Unit

2 Natural Resources

Life on this planet earth depends upon a large number of things and services provided by the nature, which are known as Natural resources. Thus water, air, soil, minerals, coal, forests, crops and wild life are all examples of natural resources.

The natural resources are of two kinds:

- Renewable resources which are inexhaustive and can be regenerated within a given span of time e.g. forests, wildlife, wind energy, biomass energy, tidal energy, hydro power etc. Solar energy is also a renewable form of energy as it is an inexhaustible source of energy.
- Non-renewable resources which cannot be regenerated e.g. Fossil fuels like coal, petroleum, minerals 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 that their rate of consumption exceeds their rate of regeneration. For example, if a species is exploited so much that its population size declines below the threshold level then it is not able to sustain itself and gradually the species becomes endangered or extinct.

It is very important to protect and conserve our natural resources and use them in a judicious manner so that we don't exhaust them. It does not mean that we should stop using most of the natural resources. Rather, we should use the resources in such a way that we always save enough of them for our future generations. In this unit we shall discuss the major natural resources:

(*i*) Forest resources
(*ii*) Water resources
(*iii*) Mineral resources
(*iv*) Food resources
(*v*) Energy resources
(*vi*) Land resources.

2.1 FOREST RESOURCES

Forests are one of the most important natural resources on this earth. Covering the earth like a green blanket these forests not only produce innumerable material goods, but also provide several environmental services which are essential for life.

About 1/3rd of the world's land area is forested which includes closed as well as open forests. Former USSR accounts for about a 5th of the world's forests, Brazil for about a 7th and Canada and USA each for 6-7%. But it is a matter of concern that almost everywhere the cover of the natural forests has declined over the years. The greatest loss occurred in tropical Asia where one third of the forest resources have been destroyed.

■ USES OF FORESTS

Commercial uses: Forests provide us a large number of commercial goods which include timber, firewood, pulpwood, food items, gum, resins, non-edible oils, rubber, fibers, lac, bamboo canes, fodder, medicine, drugs and many more items, the total worth of which is estimated to be more than $ 300 billion per year.

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 for paper industry. Many forest lands are used for mining, agriculture, grazing, and recreation and for development of dams.

Ecological uses: While a typical tree produces commercial goods worth about $ 590 it provides environmental services worth nearly $ 196, 250.

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

- **Production of oxygen:** The trees produce oxygen by photosynthesis which is so 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 forest canopy acts as a sink for CO_2 thereby reducing the problem of global warming caused by greenhouse gas CO_2.

- **Wild life 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**: Forested watersheds act like giant sponges, absorbing the rainfall, slowing 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. They also act as wind-breaks.
- **Pollution moderators:** Forests can absorb many toxic gases and can help in keeping the air pure. They have also been reported to absorb noise and thus help in preventing air and noise pollution.

■ OVER EXPLOITATION OF FORESTS

Since time immemorial, humans have depended 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. shooted 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. Excessive use of fuel wood and charcoal, expansion of urban, agricultural and industrial areas and overgrazing have together led to over-exploitation of our forests leading to their rapid degradation.

■ DEFORESTATION

The total forest area of the world in 1900 was estimated to be 7,000 million hectares which was reduced to 2890 million ha in 1975 and fell down to just 2,300 million ha by 2000. Deforestation rate is relatively less in temperate countries, but it is very alarming in tropical countries where it is as high as 40-50 percent and at the present rate it is estimated that in the next 60 years we would lose more than 90 percent of our tropical forests.

The forested area in India seems to have stabilized since 1982 with about 0.04% decline annually between 1982-90. FAO (1983) estimated that about 1.44 m ha of land was brought under afforestation during this period leading to stabilization. As per FAO estimates, the deforestation rate per unit population in India is the lowest amongst the major tropical countries, despite the fact that we have a huge population size and very low per capita forest area (0.075 ha per capita). However, we are still far behind the target of achieving 33% forest area, as per our National Forest Policy, as we are still having only 19.27 % of our land area (63.38m ha) covered by forests based on satellite data (MoEF, 1998)

Major Causes of Deforestation

(*i*) **Shifting cultivation:** There are an estimated 300 million people living as shifting cultivators who practice slash and burn agriculture and are supposed to clear more than 5 lakh ha of forests for shifting cultivation annually. In India, we have this practice in North-East and to some extent in Andhra Pradesh, Bihar and M.P which contribute to nearly half of the forest clearing annually.

(*ii*) **Fuel requirements:** Increasing demands for fuel wood by the growing population in India alone has shooted up to 300-500 million tons in 2001 as compared to just 65 million tons during independence, thereby increasing the pressure on forests.

(*iii*) **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. Plywood is in great demand for packing tea for Tea industry of Assam while fir tree wood is exploited greatly for packing apples in J&K.

(*iv*) **Development projects:** Massive destruction of forests occur for various development projects like hydroelectric projects, big dams, road construction, mining etc.

(*v*) **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.

(*vi*) **Overgrazing:** The poor in the tropics mainly rely on wood as a source of fuel leading to loss of tree cover and the cleared lands are turned into the grazing lands. Overgrazing by the cattle leads to further degradation of these lands.

Major Consequences of Deforestation

Deforestation has far reaching consequences, which may be outlined as follows:

(*i*) It threatens the existence of many wild life species due to destruction of their natural habitat.

(*ii*) Biodiversity is lost and along with that genetic diversity is eroded.

(*iii*) Hydrological cycle gets affected, thereby influencing rainfall.

(*iv*) Problems of soil erosion and loss of soil fertility increase.

(*v*) In hilly areas it often leads to landslides.

CASE STUDIES

- **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 (edaphic) and biological properties. Nutrient cycling has become poor, original rich germplasm is lost and the area is invaded by exotic weeds. These areas are not able 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.

- **Disappearing Tea gardens in Chhota Nagpur**

This hilly region used to be a good forested area towards the turn of the century and used to receive fairly frequent afternoon showers favouring tea plantations. Following the destruction of forests, rainfall declined in Chhota Nagpur to such an extent that tea -gardens also disappeared from the region.

- **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.

Major Activities in Forests

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.

Mining: Mining operations for extracting minerals and fossil fuels like coal often involves vast forest areas. 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. 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.

Large scale deforestation has been reported in Mussorie and Dehradun valley due to indiscriminate mining of various minerals over a length of about 40 Km. The forested area has declined at an average rate of 33% and the increase in non-forest area due to mining activities has resulted in relatively unstable zones leading to landslides.

Indiscriminate mining in forests of Goa since 1961 has destroyed more than 50,000 ha of forest land. 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.

