ENVIRONMENTAL SCIENCE AND ENGINEERING

UNIT-1

INTRODUCTION TO ENVIRONMENTAL STUDIES AND NATURAL RESOURCES

Definition

Environment is derived from the French word **Environ** which means to encircle or surround.

Environment is sum total of water, air, and land, inter-relationships among themselves and also with the human beings, other living organisms and property . The above definition given in Environment Act, 1986 clearly indicates that environment includes all the physical and biological surroundings and their interactions.

Scope

-

Scope of environmental science is broad. Some of the aspects of scope of environmental science are:

- Studying the interrelationships among biotic and abiotic components for sustainable human ecosystem,
- Carrying out impact analysis and environmental auditing for the further catastrophic activities,
- Developing and curbing the pollution from existing and new industries,
- Stopping the use of biological and nuclear weapons for destruction of human race,
- Managing the unpredictable disasters and so on.

There are some major issues like global warming, depletion of ozone layer, dwindling forests and energy resources, loss of global biodiversity etc., that are going to affect the mankind as a whole and for that we have to think globally.

Need for public awareness

- Public awareness very essential to help understand pros and cons of environmental problems.
- The United Nations Conference on Environment and Development held in Rio de Janerio in 1992 and popularly known as Earth summit followed by the world summit on sustainable Development in 2002, have highlighted key issues of global environmental concern.
- Environmental pollution cannot be removed by laws alone.
- The proper implementation and especially public participation are important aspects.

- Public participation is possible only when the public is aware about the ecological and environmental issues.
- A drive by the government to ban the littering of polythene cannot be successful until the public understands the environmental implications of the same.
- The public has to be educated about the fact that if we are degrading our environment we are actually harming ourselves.

Forest resources

Uses of Forests

Commercial uses:

- Man depends heavily on a larger number of plant and animal products from forests for his daily needs.
- The chief product that forests supply is wood, which is used as fuel, raw material for various industries as pulp, paper, newsprint, board, timber for furniture items, other uses as in packing articles, matches, sports goods etc.
- Indian forests also supply minor products like gums, resins, dyes, tannins, fibers, etc.
- Many of the plants are utilized in preparing medicines and drugs; Total worth of which is estimated to be more than $300 billion per year.
- Many forests lands are used for mining, agriculture, grazing, and recreation and for development of dams.

Over Exploitation of Forests

- ✓ Man depends heavily on forests for food, medicine, shelter, wood and fuel.
- ✓ With growing civilization the demands for raw material like timber, pulp, minerals, fuel wood etc. shot up resulting in large scale logging, mining, road-building and clearing of forests.
- ✓ Our forests contribute substantially to the national economy.
- ✓ The international timber trade alone is worth over US $ 40 billion per year.
- ✓ The devasting effects of deforestation in India include soil, water and wind erosion, estimated to cost over 16,400 crores every year.

Deforestation

- Deforestation means destruction of forests.
- The total forests area of the world in 1900 was estimated to be 7,000 million hectares which was reduced to 2890 million ha in 1975 fell down to just 2,300 million ha by 2000.

1. Loss of medicinal plants.
2. Loss of timber, fuel wood and others.

c) Effect on resources

1. Loss of land resource
2. Loss of soil fertility
3. Soil erosion
4. Drastic changes in biogeochemical cycles

d) Effect on economy

1. Increase in medicinal values
2. Demand of industrial products and others

e) Effect on food

1. Loss of fruit production
2. Loss of root based foods

Case Studies

Desertification in hilly regions of the Himalayas:

- Desertification 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.
- The area is invaded by exotic weeds. These areas are not able to recover and are losing their fertility.

Disappearing Tea gardens in Chhota Nagpur:

- Following the destruction of forest rain fall declined in Chhota Nagpur to such an extent that tea-gardens also disappeared from the region.

Waning rain fall in Udhagamandalam:

- 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.

Timber Extraction

- ✓ 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.

- ✓ Also road construction for making approach to the trees causes further damage to the forests.
- ✓ In India, firewood demand would continue to rise in future mostly consumed in rural areas, where alternative sources of energy, are yet to reach.

