Reasons for Land Degradation

Various factors have led to Land Degradation. Some of them are as under:

i. Unplanned destruction of forests has brought serious changes in land.
ii. The washing off of fine soil particles from deforested areas has caused great soil erosion.
iii. Soil erosion has resulted in a great increase in run-off, pollution turbidity and mineralization in rivers and extensive silting in water reservoirs.

Soil Erosion

- The literal meaning of 'soil erosion' is wearing away of soil.
- Soil erosion is defined as the movement of soil components, especially surface or top soil from one place to another.
- Soil erosion results in the loss of fertility because it is the top soil layer which is fertile.
- If we look at the world situation, we find that one third of the world's cropland is getting eroded.
- Soil erosion is basically of two types based upon the cause of erosion:
    1. Normal erosion or geologic erosion:
        - Caused by the gradual removal of top soil by natural processes.
        - It brings equilibrium between physical, biological and hydrological activities and maintains a natural balance between erosion and renewal.
    2. Accelerated erosion:
        - This is mainly caused by anthropogenic (man-made) activities and the rate of erosion is much faster than the rate of formation of soil.
        - Overgrazing, deforestation and mining are some important activities causing accelerated erosion.
- There are two types of agents which cause soil erosion:
    i. Climatic agents:
        - Water and wind are the climatic agents of soil erosion.
        - Water affects soil erosion in the form of heavy rains, rapid flow of water along slopes, run-off, wave action and melting and movement of snow.
        - Water induced soil erosion is of the following types:
            - Sheet erosion: when there is uniform removal of a thin layer of soil from a large surface area, it is called sheet erosion. This is usually due to run-off water.

- Rill erosion: When there is rainfall and rapidly running water produces finger-shaped grooves or rills over the area, it is called rill erosion.
- Gully erosion: It is a more prominent type of soil erosion. When the rainfall is very heavy, deeper cavities or gullies are formed, which may be U or V shaped.
- Slip erosion: This occurs due to heavy rainfall on slopes of hills and mountains.
- Stream bank erosion: During the rainy season, when fast running streams take a turn in some other direction, they cut the soil and make caves in the banks.

- Wind erosion is responsible for the following three types of soil movements:
  - Saltation: This occurs under the influence of direct pressure of stormy wind and the soil particles of 1-1.5 mm diameter move up in vertical direction.
  - Suspension: Here fine soil particles (less than 1 mm dia) which are suspended in the air and taken away to distant places.
  - Surface creep: Here larger particles (5-10 mm diameter) creep/crawl over the soil surface along with wind.

ii. Biotic agents:

- Excessive grazing, mining and deforestation are the major biotic agents responsible for soil erosion.
- Due to these processes the top soil is disturbed or rendered and is directly exposed to the action of various physical forces facilitating erosion.
- Overgrazing accounts for 35% of the world's soil erosion while deforestation is responsible for 30% of the earth's seriously eroded lands.
- Deforestation without reforestation, overgrazing by cattle, surface mining without land reclamation etc make the top soil vulnerable to erosion.
- Soil Conservation Practices In order to prevent soil erosion and conserve the soil the following conservation practices are employed:
  - Conservational till farming: In traditional method the land is ploughed and the soil is broken up and smoothed to make a planting surface. However, this

disturbs the soil and makes it susceptible to erosion when fallow (i.e. without crop cover).

- Contour farming: On gentle slopes, crops are grown in rows across, rather than up and down, a practice known as contour farming. Each row planted horizontally along the slope of the land to help hold soil and slow down loss of soil through run-off water.
- Terracing: It is used on steeper slope and it retains water for crops at all levels and cuts down soil erosion by controlling run off. In high rainfall areas, ditches are also provided behind the terrace to permit adequate drainage.
- Strip cropping: Here strips of crops are alternated with strips of soil saving cover crops like grasses or grass-legume mixture. Whatever run-off comes from the cropped soil is retained by the strip of cover crop and this reduces soil erosion.

Landslides

- Various anthropogenic activities like hydroelectric projects, large dams, reservoirs, construction of roads and railway lines, construction of buildings, mining etc are responsible for clearing of large forested areas.
- Earlier there were few reports of landslides between Rishikesh and Byasi on Badrinath Highway area.
- But, after the highway was constructed, 15 landslides occurred in a single year.
- During construction of roads, huge portions of mountainous areas are cut or destroyed and thrown into adjacent valleys and streams.
- These land masses weaken the mountain slopes and lead to landslides.
- They also increase the turbidity of various nearby streams, thereby reducing their productivity.