■ DAMS AND THEIR EFFECTS ON FORESTS AND PEOPLE

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). The highest one is *Tehri dam*, on river Bhagirathi in Uttaranchal and the largest in terms of capacity is Bhakra dam on river Satluj in H.P. Big dams have been in sharp focus of various environmental groups all over the world which is mainly because of several ecological problems including deforestation and socio-economic problems related to tribal or native people associated with them. The

Silent Valley hydroelectric project was one of the first such projects situated in the tropical rain forest area of Western Ghats which attracted much concern of the people. *The crusade against the ecological damage and deforestation caused due to Tehri dam was led by Sh. Sunder lal Bahuguna, the leader of Chipko movement. The cause of Sardar Sarovar Dam related issues has been taken up by the environmental activists Medha Patekar, joined by Arundhati Ray and Baba Amte.*

For building big dams, large scale devastation of forests takes place which breaks the natural ecological balance of the region. Floods, droughts and landslides become more prevalent in such areas. Forests are the repositories of invaluable gifts of nature in the form of biodiversity and by destroying them (particularly, the tropical rain forests) we are going to lose these species even before knowing them. These species could be having marvelous economic or medicinal value and deforestation results in loss of this storehouse of species which have evolved over millions of years in a single stroke.

Sardar Sarovar Dam (Uprooted Forests And Tribals): A case study

The dam is situated on river Narmada and is spread over three states of Gujarat, Maharashtra and Madhya Pradesh. Although the project is aimed at providing irrigation water, drinking water and electricity to the three states, the environmental impacts of the project have raised challenging questions.

A total of 1,44,731 ha of land will be submerged by the dam, out of which 56,547 ha is forest land. A total of 573 villages are to be submerged by the Narmada Dam.

Submergence of about 40,000 ha of forest under Narmada Sagar, 13,800 ha under Sardar Sarovar and 2,500 ha under Omkareshwar would further create pressure on remaining forest areas in adjoining areas. Submergence area is very rich in wildlife e.g. tigers, panthers, bears, wolves, pangolins, hyenas, jackals, flying squirrels, antelopes, black bucks, chinkara, marsh crocodiles, turtles etc. Many of these species are listed in schedule I & II of Wildlife Protection Act, 1972. Thus massive loss of these wildlife species is apprehended due to the devastation of the forest under the project.

As per the estimates of the Institute of Urban Affairs, New Delhi, the Narmada valley project will lead to eventual displacement of more than one million people, which is probably the largest

(*Contd.*)

rehabilitation issue ever encountered as per the World Bank. Uprooting of the tribals and their forced shifting in far-flung areas may not be easily adjusted to. Besides serious economic deprivation, the displacement will affect the tribal peoples' culture, their beliefs, myths and rituals, festivals, songs and dances, all closely associated with the hills, forest and streams. Most of these tribals belong to poor, unprivileged schedule castes and tribes who are being uprooted from a place where they have lived for generations. The displaced persons have to undergo hardship and distress for the sake of development and prosperity of a larger section of the society. It is therefore the duty of the project proponents and government to pay maximum attention for proper rehabilitation of the displaced tribals.

2.2 WATER RESOURCES

Water is an indispensable natural resource on this earth on which all life depends. About 97% of the earth's surface is covered by water and most of the animals and plants have 60-65% water in their body.

Water is characterized by certain unique features which make it a marvellous resource:

(*i*) It exists as a liquid over a wide range of temperature i.e. from 0° to100°C.

(*ii*) It has the highest specific heat, due to which it warms up and cools down very slowly without causing shocks of temperature jerks to the aquatic life.

(*iii*) It has a high latent heat of vaporization Hence, it takes a huge amount of energy for getting vaporized. That's why it produces a cooling effect as it evaporates.

(*iv*) It is an excellent solvent for several nutrients. Thus, it can serve as a very good carrier of nutrients, including oxygen, which are essential for life. But, it can also easily dissolve various pollutants and become a carrier of pathogenic microorganisms.

(*v*) Due to high surface tension and cohesion it can easily rise through great heights through the trunk even in the tallest of the trees like *Sequoia*.

(*vi*) It has an anamolous expansion behaviour i.e. as it freezes, it expands instead of contracting and thus becomes lighter. It is because of this property that even in extreme cold, the lakes freeze only on the surface. Being lighter the ice keeps floating, whereas the bottom waters remain at a higher temperature and therefore, can sustain aquatic organisms even in extreme cold.

The water we use keeps on cycling endlessly through the environment, which we call as **Hydrological Cycle**. We have enormous resources of water on the earth amounting to about 1404 million Km^3. The water from various moist surfaces evaporates and falls again on the earth in the form of rain or snow and passes through living organisms and ultimately returns to the oceans. Every year about 1.4 inch thick layer of water evaporates from the oceans, more than 90% of which returns to the oceans through the hydrological cycle. Solar energy drives the water cycle by evaporating it from various water bodies, which subsequently return through rainfall or snow. Plants too play a very important role by absorbing the groundwater from the soil and releasing it into the atmosphere by the process of transpiration.

Global distribution of water resources is quite uneven depending upon several geographic factors. Tropical rain forest areas receive maximum rainfall while the major world deserts occur in zones of dry, descending air (20-40° N and S) and receive very little rainfall.

■ WATER USE AND OVER-EXPLOITATION

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, 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.

Water use by humans is of two types: **water withdrawal:** taking water from groundwater or surface water resource and **water consumption:** the water which is taken up but not returned for reuse. Globally, only about 60 percent of the water withdrawn is consumed due to loss through evaporation.

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. On a global average 70 percent of the water withdrawn is used for agriculture. In India, we use 93% of water in agricultural sector while in a country like Kuwait, which is water-poor, only 4% is used for watering the crops. About 25% of water on global average is used in industry, which again varies from a high of 70% in European countries to as low as 5% in less developed countries. Per capita use of water shows wide variations. In USA, an average family of 4 consumes more than 1000 M^3 of water per year, which is many times more than that in most developing countries.

Water: A Precious Natural Resource

Although water is very abundant on this earth, yet it is very precious. Out of the total water reserves of the world, about 97% is salty water (marine) 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 groundwater and surface water.

Overuse of groundwater for drinking, irrigation and domestic purposes has resulted in rapid depletion of groundwater in various regions leading to lowering of water table and drying of wells. Pollution of many of the groundwater aquifers has made many of these wells unfit for consumption.

Rivers and streams have long been used for discharging the wastes. Most of the civilizations have grown and flourished on the banks of rivers, but unfortunately, growth in turn, has been responsible for pollution of the rivers.

As per the United Nations estimates (2002), at least 101 billion people do not even have access to safe drinking water and 2.4 billion do not have adequate sanitation facilities. Increasing population and expanding development would further increase the demands for wastes. It is estimated that by 2024, two-thirds of the world population would be suffering from acute water shortage.

Groundwater

About 9.86% of the total fresh water resources is in the form of groundwater and it is about 35-50 times that of surface water supplies. Till some time back groundwater was considered to be very pure. However, of late, even groundwater aquifers have been found to be contaminated by leachates from sanitary landfills etc.

A layer of sediment or rock that is highly permeable and contains water is called an **aquifer**. Layers of sand and gravel are good aquifers while clay and crystalline rocks (like granite) are not since they have low permeability. Aquifers may be of two types:

Unconfined aquifers which are overlaid by permeable earth materials and they are recharged by water seeping down from above in the form of rainfall and snow melt.