Mining

- Mining is the process of removing deposits of ores from substantially very well below the ground level.
- Mining is carried out to remove several minerals including coal.
- These mineral deposits invariably found in the forest region, and any operation of mining will naturally affect the forests.
- Mining from shallow deposits is done by surface mining while that from deep deposits is done by sub-surface mining.
- More than 80,000 ha of land of the country is presently under the stress of mining activities.

Effects of mining resources:

- Mining operation require removal of vegetation along with underlying soil mantle and overlying rock masses. This results in destruction of landscape in the area.
- Large scale of deforestation has been reported in Mussorie and Dehradun valley due to mining of various areas.
- Indiscriminate mining in Goa since 1961 has destroyed more than 50,000 ha of forest land.
- Mining of radioactive mineral in Kerala, Tamilnadu and Karnataka are posing similar threats of deforestation.

Dams and their effects on forests and tribal people

- Big dams and river valley projects have multi-purpose uses and have been referred to as "Temples of modern India".
- India has more than 1550 large dams, the maximum being in the state of Maharashtra (more than 600) followed by Gujarat (more than 250) and Madhya Pradesh (130).
- The highest one is Tehri dam, on river Bhagirathi in Utttaranchal and the largest in terms of capacity is Bhakra dam on river Sutlej.

Effects on Tribal people

- The greatest social cost of big dam is the widespread displacement of local people.

- It is estimated that the number of people affected directly or indirectly by all big irrigation projects in India over the past 50 years can be as high as 20 millions.
- The Hirakud dam, one of the largest dams executed in fifties, has displaced more than 20,000 people residing in 250 villages.

Effects on forests

Thousands of hectares of forests have been cleared for executing river valley projects which breaks the natural ecological balance of the region. Floods, landslides become more prevalent in such areas.
For example

- The Narmada sagar project alone has submerged 3.5 lakh hectares of best forest comprising of rich teak and bamboo forests.
- The Tehri dam submerged 1000 hectares of forest affecting about 430 species of plants according to the survey carried out by the botanical survey of India.

Water Resources

Uses of Water

- ❖ Due to its unique properties, water is of multiple uses for all living organisms.
- ❖ Water is absolutely essential for life.
- ❖ Most of the life processes take place in water contained in the body.
- ❖ 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, and transportation, washing and waste disposal for industries and used as a coolant for thermal power plants.
- ❖ Water shaped the earth's surface and regulates our climate.

Over utilization of surface and ground water

- ✓ With increasing human population and rapid development, the world water withdrawal demands have increased many folds and a large proportion of the water withdrawn is polluted due to anthropogenic activities.
- ✓ Out of the total water reserves of the world, about 97% is salty water and only 3% is fresh water.
- ✓ Even this small fraction of fresh water is not available to us as most of it is locked up in polar ice caps and just 0.003% is readily available to us in the form of ground water and surface water.

Effects of over exploitation of water

- **Subsidence:** When ground water withdrawal is more than its recharge rate, the sediments in the aquifer (a layer of rock that is highly permeable and contains water) get compacted, a phenomenon knows as ground subsidence. It results in sinking of overlying land surface. Due to this structural damage in buildings, fracture in pipes etc., occurs.
- **Lowering of water table**: Mining of groundwater is done extensively for irrigating crop fields. However, excessive mining would cause lowering of water table.
- **Water logging**: When excessive irrigation is done with brackish water it raises the water table gradually leading to water-logging and salinity problems.

Floods and drought

- ✓ Heavy rainfall often causes floods in the low-lying coastal areas.
- ✓ Prolonged downpour can also cause the over-flowing of lakes and rivers

- ✓ When annual rainfall is below normal and less than evaporation, drought conditions are created.

Causes of flood and drought:

- Deforestation, overgrazing, mining, rapid industrialization, global warming etc., have contributed largely to a sharp rise in the incidence of floods.
- Deforestation leads to desertification and drought too. When the trees are cut, the soil is subject to erosion by heavy rains, winds and sun.
- The removal of thin top layer of soil takes away the nutrients and the soil becomes useless.
- The eroded soils exhibit droughty tendency.

Preventive measures:

Clear knowledge in control of drought and desertification can be very useful for dealing with the problem.

- Carefully selected mixed cropping helps to 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 requirement and natural process.

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. Many countries are engaged in bitter rivalries over this precious resource.