Desertification

- Desertification is a type of land degradation in dry lands in which biological productivity is lost due to natural processes or induced by human activities.
- It is a process whereby the productive potential of arid or semiarid lands falls by ten percent or more.

- Moderate desertification is 10-25% drop in productivity, severe desertification causes 25-50% drop while very severe desertification results in more than 50% drop in productivity.
- Desertification leads to the conversion of irrigated croplands to desert like conditions in which agricultural productivity falls.
- Desertification is characterized by devegetation and loss of vegetal over, depletion of groundwater, salinization and severe soil erosion.
- Road construction caused desertification in the following way:
    I. It affected the stability of hill slopes.
    II. It damaged the protective vegetation over both above and below roads.
    III. It blocked natural drainage.

Causes of Desertification:

- Formation of deserts may take place due to natural phenomena like climate change or may be due to abusive use of land.
- The major anthropogenic activities responsible for desertification are as follows:
- Deforestation: The process of removal of vegetable cover from the forests. Since there is no vegetation to hold the surface run-off, water drains off quickly before it can soak into the soil to nourish the plants or to replenish the groundwater. This increases soil erosion, loss of fertility and loss of water.
- Overgrazing: The regions most seriously affected by desertification are the cattle producing areas of the world. This is because the increasing cattle population heavily graze in grasslands or forests and it leads to desertification.
- Shifting cultivation: Due to increase in shifting cultivation, desertification may inceased due to loss of vegetable cover.
- Mining and quarrying: These activities are also responsible for loss of vegetal cover and denudation of extensive land areas leading to desertification.

Role of individual in conservation of natural resources.

- Different natural resources like forests, water, soil, food, mineral and energy resources play a vital role in the development of a nation.
- However, overuse of these resources in our modern society is resulting in fast depletion of these resources.

- Environment belongs to each one of us and all of us have a responsibility to contribute towards its conservation and protection.
- Small droplets of water together form a big ocean. Similarly, with our small individual efforts we can together help in conserving our natural resources to a large extent.
- These are some points summarized how to conserve different resources:
    - Conserve Water:
        - Don't keep water taps running while brushing, shaving, washing or bathing.
        - In washing machines fill the machine only to the level required for your clothes.
        - Install water-saving toilets that use not more than 6 liters per flush.
        - Check for water leaks in pipes and toilets and repair them promptly.
        - A small pin-hole sized leak will lead to the wastage of 640 liters of water in a month.
        - Water the plants in your kitchen-garden and the lawns in the evening when evaporation losses are minimum. Never water the plants in mid-day.
        - Use drip irrigation and sprinkling irrigation to improve irrigation efficiency and reduce evaporation.
        - Install a small system to collect used water from sinks, cloth-washers, bathtubs etc. which can be used for watering the plants.
        - Build rain water harvesting system in your house.
    - Conserve energy:
        - Turn off lights, fans and other appliances when not in use.
        - Obtain as much heat as possible from natural sources.
        - Dry the clothes in sun instead of drier if it is a sunny day.
        - Use solar cooker for cooking your food on sunny days which will be more nutritious and will cut down on your LPG expenses.
        - Build your house with provision for sunspace which will keep your house warmer and will provide more light.
        - Grow deciduous trees at proper places outside your home to cut off intense heat of summers and get a cool breeze and shade.

- This will cut off your electricity charges on coolers and air-conditioners.
- A big tree is estimated to have a cooling effect equivalent to five air conditioners.
- Drive less, make fewer trips and use public transportations whenever possible.
- During winter close the windows at night. During summer close the windows during days if using an A.C. Otherwise loss of heat would be more, consuming more electricity.
- Try riding bicycle or just walk down small distances instead of using your car or scooter.

- Protect the soil:
  - While constructing your house, don't uproot the trees as far as possible.
  - Grow different types of ornamental plants, herbs and trees in your garden.
  - Grow grass in the open areas which will bind the soil and prevent its erosion.
  - Make compost from your kitchen waste and use it for your kitchen-garden or flower-pots.
  - Do not irrigate the plants using a strong flow of water, as it would wash off the soil.
  - Better use sprinkling irrigation.
  - If you own agricultural fields, do not over-irrigate your fields without proper drainage to prevent water logging and salinisation.
  - Use mixed cropping so that some specific soil nutrients do not get depleted.
- Promote Sustainable Agriculture:
  - Do not waste food. Take as much as you can eat.
  - Reduce the use of pesticides.
  - Fertilize your crop primarily with organic fertilizers.
  - Use drip irrigation to water the crops.
  - Eat local and seasonal vegetables. This saves lot of energy on transport, storage and preservation.
  - Control pests by a combination of cultivation and biological control methods.