Confined aquifers which are sandwitched between two impermeable layers of rock or sediments and are recharged only in those areas where the aquifer intersects the land surface. Sometimes the recharged area is hundreds of kilometers away from the location of the well. Fig 2.2.1 shows the groundwater system. Groundwater is not static, it moves, though at a very slow rate of about a meter or so in a year.

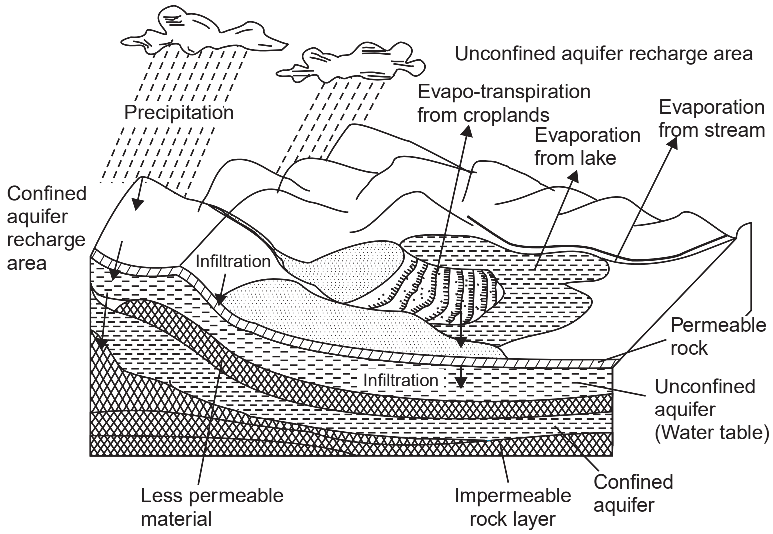

Fig. 2.2.1. The groundwater system. An unconfined aquifer (water table) is formed when water collects over a rock or compact clay. A confined aquifer is formed sandwitched between two layers having very low permeability.

Effects of Groundwater Usage

(*i*) **Subsidence:** When groundwater withdrawal is more than its recharge rate, the sediments in the aquifer get compacted, a phenomenon known as *ground subsidence*. Huge economic losses may occur due to this phenomenon because it results in the sinking of overlying land surface. The common problems associated with it include structural damage in buildings, fracture in pipes, reversing the flow of sewers and canals and tidal flooding.

(*ii*) **Lowering of water table:** Mining of groundwater is done extensively in arid and semi-arid regions for irrigating crop fields. However, it is not advisable to do excessive mining as it would cause a sharp decline in future agricultural production, due to lowering of water table.

(*iii*) **Water logging:** When excessive irrigation is done with brackish water it raises the water table gradually leading to water-logging and salinity problems.

Surface Water

The water coming through precipitation (rainfall, snow) when does not percolate down into the ground or does not return to the atmosphere as evaporation or transpiration loss, assumes the form of streams, lakes, ponds, wetlands or artificial reservoirs known as surface water. The surface water is largely used for irrigation, industrial use, public water supply, navigation etc. A country's economy is largely dependent upon its rivers.

Water rich vs. Water poor countries

The top ten water rich countries are Iceland, Surinam, Guyana, Papua New Guinea, Gabon, Solomon Islands, Canada, Norway, Panama, and Brazil lying in the far north and have low evaporation losses.

The water poor countries include Kuwait, Egypt, United Arab Emirates, Malta, Jordon, Saudi Arabia, Singapore, Maldovia, Israel and Oman, lying in the desert belt at about 15° to 25° Latitude and some of them like Malta and Singapore are densely populated areas resulting in low per capita water.

■ 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, which otherwise is a natural disaster.

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 accustomed to moderate flooding during monsoon and they utilize the flood water for raising paddy. But, severe floods like that in 1970, 1988 and 1991 resulting from excessive Himalayan runoff and storms, had very disastrous consequences causing massive deaths and damages. In 1970, about one million people were drowned while 1,40,000 people died in 1991. 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 semi-arid regions that experience frequent spells of droughts, very often extending up to year long duration. **When annual rainfall is below normal and less than evaporation, drought conditions are created.** Ironically, these drought- hit areas are often having a high population growth which leads to poor land use and makes the situation worse.

Anthropogenic causes: Drought is a meteorological phenomenon, but due to several anthropogenic causes like over grazing, 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.

Erroneous and intensive cropping pattern and increased exploitation of scarce water resources through well or canal irrigation to get high productivity has converted drought - prone areas into desertified ones. 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.

Remedial measures: Indigenous knowledge in control of drought and desertification can be very useful for dealing with the problem. 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, otherwise it may even boomrang. The Kolar district of Karnataka is one of the leaders in Social Forestry with World Bank Aid, but all its 11 talukas suffer from drought. It is because the tree used for plantation here was *Eucalyptus* which is now known to lower the water table because of its very high transpiration rate.

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.

- **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. But, it would drastically reduce the flow of water to Syria and Iraq, lying downstream. Turkey dreams to become the region's water Super power. It plans to transport and sell water to starved Saudi Arabia, Kuwait, Syria, Israel and Jordan. Probably, the next war in the Middle East would be fought over water and not oil.

- **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.
- **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. 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 1991-92 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.

- **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 Eradi Tribunal (1985) based the allocation of water on the basis of the time-inflow data of 20 years (1960-80), according to which 17.17 MAF (million acre feet) water was available. However, now it is argued by Punjab that in the last 17 years there has been consistent decline reducing the quantity to 14.34 MAF. 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 is that Punjab being the riparian state for Beas, Ravi and Satluj stakes its claim, Haryana has faced acute shortage of water after it became a state in 1966 and has been trying to help it out by signing an MOU (Memorandum of understanding) with UP, Rajasthan and Delhi for allocation of Yamuna waters. The Yamuna basin covers the state of Haryana while the Indus basin covers Punjab.

  The conflict revolving around sharing of river water needs to be tackled with greater understanding and objectivity.

Traditional Water Management System

In India, even today, there are several villages where water management is done not by the Irrigation Department, but by local managers. In south India, a ***neerkatti*** manages the traditional tanks very efficiently based on his/her knowledge of the terrain, drainage and irrigation needs. They usually give preference to the tail end fields and decide per capita allocation of water based on the stock of available water in the tank and crop needs. In Maharashtra, the water mangers are called ***havaldars*** or ***jaghyas*** who manage and resolve conflicts by overseeing the water channels from main canal to the distributory canals. In Ladakh, the water manager is known as ***churpun*** who has got complete charge with full powers over allocation of available water. The major source of water is melt water from glaciers and snow supplementary by water from springs and marshes. The water is distributed to different fields through an intricate network of earthen channels.

In traditional water management, innovative arrangements ensure equitable distribution of water, which are democratically implemented. The 'gram-sabhas' approve these plans publicly. While water disputes between states and nations often assume battle like situations, our traditional water managers in villages prove to be quite effective.