For instance,

- Argentina and Brazil, dispute each other's claims to the La Plata river,
- India and Pakistan fight over the rights to water from the Indus,
- Mexico and USA have come in conflict over the Colorado river,
- India and Bangladesh are fighting for Bhrahmaputra river, and
- Iran and Iraq contest for the water from Shatt-Al- Arab River.

Within India, water conflicts are still being continues between the states. For Eg.,

- Sharing of Krishna water between Karnataka and Andhra Pradesh,
- Sharing of Siruvani water between Tamilnadu and Kerala, and others.
- Sharing of Cauvery between Karnataka and Tamilnadu
- On June 2,1990, the Cauvery Water dispute Tribunal was set up which through an interim award directed Karnataka to ensure that 205 TMCF of water was made available in Tamil Nadu's Mettur dam every year, till a settlement was reached.
- In 1991-1992 due to good monsoon, there was no dispute. 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.
- Samba paddy in winter, Kuravai 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 are suggested as some measures to solve the problem

Big-Dams –Benefits and Problems

Benefits:

- ✓ River valley projects with big dams play a key role in the development process due to their multiple uses.
- ✓ These dams aim at providing employment for tribal people and raising the standard and quality of life.
- ✓ Dams can help in checking floods and 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.

Problems:

The impacts of big dams can be upstream as well as downstream levels.

The upstream problems include the following:

- ❖ Displacement of tribal people
- ❖ Loss of forests, flora and fauna
- ❖ Changes in fisheries

- ❖ Saltation and sedimentation of reservoirs
- ❖ Loss of non-forest land
- ❖ Stagnation and waterlogging near reservoir
- ❖ Breeding vectors and spread of vector –borne diseases
- ❖ Reservoir induces seismicity causing earthquakes
- ❖ Microclimatic changes
- ❖ Growth of aquatic weeds

The downstream problems include the following:

- ❖ Water logging and salinity due to over irrigation
- ❖ Microclimatic changes
- ❖ Reduced water flow and slit deposition in river
- ❖ Flash foods
- ❖ Salt water intrusion at river mouth
- ❖ Loss of land fertility
- ❖ Outbreak of vector-borne diseases like malaria.

Mineral Resources

Uses of minerals

Mineral is an element or inorganic compound that occurs naturally. The main uses of minerals are as follows:

- Development of industrial plants and machinery
- Generation of energy e.g. coal, lignite, uranium
- Construction, housing ,settlements
- Defense equipments- weapons, settlement
- Transportation means
- Communication-telephone wires, cables, electronic devices
- Medical system- particularly in Ayurvedic System
- Formation of alloys for various purposes
- Agriculture- as fertilizers, seed dressings and fungicides
- Jewellery- eg. Gold, silver, platinum, diamond

Major reserves and important uses of some of the metals:

Metals	**Major world reserves**	**Major uses**
Aluminium	Australia, Jamaica	Packing food items, transportation, utensils, electronics
Chromium	CIS(The common wealth of Independent states), South Africa	For making high strength steel alloys, in textiles and tanning industries

Copper	U.S.A, Canada, CIS	Electronic and electrical goods, building, construction, vessels
Iron	CIS, Canada, U.S.A	Heavy machinery, steel production transportation means.
Manganese	South Africa, CIS	For making high strength heat resistant steel alloys
Platinum	South Africa, CIS	Use in automobiles, catalytic converters, electronics, medical uses.
Gold	South Africa, CIS, Canada	Ornaments, medical use, electronic use, in aerospace
Silver	Canada, South Africa	Photography, electronic jewellery.
Nickel	CIS, Canada	Chemical industry, steel alloys

Major uses of some of the non metallic minerals

Non-metal mineral	**Major uses**
Silicate minerals	Sand and grovel for construction, bricks, paving etc.
Limestone	Used for concrete, building stone, used in agriculture for neutralizing acid soils, used in cement industry
Gypsum	Used in plaster wall-board, in agriculture
Potash, phosphorite	Used as fertilizers
Sulphur pyrites	Used in medicine, car battery, industry

Environmental impacts of mineral extraction:

Major mines which are known for causing severe problems are given below:

- Jaduguda Uranium Mine, Jharkhand- exposing local people to radioactive hazards.