Equitable use of resources for sustainable life styles.

- The world is now divided in more developed countries (MDC's) and less developed countries (LDC's).
- The less developed does not mean that they are backward as such, they are culturally very rich or even much more developed, but economically they are less developed.
- The gap between the two is mainly because of population and resources.
- The MDC's have only 22% of world's population, but they use 88% of its natural resources, 73% of its energy.
- These countries include USA, Canada, Japan, the CIS, Australia , New Zealand and Western European Countries.
- The LDC's, on the other hand, have very low or moderate industrial growth, have 78% of the world's population and use about 12% of natural resources and 27% of energy.
- The gap between the two is increasing with time due to sharp increase in population in the LDC's.
- The rich have grown richer while the poor have stayed poor or gone even poorer.
- Their share of resources is too little leading to unsustainability.
- Our earth's resources are limited and even the renewable resources will become unsustainable if their use exceeds their regeneration.
- Thus, the solution to this problem is to have more equitable distribution of resources and wealth to meet everyone's basic needs
- We cannot expect the poor countries to stop growth in order to check pollution because development brings employment and the main problem of these countries is to tackle poverty.
- The rich countries will have to lower down their consumption levels while needs of the poor countries have to be fulfilled by providing them resources.
- A fairer sharing of resources will narrow down the gap between the rich and the poor and will lead to sustainable development for all.

Concept of ecosystem

- Various kinds of life supporting systems like the forests, grasslands, oceans, lakes, rivers, mountains, deserts and estuaries show wide variations in their structural composition and functions.
- However, they all are alike in the fact that they consist of living entities interacting with their surroundings exchanging matter and energy.
- The term Ecology was coined by Earnst Haeckel in 1869. It is derived from the Greek words Oikos- home + logos- study.
- So ecology deals with the study of organisms in their natural home interacting with their surroundings.
- The surroundings or environment consists of other living organisms (biotic) and physical (abiotic) components.
- Modern ecologists believe that an adequate definition of ecology described by Tansley (1935) was ecosystem.
- An ecosystem is a group of biotic communities of species interacting with one another and with their non-living environment exchanging energy and matter.
- Now ecology is often defined as the study of ecosystems.
- An ecosystem is an integrated unit consisting of interacting plants, animals and microorganisms whose survival depends upon the maintenance and regulation of their biotic and abiotic structures and functions.
- The ecosystem is thus, a unit or a system which is composed of a number of sub-units, that are all directly or indirectly linked with each other.

Ecosystem Characteristics

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

I. Structural Features

- Composition and organization of biological communities and abiotic components constitute the structure of an ecosystem.

a) Biotic Structure

- The plants, animals and microorganisms present in an ecosystem form the biotic component.
- These organisms have different nutritional behaviour and status in the ecosystems and are accordingly known as Producers or Consumers, based on how do they get their food.

i. Producers:

- They are mainly the green plants, which can synthesize their food themselves by making use of carbon dioxide present in the air and water in the presence of sunlight.
- They are also known as photo autotrophs (auto=self; troph=food, photo=light).
- There are some microorganisms also which can produce organic matter through oxidation of certain chemicals in the absence of sunlight. They are known as chemosynthetic organisms or chemo-autotrophs.
- In the ocean depths, where there is no sunlight, chemoautotrophic sulphur bacteria make use of generating heat by decaying of radioactive elements.
- They use this heat to convert dissolved hydrogen sulphide (H_2S) and carbon dioxide (CO_2) into organic compounds.

ii. Consumers:

- All organisms which get their organic food by feeding upon other organisms are called consumers, which are of the following types:
- Herbivores (plant eaters): They feed directly on producers and hence also known as primary consumers. e.g. rabbit, insect, man.
- Carnivores (meat eaters): They feed on other consumers. If they feed on herbivores they are called secondary consumers (e.g. frog) and if they feed on other carnivores (snake, big fish etc.) they are known as tertiary carnivores/consumers.
- Omnivores: They feed on both plants and animals. e.g. humans, rat, fox, many birds.