■ 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 and famines, 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.

Environmental Problems

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.

(A) 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 waterlogging 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.

(B) 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.

2.3 MINERAL RESOURCES

Minerals are naturally occurring, inorganic, crystalline solids having a definite chemical composition and characteristic 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. These minerals, in turn, are composed of some elements like silicon, oxygen, iron, magnesium, calcium, aluminium etc.

■ USES AND EXPLOITATION

Minerals find use in a large number of ways in everyday use in domestic, agricultural, industrial and commercial sectors and thus form a very important part of any nation's economy. The main uses of minerals are as follows:

(*i*) Development of industrial plants and machinery.
(*ii*) Generation of energy e.g. coal, lignite, uranium.
(*iii*) Construction, housing, settlements.
(*iv*) Defence equipments-weapons, armaments.
(*v*) Transportation means.
(*vi*) Communication- telephone wires, cables, electronic devices.
(*vii*) Medicinal system- particularly in Ayurvedic System.
(*viii*) Formation of alloys for various purposes (e.g. phosphorite).
(*ix*) Agriculture–as fertilizers, seed dressings and fungicides (e.g. zineb containing zinc, Maneb-containing manganese etc.).
(*x*) Jewellery–e.g. Gold, silver, platinum, diamond.

Based on their properties, minerals are basically of two types:

(*i*) Non metallic minerals e.g. graphite, diamond, quartz, feldspar.
(*ii*) Metallic minerals e.g. Bauxite, laterite, haematite etc.

Use of metals by human beings has been so extensive since the very beginning of human civilization that two of the major epochs of human history are named after them as Bronze Age and Iron Age. The reserves of metals and the technical know-how to extract them have been the key elements in determining the economy and political power of nations. Out of the various metals, the one used in maximum quantity is Iron and steel (740 million metric tons annually) followed by manganese, copper, chromium, aluminium and Nickel.

Distribution and uses of some of the major metallic and non-metallic minerals are given in Tables 2.3.1 and 2.3.2.

Table 2.3.1. Major reserves and important uses of some of the major metals

Metal	Major World Reserves	Major Uses
Aluminium	Australia, Guinea, Jamaica	Packaging food items, transportation, utensils, electronics
Chromium	CIS, South Africa	For making high strength steel alloys, In textile/tanning industries
Copper	U.S.A., Canada, CIS, Chile, Zambia	Electric and electronic goods, building, construction, vessels
Iron	CIS, South America, Canada, U.S.A.	Heavy machinery, steel production transportation means
Lead	North America, U.S.A., CIS	Leaded gasoline, Car batteries, paints, ammunition
Manganese	South Africa, CIS, Brazil, Gabon	For making high strength, heat-resistant steel alloys
Platinum group	South Africa, CIS	Use in automobiles, catalytic converters, electronics, medical uses.
Gold	South Africa, CIS, Canada	Ornaments, medical use, electronic use, use in aerospace
Silver	Canada, South Africa, Mexico	Photography, electronics jewellery
Nickel	CIS, Canada, New Caledonia	Chemical industry, steel alloys

Table 2.3.2. Major uses of some non-metallic minerals

Non-metal Mineral	Major Uses
Silicate minerals	Sand and gravel 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.

It is evident from the Tables that the CIS countries (The Commonwealth of Independent States *i.e.* 12 repubics of former USSR), the United States of America, Canada, South Africa and Australia are having the major world reserves of most of the metallic minerals. Due to huge mineral and energy resources, the USA became the richest and the most powerful nation in the world in even less than 200 years. Japan too needs a mention here, as there are virtually no metal reserves, coal, oil and timber resources in Japan and it is totally dependent on other countries for its resources. But, it has developed energy efficient technologies to upgrade these resources to high quality finished products to sustain its economy.

Minerals are sometimes classified as **Critical** and **Strategic**.

Critical minerals are essential for the economy of a nation e.g. iron, aluminium, copper, gold etc.

Strategic minerals are those required for the defence of a country e.g. Manganese, cobalt, platinum, chromium 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, Andhra Pradesh and Uttaranchal.

■ ENVIRONMENTAL IMPACTS OF MINERAL EXTRACTION AND USE

The issue related to the limits of the mineral resources in our earth's crust or in the ocean is not so significant. 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 a 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, Cr^{6+} being highly toxic and carcinogenic.

(*iv*) **Kudremukh iron ore mine, Karnataka**—causing river pollution and threat to biodiversity.

(*v*) **East coast Bauxite mine, Orissa**—Land encroachment and issue of rehabilitation unsettled.

(*vi*) **North-Eastern Coal Fields, Assam**—Very high sulphur contamination of groundwater.

Impacts of 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**. The former method is more destructive, dangerous and expensive including risks of occupational hazards and accidents.

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).

The environmental damage caused by mining activities are as follows:

(*i*) **Devegetation and defacing of landscape:** The topsoil 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 as already discussed in the previous section, the landscape also gets badly affected. The huge quantities of debris and tailings alongwith big scars and disruptions spoil the aesthetic value of the region and make it prone to soil erosion.

(*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.

Remedial measures: Safety of mine workers is usually not a priority subject of industry. Statistical data show that, on an average, there are 30 non-fatal but disabling accidents per ton of mineral produced and one death per 2.5 tons of mineral produced.

In order to minimize the adverse impacts of mining it is desirable to adopt eco-friendly mining technology. The low-grade ores can be better utilized by using **microbial-leaching technique.** The bacterium *Thiobacillus ferroxidans* has been successfully and economically used for extracting gold embedded in iron sulphide ore. The ores are inoculated with the desired strains of bacteria, which remove the impurities (like sulphur) and leave the pure mineral. This biological method is helpful from economic as well as environmental point of view.

Restoration of mined areas by re-vegetating them with appropriate plant species, stabilization of the mined lands, gradual restoration of flora, prevention of toxic drainage discharge and conforming to the standards of air emissions are essential for minimizing environmental impacts of mining.

CASE STUDIES

- **Mining and quarrying in Udaipur**

About 200 open cast mining and quarrying centers in Udaipur, about half of which are illegal are involved in stone mining including soapstone, building stone, rock phosphate and dolomite. The mines spread over 15,000 hectares in Udaipur have caused many adverse impacts on environment. About 150 tonnes of explosives are used per month in blasting. The overburden, washoff, discharge of mine water etc. pollute the water. The Maton mines have badly polluted the Ahar river. The hills around the mines are devoid of any vegetation except a few scattered patches and the hills 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 blasting activity has adversely affected the fauna and the animals like tiger, lion, deer and even hare, fox, wild cats and birds have disappeared from the mining area.

- **Mining in Sariska Tiger Reserve in Aravallis**

The Aravalli range is spread over about 692 km in the North-west India covering Gujarat, Rajasthan, Haryana and Delhi. The hill region is very rich in biodiversity as well as mineral resources. The Sariska tiger reserve has gentle slopy hills, vertical rocky valleys, flat plains as well as deep gorges. The reserve is very rich in wild life and has enormous mineral reserves like quartzite, Schists, marble and granite in abundance.