Major uses of some of the non metallic minerals

Non-metal mineral	**Major uses**
Silicate minerals	Sand and grovel for construction, bricks, paving etc.
Limestone	Used for concrete, building stone, used in agriculture for neutralizing acid soils, used in cement industry
Gypsum	Used in plaster wall-board, in agriculture
Potash, phosphorite	Used as fertilizers
Sulphur pyrites	Used in medicine, car battery, industry

Environmental impacts of mineral extraction:

Major mines which are known for causing severe problems are given below:

- Jaduguda Uranium Mine, Jharkhand- exposing local people to radioactive hazards.

- ♠ Jharia coal mines, Jharkhand- underground fire leading to land subsidence and forced displacement of people.
- ♠ Sukinda chromite mines, Orissa- Seeping of hexavalent chromium into river posing serious health hazard, Cr^{6+} being highly toxic and carcinogenic.
- ♠ Kudremukh iron ore mine, Karnataka- causing river pollution and threat to biodiversity.
- ♠ East coast Bauxite mine, Orissa-Land encroachment and issue of rehabilitation unsettled.

- ♠ North-Eastern Coal Fields, Assam-Very high sulphur contamination of groundwater.

Impacts of mining: Mining is done to extract minerals from deep deposits in soil. Environmental damages caused by mining activities are as follows:

- **Devegetation and defacing of lands:** Mining requires removal of vegetation along with underlying soil mantle and overlying rock masses. This results in destruction of landscape in the area.
- **Subsidence of land:** Subsidence of mining areas results in tilting of buildings, cracks in houses, buckling of roads, bending of rail tracks and leaking of gas from cracked pipe lines leading to serious disasters.
- **Groundwater contamination:** Mining 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.
- **Surface water pollution:** The acid mine drainage often contaminates the nearby streams and lakes. The acidic water, radioactive substances like uranium, heavy metals also contaminate the water bodies and kill aquatic animals.
- **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. Oxides of sulphur, arsenic, cadmium and lead etc. shoot up in the atmosphere near the smelters and the public suffers from several health problems.
- **Occupational Health Hazards:** Miners working in different type of mines suffer from asbestosis, silicosis, black lung disease etc

Remedial measures:

- Adopting eco-friendly mining technology
- Utilization of low grade ores by using microbial – leaching technique. In this method, the ores are inoculated with the desired strains of bacteria like Thiobacillus ferroxidans, which remove the impurities and leave the pure mineral.
- Re-vegetating mined areas with appropriate plants
- Gradual restoration of flora
- Prevention of toxic drainage discharge.

Case studies

1. Mining and quarrying in Udaipur

- Soap stones, building stone, and dolomite mines spread over 15,000 hectares in Udaipur have caused many adverse impacts on environment.
- About 150 tones of explosives are used per month in blasting.
- The Maton mines have badly polluted the Ahar river.
- The hills around the mines are suffering from acute soil erosion.
- The waste water flows towards a big tank of " Bag Dara".

    - Due to scarcity of water people are compelled to use this effluent for irrigation purpose.
    - The animals like tiger, lion, deer, and birds have disappeared from the mining area.

2. Mining in Sariska Tiger Reserve in Aravallis

    - The Aravalli range is spread over about 692 Km in the North-west India covering Gujrat, Rajasthan, Haryana, and Delhi.
    - The hill is rich in mineral resources.
    - Mining operations within and around the Sariska Tiger reserve has left many areas permanently infertile and barren.
    - The precious wild life is under serious threat.

Food resources

World Food Problems

- ✓ During the last 50 years world grain production has increased almost three times.
- ✓ The per capita production is increased by about 50%.
- ✓ At the same time population growth increased at such a rate in less developed countries.
- ✓ Every 40 million people 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.
- ✓ This statistics emphasize the need to increase our food production, and also to control population growth.
- ✓ It is estimated that 300 millions are still undernourished.

Impacts of overgrazing and agriculture.

Overgrazing:

Overgrazing can limit livestock production. Over grazing occurs when too many animals graze for too long and exceed the carrying capacity of a grass land area.

Impact of overgrazing:

- ✓ **Land degradation:** Overgrazing removes the grass cover. The humus content of the soil is decreased and it leads to poor, dry, compacted soil.
- ✓ **Soil erosion:** The soil 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.
- ✓ **Loss of useful species:** Due to overgrazing the nutritious species like cenchrus, panicum etc. are replaced by thorny plants like Parthenium, Xanthium etc. These species do not have a good capacity of binding the soil particles and, therefore, the soil becomes more prone to soil erosion.