- Detritivores (Detritus feeders or Saprotrophs): They feed on the parts of dead organisms, wastes of living organisms, their castoffs e.g. beetles, termites, ants, crabs, earthworms etc.

iii. Decomposers:

- They derive their nutrition by breaking down the complex organic molecules to simpler organic compounds and ultimately into inorganic nutrients.

b) Abiotic Structure

- The physical and chemical components of an ecosystem constitute its abiotic structure.
- It includes climatic factors, edaphic (soil) factors, geographical factors, energy, nutrients and toxic substances.

i. Physical factors:

- The sunlight and shade, intensity of solar flux, duration of sun hours, average temperature, maximum-minimum temperature, annual rainfall, wind, latitude and altitude, soil type, water availability, water currents etc. are some of the important physical features which have a strong influence on the ecosystem.
- We can clearly observe the physical factors like temperature and precipitation (rainfall, snow etc.) pattern in ecosystem.

ii. Chemical factors:

- Availability of major essential nutrients like carbon, nitrogen, phosphorus, potassium, hydrogen, oxygen and sulphur, level of toxic substances, salts causing salinity and various organic substances present in the soil or water largely influence the functioning of the ecosystem.
- All the biotic components of an ecosystem are influenced by the abiotic components and vice versa, and they are linked together through.

II. Functional Attributes

- Every ecosystem performs under natural conditions in a systematic way.

- It receives energy from the sun and all life depends upon this flow of energy.
- Besides energy, various nutrients and water are also required for life which was exchanged by the biotic components and abiotic components within or outside the ecosystem.
- The major functional attributes of an ecosystems are as follows:
    1. Food chain, food webs and trophic structure
    2. Energy flow
    3. Cycling of nutrients (Biogeochemical cycles)
    4. Primary and Secondary production
    5. Ecosystem development and regulation.

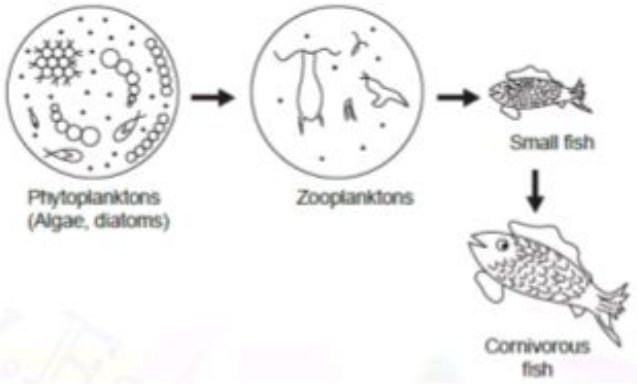
1. Trophic Structure
    - The structure and functions of ecosystems are very closely related and influence each other.
    - The flow of energy is mediated through a series of feeding relationships in a definite sequence or pattern which is known as food chain.
    - Nutrients too move along the food chain.
    - The producers and consumers are arranged in the ecosystem in a definite manner and their interactions along with population size are expressed together as trophic structure.
    - Each food level is known as trophic level and the amount of living matter at each trophic level at a given time is known as standing crop or standing biomass.
2. Food Chains
    - The sequence of eating and being eaten in an ecosystem is known as food chain.
    - All organisms, living or dead, are potential food for some other organism and thus, there is essentially no waste in the functioning of a natural ecosystem.
    - A caterpillar eats a plant leaf, a sparrow eats the caterpillar, a cat or a hawk eats the sparrow and when they all die, they are all consumed by microorganisms like bacteria or fungi (decomposers) which break down the

organic matter and convert it into simple inorganic substances that can again be used by the plants the primary producers.

- Some common examples of simple food chains are:
  Grass → grasshopper → Frog → Snake → Hawk (Grassland ecosystem)
  Phytoplanktons → water fleas → small fish → Tuna (Pond ecosystem)
  Lichens → reindeer → Man (Arctic tundra)
- Each organism in the ecosystem is assigned a feeding level or trophic level depending on its nutritional status.
- Thus, in the grassland food chain, grasshopper occupies the Ist trophic level, frog the 2nd and snake and hawk occupy the 3rd and the 4th trophic levels, respectively.
- The decomposers consume the dead matter of all these trophic levels.
- In nature, we come across two major types of food chains:

a. Grazing food chain:

- It starts with green plants (primary producers) and culminates in carnivores.
- All the examples cited above show this type of food chain.
- Another example could be Grass → Rabbit → Fox