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. We must preserve the Aravalli series as a National Heritage and the Supreme Court on December 31st, 1991 has given a judgement in response to a Public Interest Litigation of Tarun Bharat Sangh, an NGO wherein both Centre and State Government of Rajasthan have been directed to ensure that all mining activity within the park be stopped. More than 400 mines were shut immediately. But, still some illegal mining is in progress.

- **Uranium Mining in Nalgonda, A.P.—The public hearing**

The present reserves of Uranium in Jaduguda mines, Jharkhand can supply the yellow cake only till 2004. There is a pressing need for mining more uranium to meet the demands of India's nuclear programme. The Uranium Corporation of India (UCIL) proposes to mine uranium from the deposits in Lambapur and Peddagattu villages of Nalgonda district in Andhra Pradesh and a processing unit at about 18 kms at Mallapur. The plan is to extract the ore of 11.02 million tons in 20 years. The IUCL is trying its best to allure the villagers through employment opportunities. But, experts charge the company for keeping silence on the possible contamination of water bodies in the area. The proposed mines are just 1 km from human habitation and hardly 10 km from Nagarjun Sagar Dam and barely 4 km from the Akkampalli reservoir which is Hyderabad's new source of drinking water.

It is estimated that 20 years of mining would generate about 7.5 million metric tones of radioactive waste of which 99.9% will be left behind. The villagers are very likely to be affected by the radioactive wastes. Though IUCL claims that there won't be any such accidents, but no one can deny that it is a highly hazardous industry and safety measures cannot be overlooked. The pathetic condition of Jaduguda Uranium mines in Jharkhand where there is a black history of massive deaths and devastation have outraged the public, who don't want it to be repeated for Nalgonda.

The proposed mines would cover about 445 ha of Yellapurum Reserve Forest and the Rajiv Gandhi Tiger Sanctuary. The public hearing held just recently in February, 2004 witnessed strong protests from NGOs and many villagers. The fate of the proposed mining is yet to be decided.

2.4 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. But there are indications that we have already surpassed sustainable harvests of fish from most of the world's oceans.

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. People receiving less than 90% of these minimum dietary calories are called **undernourished** and if it is less than 80% they are said to be **seriously undernourished**. Besides the minimum caloric intake we also need proteins, minerals etc. Deficiency or lack of nutrition often leads to **malnutrition** resulting in several diseases as shown in Table 2.4.1.

Table 2.4.1. Impacts of malnutrition

Deficiency	Health Effect	No. of Cases	Deaths per year (in millions)
Proteins and Calories	Stunted growth, Kwashiorkor, Marasmus	750 1 million	15-20
Iron	Anemia	350 million	0.75-1
Iodine	Goitre, Cretinism	150 million, 6 million	
Vitamin A	Blindness	6 million	

■ 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.*** These startling statistical figures more than emphasize the need 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. India has only half as much 1and as USA, but it has nearly three times population to feed. Our food problems are directly related to population.

The **World Food Summit, 1996** has set the target to reduce the number of undernourished to just half by 2015, which still means 410 million undernourished people on the earth.

■ IMPACTS OF OVERGRAZING AND AGRICULTURE

(A) Overgrazing

Livestock wealth plays a crucial role in the rural life of our country. India leads in live stock population in the world. The huge population of livestock needs to be fed and the grazing lands or pasture areas are not adequate. Very often we find that the live stock grazing on a particular piece of grassland or pasture surpass the carrying capacity. **Carrying capacity** of any system is the maximum population that can be supported by it on a sustainable basis. However, most often, the grazing pressure is so high that its carrying capacity is crossed and the sustainability of the grazing lands fails. Let us see what are the impacts of overgrazing.

Impact of Overgrazing

(*i*) **Land Degradation:** Overgrazing removes the vegetal cover over the soil and the exposed soil gets compacted due to which the operative soil depth declines. So the roots cannot go much deep into the soil and adequate soil moisture is not available. Organic recycling also declines in the ecosystem because not enough detritus or litter remains on the soil to be decomposed. 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 and as a result of this more water gets lost from the ecosystem along with surface run off. Thus over grazing 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. Ultimately the nutritious, juicy fodder giving species like *Cenchrus, Dichanthium, Panicum* and *Heteropogon* etc. are replaced by unpalatable and sometimes thorny plants like *Parthenium*, *Lantana, 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.

As a result of overgrazing vast areas in Arunachal Pradesh and Meghalaya are getting invaded by thorny bushes, weeds etc. of low fodder value. Thus overgrazing makes the grazing land lose its regenerating capacity and once good quality pasture land gets converted into an ecosystem with poor quality thorny vegetation.

(B) Agriculture

In the early years of human existence on this earth, man was just a hunter gatherer and was quite like other animal species. Some 10,000 to 12,000 years ago he took to agriculture by cultivating plants of his own choice. He used the practice of **Slash and burn cultivation or shifting cultivation,** which is still prevalent in many tribal areas, as in the North East Hills of India. The 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 show lots of differences.

1. 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.

2. 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 problematic off-shoots as discussed below:

(*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 the 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 off and along with runoff water reach the 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. This shows how an unmindful action can have far reaching impacts.

(*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 (Dichlorodiphenyl 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. 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%.

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 profile (Fig. 2.4.1)

Thousands of hectares of land area in Haryana and Punjab are affected by soil salinity and alkalinity. Salinity causes stunted plant growth and lowers crop yield. Most of the crops cannot tolerate high salinity.

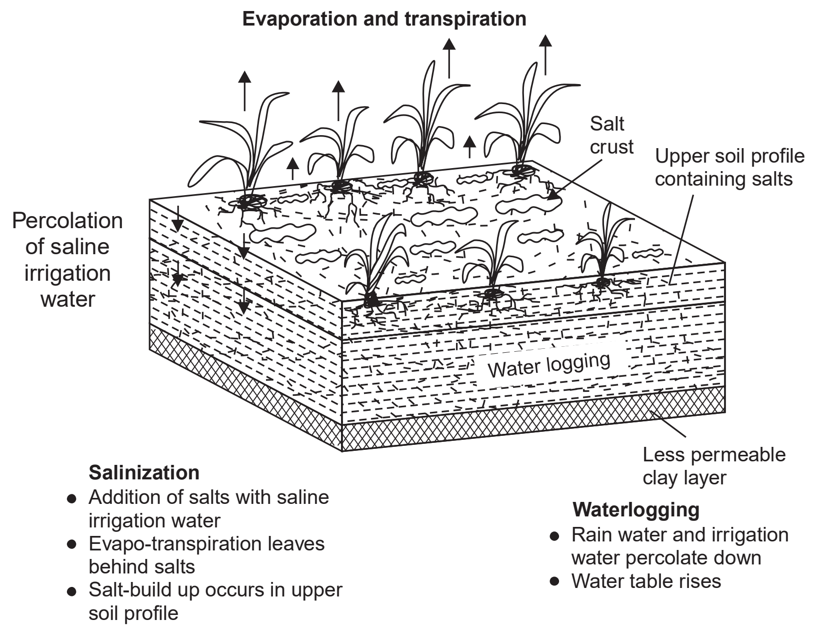

Fig. 2.4.1. Salinization and water logging.