Agriculture:

Traditional Agriculture and its impacts:

- Usually involves a small plot
- Simple tools
- Naturally available water
- Organic fertilizer and a mix of crops

Main impacts:

- Deforestation
- Soil erosion
- Depletion of nutrients

Modern Agriculture and its impacts:

- It makes use of hybrid seeds of selected and single crop variety.
- high-tech equipments, lots of energy subsidies in the form of fertilizers and, pesticides
- Irrigation water

Main impacts:

Main impacts:

I. **Impacts related to high yielding verities (HYV**): The uses of HYVs encourage monoculture i.e. the same genotype is grown over vast areas. Incase 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:** Chemical fertilizers have nitrogen, phosphorus and potassium (N,P,K) which are essential macronutrients. 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 the infants to the maximum extent causing even death.

c. **Eutrophication**: A large proportion of nitrogen and phosphorus used in crop fields is washed off along with runoff water and reach the water bodies causing over nourishment of the lakes, a process known as Eutrophication. (Eu=more, tropic=nutrition). Due to Eutrophication the lakes get invaded by algal blooms. These algal species grow very fast by rapidly using up the nutrients. The algal species quickly complete their life cycle and die thereby adding a lot of dead matter. The fishes are also killed and there is 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. They have number of side effects as discussed below:
    a. **Creating resistance in pests and producing new pests**: 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 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. This is very harmful.

IV. **Water Logging**: Over irrigation of croplands by farmers for good growth of their crop usually leads to water logging. Inadequate drainage caused 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 due to adequate canal water supply or tube-well water. 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. Saline soils are characterized by the accumulation of soluble salts like sodium chloride, sodium sulphate, calcium chloride, magnesium chloride etc. in the soil profile. 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%.

Remedy:

(i) The most common method for getting rid of salts is to flush them out by applying more good quality water to such soils.

(ii) Another method is laying underground network of perforated drainage pipes for flushing out the salts slowly.

Case studies

Salinity and water logging in Punjab, Haryana and Rajasthan:

- The first alarming report of salt-affected wasteland formation due to irrigation practices came from Haryana in 1858.
- Several villages in Panipat, and Delhi lying in Western Yamuna Canal were suffering from salinity problems.
- The floods of 1947, 1950, 1952, 1954-55 in Punjab resulted in aggravated water logging with serious drainage problems.
- Introduction to canal irrigation in 1.3 m ha in Haryana resulted in raise in water table followed by water-logging and salinity in many irrigated areas as a result of fall in crop productivity.
- Rajasthan too has suffered badly in this regard following the biggest irrigation project "Indhra Gandhi Canal Project"

Energy resources

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.
- In developed countries like U.S.A and Canada an average person consumes 300 GJ per year.
- By contrast, an average man in a poor country like Bhutan, Nepal or Ethiopia consumes less than 1 GJ per year.
- This clearly shows that our life-style and standard of living are closely related to energy needs.

Renewable and Non-Renewable energy sources

Life on earth depends upon a large number of things and services provided by nature, which are knows as energy resources.

Energy Resources are of two kinds.

I. **Renewable resources:** which are inexhaustive and can be regenerated within a given span of time eg. Forests, wildlife, wind energy, biomass energy etc. Solar energy is also a renewable form of energy as it is an inexhaustible source of energy.
II. **Non-renewable resources** which cannot be regenerated eg. Fossil fuels like coal, petroleum etc. Once we exhaust these reserves, the same cannot be replenished.

Even our renewable resources can become non-renewable if we exploit them to such extent their rate of consumption exceeds their rate of regeneration.

Renewable energy resources:

I. **Solar energy:**
   a. Sun releases enormous quantity of energy in the form of heat and light.
   b. The solar energy received by the near earth space is approximately1.4 $kJ/s/m^2$ known as solar constant.
   c. Now we have several techniques for harnessing solar energy.
   d. Solar heat collectors, solar cells, solar cooker, solar water heater, solar furnace and solar power plant are some important solar energy harvesting devices.

II. **Wind Energy**:
   a. The high speed winds have a lot of energy in them as kinetic energy due to their motion.
   b. Wind energy is very useful as it does not cause any air pollution.
   c. After the installation cost, the wind energy is very cheap.