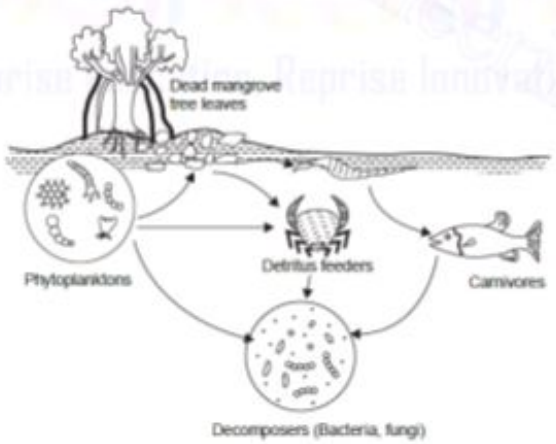


Grazing food chain in a pond ecosystem

b. Detritus food chain:

- It starts with dead organic matter which the detritivores and decomposers consume.

- Partially decomposed dead organic matter and even the decomposers are consumed by detritivores and their predators. An example of the detritus food chain is seen in a Mangrove (estuary).



  - Here, a large quantity of leaf material falls in the form of litter into the water.
  - The leaf fragments are eaten by saprotrophs. (Saprotrophs are those organisms which feed on dead organic matter).
  - These fallen leaves are colonized by small algae, which are also consumed by the saprotrophs or detritivores consisting of crabs, mollusks, shrimps, insect larvae, nematodes and fishes.
  - The detritivores are eaten by small carnivorous fishes, which is turn are eaten by large carnivorous fishes.
  - Leaf litter → algae → crabs → small carnivorous fish → large carnivorous fish (Mangrove ecosystem) Dead organic matter → fungi → bacteria (Forest ecosystem)
- Thus the grazing food chain derives its energy basically from plant energy while in the detritus food chain it is obtained primarily from plant biomass, secondarily from microbial biomass and tertiarily from carnivores.
- Both the food chains occur together in natural ecosystems, but grazing food chain usually predominates.

3. Food Web

- Food chains in ecosystems are rarely found to operate as isolated linear sequences.
- Rather, they are found to be interconnected and usually form a complex network with several linkages and are known as food webs.
- Thus, food web is a network of food chains where different types of organisms are connected at different trophic levels, so that there are a number of options of eating and being eaten at each trophic level.
- Why nature has evolved food webs in ecosystems instead of simple linear food chains?
- This is because food webs give greater stability to the ecosystem. In a linear food chain, if one species becomes extinct or one species suffers then the species in the subsequent trophic levels are also affected.
- In a food web, on the other hand, there are a number of options available at each trophic level. So if one species is affected, it does not affect other trophic levels so seriously.
- Just consider the simple food chains of arctic tundra ecosystem:
  Cladonia → Reindeer → Man
  Grass → Caribou → Wolf
- If due to some stress, the population of reindeer or Caribou falls, it will leave little option for man or wolf to eat from the ecosystem.

Significance of food chains and food webs

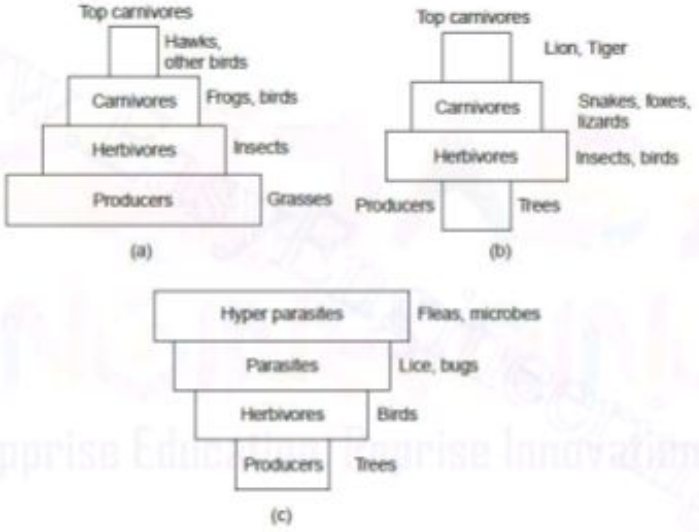
- Food chains and food webs play a very significant role in the ecosystem because the two most important functions of energy flow and nutrient cycling take place through them.
- The food chains also help in maintaining and regulating the population size of different animals and thus, help maintain the ecological balance.
- Food chains show a unique property of biological magnification of some chemicals. There are several pesticides, heavy metals and other chemicals which are non-biodegradable in nature. Such chemicals are not decomposed by microorganisms and they keep on passing from one trophic level to another. And, at each successive trophic level, they keep on increasing in

concentration. This phenomenon is known as biomagnification or biological magnification.