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. The Central Soil Salinity Research Institute (CSSRI) located in Karnal, Haryana has to its achievement the success story of converting *Zarifa Viran* village to *Zarifa Abad* i.e. '*from the barren land to productive land*' through its research applications.

CASE STUDIES

Salinity and water logging in Punjab, Haryana and Rajasthan : The first alarming report of salt-affected wasteland formation in connection with irrigation practices came from Haryana (then Punjab) in 1858. It was reported that several villages in Panipat, Rohtak and Delhi lying in command area of Western Yamuna Canal were suffering from destructive saline efflorescence. The "Reh Committee" in 1886 drew the attention of the government on some vital points showing a close relationship between irrigation, drainage and spread of "reh" and "usar" soils.

(Contd.)

The floods of 1947, 1950, 1952, 1954-56 in Punjab resulted in aggravated water logging with serious drainage problems. Introduction of canal irrigation in 1.2 m ha in Haryana resulted in rise in water-table followed by water-logging and salinity in many irrigated areas causing huge economic losses as a result of fall in crop productivity. Rajasthan too has suffered badly in this regard following the biggest irrigation project "Indira Gandhi Canal Project" and the sufferings of a big area in Western Rajasthan have changed from a condition of "water-starved wasteland" to that of a "water soaked wasteland".

2.5. 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. We find wide disparities in per capita energy use between the developed and the developing nations.

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. In 1970's due to Iranian revolution and Arab oil embargo the prices of oil shooted up. This ultimately led to exploration and use of several alternate sources of energy.

■ 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. Our life style is changing very fast and from a simple way of life we are shifting to a luxurious life style. 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 there 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. Fig. 2.5.1 shows the strong correlation between per capita energy use and GNP (Gross National product). U.S.A., Norway, Switzerland etc. with high GNP show high energy use while India, China etc have low GNP and low energy use. Bahrain and Quatar are oil rich states (UAE) and hence their energy consumption and GNP are more, although their development is not that high.

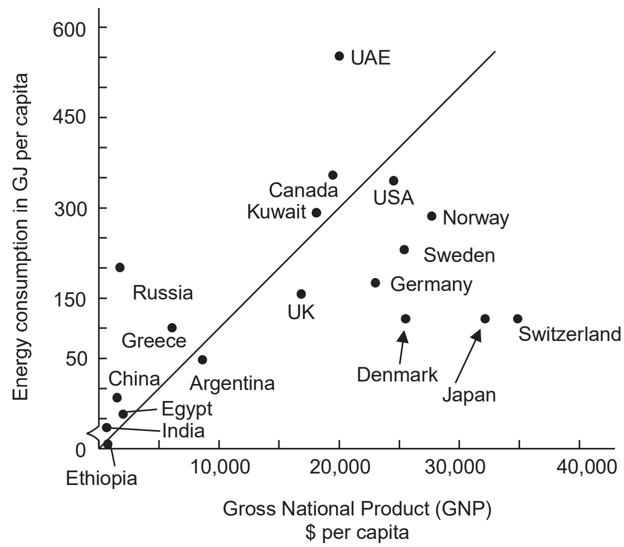

Fig. 2.5.1. Per capita energy use and GNP
(Data from World Resources Institute, 1997)

■ 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.

(*a*) **Renewable Energy Resources**

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. Silicon can be obtained from silica or sand, which is abundantly available and inexpensive. 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. Fig. 2.5.2 (*a*) shows the structure of a solar cell.

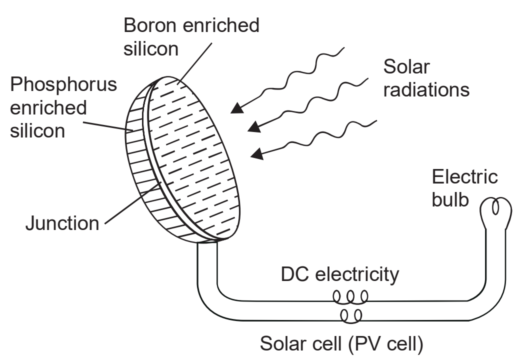

Fig. 2.5.2. (*a*) Solar cell.

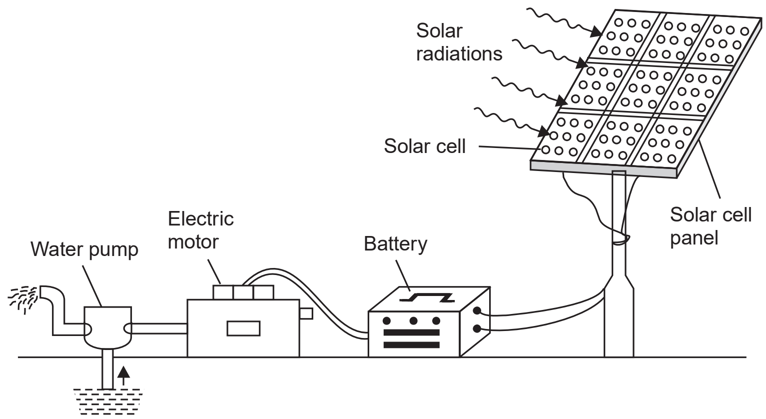

Fig. 2.5.2. (*b*) A solar pump run by electricity produced by solar cells.

A group of solar cells joined together in a definite pattern form a solar panel which can harness a large amount of solar energy and can produce electricity enough to run street-light, irrigation water pump etc. (Fig. 2.5.2).

Solar cells are widely used in calculators, electronic watches, street lighting, traffic signals, water pumps etc. They are also used in artificial satellites for electricity generation. Solar cells are used for running radio and television also. 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

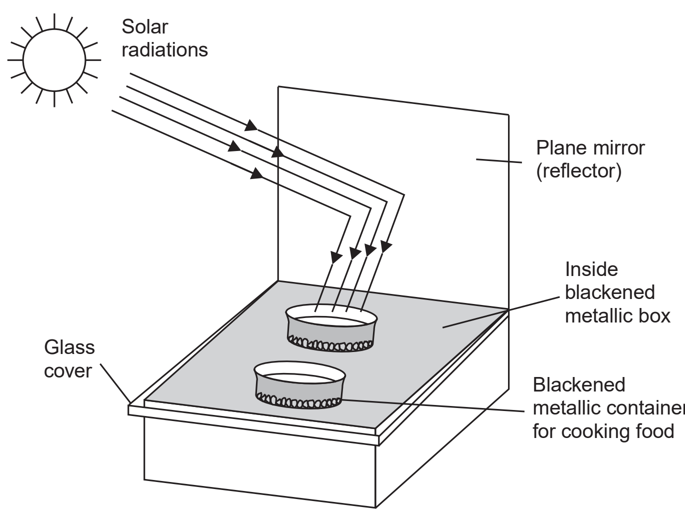

Fig. 2.5.3. Simple box-type solar cooker.

which covers the black insulated box within which the raw food is kept as shown in Fig. 2.5.3. A new design of solar cooker is now available which involves a spherical reflector (concave or parabolic reflector) instead of plane mirror that has more heating effect and hence greater efficiency.