III. **Hydro power**:
   a. 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.
   b. The blades of turbine located at the bottom of the dam move with the fast moving water which in turn rotates the generator and produces electricity.
   c. Hydro power does not cause any pollution.
   d. Hydro power projects help in controlling floods, used for irrigation, navigation etc.

IV. **Tidal energy**:
   a. Ocean tides produced by gravitational forces of sun and moon contain enormous amounts of energy.
   b. The tidal energy is harnessed by constructing a tidal barrage.
   c. During high tide, the water flows into the reservoir of the barrage and turns the turbine, which in turn produces electricity by rotating the generators.
   d. 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.

V. **Ocean thermal energy (OTE)**:
   a. The energy available due to the difference in the temperature of water at the surface of the tropical oceans and at deeper levels is called OTE.
   b. This energy is used to boil liquid like ammonia.
   c. The high pressure vapours of the liquid formed by boiling are then used to turn the turbine of a generator and produce electricity.

VI. **Geothermal energy:**
   a. The energy harnessed from hot rocks present inside the earth is called geothermal energy.
   b. Sometimes the steam or boiling water underneath the earth does not find any place to come out.

c. We can 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 electricity.

VII. Biomass energy:

a. Biomass is the organic matter produced by the plants or animals which include wood, crop, residues, cattle dung agricultural wastes etc.
b. The burning of biogas cause air pollution and produce a lot of ash.
c. It is therefore more useful to convert biomass into biogas or bio fuels.

VIII. Biogas:

a. Biogas is a mixture of methane, carbon dioxide, hydrogen and hydrogen sulphide.
b. Biogas is produced by anaerobic degradation of animal wastes in the presence of water.
c. Anaerobic degradation means break down of organic matter by bacteria in the absence of oxygen.
d. Biogas has many advantages. It is clean, non-polluting and cheap.
e. There is direct supply of gas from the plant and there is no storage problem

IX. Bio fuels:

a. Biomass can be fermented to alcohols like ethanol and methanol which can be used as fuels.
b. Gasohol is common fuel in Brazil and Zimbabwe for running cars and buses.
c. Methanol is very useful since it burns at a lower temperature than gasoline or diesel.
d. Due to its high calorific value, hydrogen can serve as an excellent fuel.
e. Moreover it is non-polluting and can be easily produced.
f. Presently H_2 is used in the form of liquid hydrogen as a fuel in spaceships.

Non -Renewable energy resources:

I. Coal:

a. Coal was formed 255-250 million years ago in the hot, damp regions of the earth during the carboniferous age.
b. The ancient plants along the banks of rivers were buried after death into the soil and due to the heat and pressures gradually got converted into peat and coal over million years of time.
c. When coal burnt it produces carbon dioxide, which is a green house gas responsible for causing enhanced global warming.

II. Petroleum:

a. It is the life line of global economy.
b. Petroleum is a cleaner fuel as compared to coal as it burns completely and leaves no residue.

c. It is also easy to transport and use.

d. Crude petroleum is a complex mixture of alkane hydrocarbons.
e. Hence it has to be refined by the process of fractional distillation, during which we get large variety of products namely, petroleum gas, kerosene, petrol, diesel, fuel oil, lubricating oil, paraffin wax etc.
f. The petroleum gas is easily converted to liquid form under pressure as LPG.

III. Natural gas:

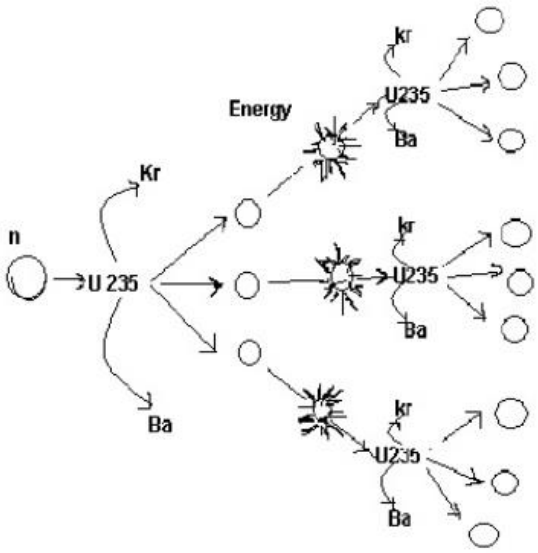
a. It is mainly composed of methane with small amounts of propane and ethane.
b. It is used as a domestic and industrial fuel in thermal power plants for generating electricity.
c. It is used as a source of hydrogen gas in fertilizer industry and as a source of carbon in tier industry.