Ecological Pyramids

- Graphic representation of trophic structure and function of an ecosystem, starting with producers at the base and successive trophic levels forming the apex is knows as an ecological pyramid.
- Ecological pyramids are of three types:

1. Pyramid of numbers:
    - It represents the number of individual organisms at each trophic level.
    - We may have upright or inverted pyramid of numbers, depending upon the type of ecosystem and food chain as shown in figure.
    - A grassland ecosystem (Fig. a) and a pond ecosystem show an upright pyramid of numbers.
    - The producers in the grasslands are grasses and that in a pond are phytoplanktons (algae etc.), which are small in size and very large in number. So the producers form a broad base.
    - The herbivores in a grassland are insects while tertiary carnivores are hawks or other birds which are gradually less and less in number and hence the pyramid apex becomes gradually narrower forming an upright pyramid.

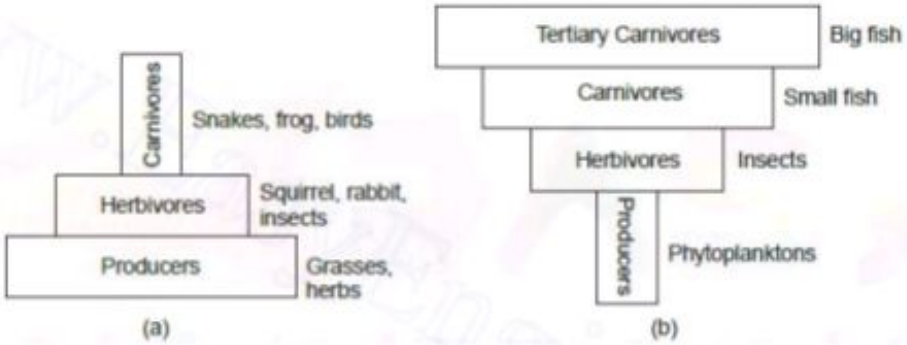


Pyramid of numbers (a) grassland (b) forest (c) Parasitic food chain.

- In a forest ecosystem, big trees are the producers, which are less in number and hence form a narrow base.
- A larger number of herbivores including birds, insects and several species of animals feed upon the trees (on leaves, fruits, flowers, bark etc.) and form a much broader middle level.
- The secondary consumers like fox, snakes, lizards etc. are less in number than herbivores while top carnivores like lion, tiger etc. are still smaller in number.
- So the pyramid is narrow on both sides and broader in the middle (Fig. b).
- Parasitic food chain shows an inverted pyramid of number.
- The producers like a few big trees are less in number and eating birds acting like herbivores which are larger in number.
- A much higher number of lice, bugs etc. grow as parasites on these birds while a still greater number of hyperparasites like bugs, fleas and microbes feed upon them, thus making an inverted pyramid (Fig. c).

2. Pyramid of biomass:

- It is based upon the total biomass (dry matter) at each trophic level in a food chain.
- The pyramid of biomass can also be upright or inverted. Fig. (a, b) show pyramids of biomass in a forest and an aquatic ecosystem.
- The pyramid of biomass in a forest is upright in contrast to its pyramid of numbers.
- This is because the producers (trees) accumulate a huge biomass while the consumers' total biomass feeding on them declines at higher trophic levels, resulting in broad base and narrowing top.



Pyramid of biomass (a) Grassland (b) Pond.

- The pond ecosystem shows an inverted pyramid of biomass (Fig. b).

- The total biomass of producers (phytoplanktons) is much less as compared to herbivores (zooplanktons, insects), Carnivores (Small fish) and tertiary carnivores (big fish).
- Thus the pyramid takes an inverted shape with narrow base and broad apex.

3. Pyramid of Energy:

- The amount of energy present at each trophic level is considered for this type of pyramid.
- Pyramid of energy gives the best representation of the trophic relationships and it is always upright.
- At every successive trophic level, there is a huge loss of energy (about 90%) in the form of heat, respiration etc.
- Thus, at each next higher level only 10% of the energy passes on. Hence, there is a sharp decline in energy level of each successive trophic level as we move from producers to top carnivores. Therefore, the pyramid of energy is always upright as shown in figure.