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. Inside the box it has black painted copper coil through which cold water is made to flow in, which gets heated and flows out into a storage tank. The hot water from the storage tank fitted on roof top is then supplied through pipes into buildings like hotels and hospitals.

(*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.

■ WIND ENERGY

The high speed winds have a lot of energy in them as kinetic energy due to their motion. The driving force of the winds is the sun. 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. After the initial installation cost, the wind energy is very cheap. It is believed that by the middle of the century wind power would supply more than 10% of world's electricity.

■ 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 hydel 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 4×10^{11} 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 which have already been discussed in the previous section.

■ 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. (Fig. 2.5.4)

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.

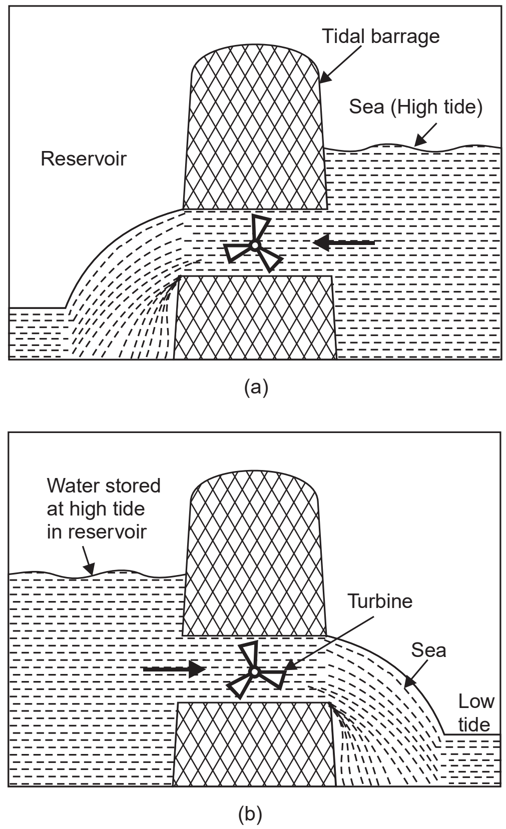

Fig. 2.5.4. Water flows into the reservoir to turn the turbine at high tide (*a*), and flows out from the reservoir to the sea, again turning the turbine at low tide (*b*).

■ 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.

■ 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.

■ 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 :

(*a*) **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.

(*b*) **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.

(*c*) **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**' which usually produce smoke and are not so efficient (efficiency is <8 %). Now improved Chulhas with tall chimney have been designed which have high efficiency and are smokeless.

The burning of plant residues or animal wastes cause air pollution and produce a lot of ash as waste residue. The burning of dung destroys essential nutrients like N and P. It is therefore, more useful to convert the biomass into biogas or bio fuels.

■ BIOGAS

Biogas is a mixture of methane, carbon dioxide, hydrogen and hydrogen sulphide, the major constituent being methane. Biogas is produced by anaerobic degradation of animal wastes (sometimes plant wastes) in the presence of water. Anaerobic degradation means break down of organic matter by bacteria in the absence of oxygen.

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. India has the largest cattle population in the world (240 million) and has tremendous potential for biogas production. From cattle dung alone, we can produce biogas of a magnitude of 22,500 Mm^3 annually. A sixty cubic feet gobar gas plant can serve the needs of one average family.

Biogas has the following main advantages : It is clean, non-polluting and cheap. There is direct supply of gas from the plant and there is no storage problem. The sludge left over is a rich fertilizer containing bacterial biomass with most of the nutrients preserved as such. Air-tight digestion/degradation of the animal wastes is safe as it eliminates health hazards which normally occur in case of direct use of dung due to direct exposure to faecal pathogens and parasites.

Biogas plants used in our country are basically of two types:

1. Floating gas-holder type and 2. Fixed-dome type.

1. Floating gas holder type biogas plant: This type has a well-shaped digester tank which is placed under the ground and made up of bricks. In the digester tank, over the dung slurry an inverted steel drum floats to hold the bio-gas produced. The gas holder can move which is controlled by a pipe and the gas outlet is regulated by a valve. The digester tank has a partition wall and one side of it receives the dung-water mixture through inlet pipe while the other side discharges the spent slurry through outlet pipe. (Fig 2.5.5)

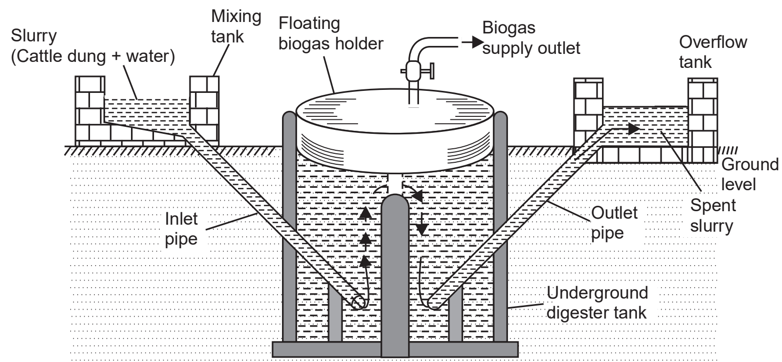

Fig. 2.5.5. Floating gas holder type biogas plant.

Sometimes corrosion of steel gas-holder leads to leakage of biogas. The tank has to be painted time and again for maintenance which increases the cost. Hence another type was designed as discussed below :

2. Fixed dome type biogas plant: The structure is almost similar to that of the previous type. However, instead of a steel gas-holder there is dome shaped roof made of cement and bricks. Instead of partitioning, here there is a single unit in the main digester but it has inlet and outlet chambers as shown in Fig 2.5.6.

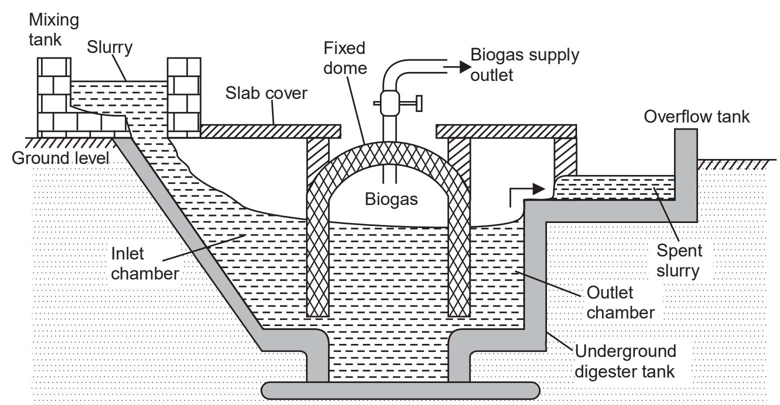

Fig. 2.5.6. Fixed dome type Biogas plant.