IV. Nuclear energy:

a. Nuclear energy is known for its high destructive power.
b. Nuclear energy can be generated by two types of reactions:

(i) Nuclear fission: It is the nuclear reaction in which heavy isotopes are split into lighter nuclei on bombardment by neutrons. Fission reaction of U^{235} is given below.

$$_{92}U^{235} + _{0}n1 \longrightarrow {}_{36}Kr^{92} + {}_{56}Ba^{141} + 3\ {}_{0}n^{1} + \text{energy}$$



(ii) Nuclear fusion: Here two isotopes of a light element are forced together at extremely high temperatures (1 billion °C) until they fuse to form a heavier nucleus releasing enormous amount of energy in the process.

$$_{1}H^{2} + _{1}H^{2} \longrightarrow {}_{3}He^{2} + {}_{0}n^{1} + \text{energy}$$

Nuclear energy has tremendous potential but any leakage from the reactor may cause devastating nuclear pollution. Disposal of the nuclear waste is also a big problem.

Land Resources

Land as a resource

- We depend upon land for our food, fibre, and fuel wood.
- 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 for land for producing food, fibre and fuel wood is also increasing.
- Hence there is more and more pressure on limited land resources which are getting degraded due to over-exploitation.
- 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.

Man induced 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 the construction of roads, mining activities etc. huge portions of fragile mountainous areas are cut or destroyed by dynamite and thrown into adjacent valleys and streams.
- These land masses weaken the already fragile mountain slopes and lead to landslides.
- They also increase the turbidity of various nearby streams, thereby reducing their productivity.

Soil erosion

- Soil erosion is defined as the movement of soil components, especially surface litter and 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.

Soil erosion is basically of two types based upon the cause of erosion:

a) **Normal erosion or geological erosion:** caused by the gradual removal of top soil by natural processes which bring equilibrium between physical, biological and hydrological activities and maintain a natural balance between erosion and renewal.
b) **Accelerate erosion**: This is mainly caused by 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. They are climatic agents and biotic agents.

I. Climatic Agents – Water and Wind:

Water affects soil erosion in the form of rain. **Water induced soil erosion** is of following types:

a) **Sheet erosion:** When there is uniform removal of a thin layer of soil from a large surface area, it is called sheet erosion.
b) **Rill erosion:** when there is rainfall and rapidly running water produces finger-shaped grooves or rills over the area, it is called rill erosion.
c) **Gully 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.
d) **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 bank

Wind erosion is responsible for the following three types of soil movements:

a) **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.
b) **Suspension**: Here fine soil particles (less than 1mm diameter) which are suspended on the air are kicked up and taken away to distant places.
c) **Surface creep:** Here the large particles (5-10 mm diameter) creep over the soil surface along with wind.

II. Biotic Agents:

a. Excessive grazing, mining, and deforestation are the major biotic agents responsible for soil erosion.

b. Deforestation without reforestation, overgrazing by cattle, surface mining without land reclamation, irrigation techniques that lead to salt build- up, water logged soil, make the top soil vulnerable to erosion.

Soil conservation practices:

In order to prevent soil erosion and conserve the soil the following practices are employed.

1. **Conventional till farming:**
   a. In traditional method the soil is broken up and smoothed to make a planting surface.
   b. This disturbs the soil and makes it susceptible to erosion.
   c. Conservational till farming, popularly known as no-till-farming causes minimum disturbance to the top soil.
   d. Here special tillers break up and loosen the subsurface soil without turning over the top soil.
   e. The tilting machines make slits in the soil and inject seeds, fertilizers, and little water in the slit, so that crop grows successfully.
2. **Contour farming:**
   a. On gentle slopes, crops are grown in rows across, rather up and down.
   b. This practice is knows as contour farming.
   c. It helps to hold soil and slow down loss of soil through run-off water.
3. **Terracing:**
   a. It is used on still steeper slopes are converted into a series of broad terraces which run across the contour.
   b. Terracing retains water for crops at all levels and cuts down soil erosion.
4. **Strip cropping** :
   a. Here strops of crops are alternated with strips of soil saving crops like grasses or grass- legume mixture.
   b. What ever run-off comes from the cropped soil is retained by the strip of cover- crop and this reduces soil erosion.
5. **Alley cropping:**
   a. It is a form of inter – cropping in which crops are planted between rows of trees or shrubs. This is also called **Agro forestry**.
   b. Even when the crop is harvested, the soil is not fallow because trees and shrubs still remain on the soil holding the soil particles and prevent soil erosion.
6. **Wind breaks or shelterbelts**:
   a. The trees are planted in long rows along the cultivated land boundary so that wind is blocked.
   b. **)** The wind speed is substantially reduced which helps in preventing wind erosion of soil.

Desertification

- ★ Desertification is characterized by devegitation and loss of vegetal over, depletion of groundwater, salinization and severe soil erosion.
- ★ Desertification leads to the conversion of irrigated croplands to desert like conditions in which agricultural productivity falls.
- ★ Moderate desertification produce 10-25% drop in productivity.
- ★ Severe desertification cause 25-50% drop while very severe desertification results in 50% drop in productivity.

Causes of Desertification: The major man made activities responsible for desertification are as follows.

I. Deforestation:
- **a.** Deforestation means destruction of forests.
- **b.** The total forests area of the world in 1900 was estimated to be 7,000 million hectares which was reduced to 2890 million ha in 1975 fell down to just 2,300 million ha by 2000.
- **c.** Deforestation rate is relatively less in temperature countries, but it is very alarming in tropical countries.

II. Overgrazing:
- **a.** Overgrazing can limit livestock production.
- **b.** Over grazing occurs when too many animals graze for too long and exceed the carrying capacity of a grass land area.
- **c.** Overgrazing removes the grass cover.
- **d.** The humus content of the soil is decreased and it leads to poor, dry, compacted soil.
- **e.** The soil roots are very good binders of soil.
- **f.** When the grasses are removed, the soil becomes loose and susceptible to the action of wind and water.
- **g.** The dry barren land reflects more of the suns heat, changing wind patterns leading to further desertification.

III. Mining and quarrying:
- **a.** Mining operation requires removal of vegetation along with underlying soil mantle and overlying rock masses. This results in destruction of landscape in the area.

Conservation of natural resources: role of an individual

Different natural resources like forests, water, soil, food, mineral and energy resources play a vital role in the development of a nation. While conservation efforts are underway at National as well as International level, the individual efforts for conservation of natural resources can go a long way.

Conserve Water
- Don't keep water taps running while brushing, shaving, washing or bathing.

- 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.
- Use drip irrigation and sprinkling irrigation to improve irrigation efficiency and reduce evaporation.
- Install a small system to capture rain water and collect normally wasted used water from sinks, cloth-washers, bathtubs etc. which can be used for watering the plants
- Build rain water harvesting system in your house. Even the President of India is doing this.

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.
- Grow deciduous trees and climbers 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.
- 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. Plant the disturbed areas with a fast growing native ground cover.
- 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.
- 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.
- 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 style

- There is a big divide in the world as North and South, the more developed countries (MDC'S) and less developed countries (LDC'S), the haves and the have nots.

- The MDC's have only 22% of world's population, but they use 88% of its natural resources, 73% of its energy and command 85% of its income.
- As the rich nations continue to grow, they will reach a limit.
- If they have a growth rat of 10% every year, they will show 1024 times increase in the next 70 years.
- Will this much of growth be sustainable? The answer is 'No' because many of 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.
- 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 poor in the LDC'S are at least able to sustain their life.
- Unless they are provided with such basic resources, we cannot think of rooting out the problems related to dirty, unhygienic, polluted, disease infested settlements of these people-which contribute to unsustainability.
- Thus, the two basic causes of unsustainability are over population in poor countries who have under consumption of resources and over consumption of resources by the rich countries, which generate wastes.
- In order to achieve sustainable life styles it is desirable to achieve a more balanced and equitable distribution of global resources and income to meet everyone's basic needs.
- The rich countries will have to lower down their consumption levels while the bare minimum needs of the poor 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 and not just for a privileged group.