The Ministry of Non-Conventional Energy Sources (MNES) has been promoting the Biogas Programme in India. Out of the various models, the important ones used in rural set-up are KVIC Model

(Floating drum type), Janta Model (Fixed dome type), Deenbandhu Model (Fixed dome type), Pragati Model (floating drum type), Ganesh Model (KVIC type but made of bamboo and polythene sheet) and Ferro-cement digester Model (KVIC type with ferro-cement digester).

■ 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. It burns clean and is non-polluting. 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:

(*i*) By thermal dissociation of water (at 3000°K or above) hydrogen (H_2) is produced.

(*ii*) 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 as in direct thermal method and ultimately H_2 is produced.

(*iii*) Electrolytic method dissociates water into hydrogen (H_2) and oxygen by making a current flow through it.

(*iv*) 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. Efforts are underway to trap hydrogen molecule which is produced during photosynthesis.

However, hydrogen is highly inflammable and explosive in nature. Hence, safe handling is required for using H_2 as a fuel. Also, it is difficult to store and transport. And, being very light, it would have to be stored in bulk.

Presently, H_2 is used in the form of liquid hydrogen as a fuel in spaceships.

(*b*) **Non-Renewable Energy Sources**

These are the fossil fuels like coal, petroleum, natural gas and nuclear fuels. These were formed by the decomposition of the remains of plants and animals buried under the earth millions of years ago. The fuels are very precious because they have taken such a long time to be formed and if we exhaust their reserves at such a fast rate as we have been doing, ever since we discovered them, then very soon we will lose these resources forever.

■ COAL

Coal was formed 255-350 million years ago in the hot, damp regions of the earth during the carboniferous age. The ancient plants along the banks of rivers and swamps were buried after death into the soil and due to the heat and pressure gradually got converted into peat and coal over millions of years of time. 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. Coal is the most abundant fossil fuel in the world. ***At the present rate of usage, the coal reserves are likely to last for about 200 years and if its use increases by 2% per year, then it will last for another 65 years.***

India has about 5% of world's coal and Indian coal is not very good in terms of heat capacity. Major coal fields in India are Raniganj, Jharia, Bokaro, Singrauli, and Godavari valley. The coal states of India are Jharkhand, Orissa, West Bengal, Madhya Pradesh, Andhra Pradesh and Maharashtra. Anthracite coal occurs only in J & K.

When coal is burnt it produces carbon dioxide, which is a greenhouse gas responsible for causing enhanced global warming. Coal also contains impurities like sulphur and therefore as it burns the smoke contains toxic gases like oxides of sulphur and nitrogen.

■ PETROLEUM

It is the lifeline of global economy. 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.

At the present rate of usage, the world's crude oil reserves are estimated to get exhausted in just 40 years. Some optimists, however, believe that there are some yet undiscovered reserves. Even then the crude oil reserves will last for another 40 years or so. 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. We get a large variety of products from this, namely, petroleum gas, kerosene, petrol, diesel, fuel oil, lubricating oil, paraffin wax, asphalt, plastic etc.

Petroleum is a cleaner fuel as compared to coal as it burns completely and leaves no residue. It is also easier to transport and use. That is the reason why petroleum is preferred amongst all the fossil fuels.

Liquefied petroleum gas (LPG): The main component of petroleum is butane, the other being propane and ethane. The petroleum gas is easily converted to liquid form under pressure as LPG. It is odourless, but the LPG in our domestic gas cylinders gives a foul smell. This is, in fact, due to ethyl mercaptan, a foul smelling gas, added to LPG so that any leakage of LPG from the cylinder can be detected instantaneously.

Oil fields in India are located at Digboi (Assam), Gujarat Plains and Bombay High, offshore areas in deltaic coasts of Gadavari, Krishna, Kaveri and Mahanadi.

■ NATURAL GAS

It is mainly composed of methane (95%) with small amounts of propane and ethane. It is 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. **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.

Currently, the amount of natural gas deposits in the world are of the order of 80, 450 g m^{-3}. Russia has maximum reserves (40%), followed by Iran (14%) and USA (7%). Natural gas reserves are found in association with all the oil fields in India. Some new gas fields have been found in Tripura, Jaisalmer, Off-shore area of Mumbai and the Krishna Godavari Delta.

Natural gas is used as a domestic and industrial fuel. It is used as a fuel in thermal power plants for generating electricity. It is used as a source of hydrogen gas in fertilizer industry and as a source of carbon in tyre industry.

Compressed natural gas (CNG): It is being used as an alternative to petrol and diesel for transport of vehicles. Delhi has totally switched over to CNG where buses and auto rickshaws run on this new fuel. CNG use has greatly reduced vehicular pollution in the city.

Synthetic natural gas (SNG): It is a mixture of carbon monoxide and hydrogen. It is a connecting link between a fossil fuel and substituted natural gas. Low grade coal is initially transformed into synthetic gas by gasification followed by catalytic conversion to methane.

■ NUCLEAR ENERGY

Nuclear energy is known for its high destructive power as evidenced from nuclear weapons. The nuclear energy can also be harnessed for providing commercial energy. Nuclear energy 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 shown in Fig. 2.5.7 (*a*).

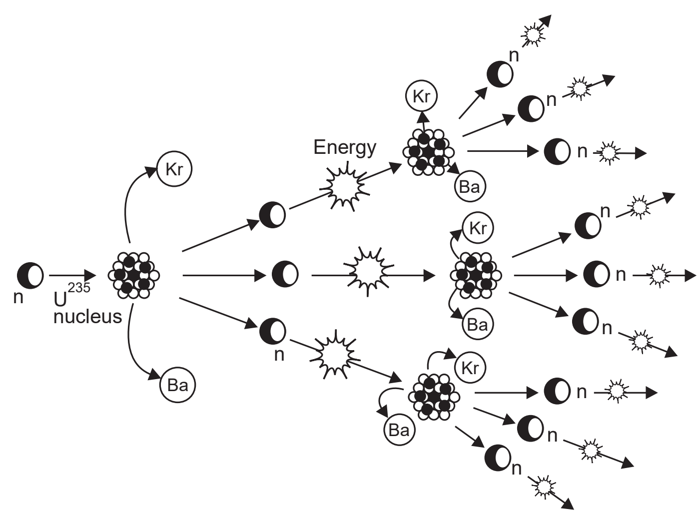

Fig. 2.5.7. (*a*) Nuclear fission—a chain reaction initiated by one neutron that bombards a Uranium (U^{235}) nucleus, releasing a huge quantity of energy, two smaller nuclei (Ba, Kr) and 3 neutrons.

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

Nuclear Reactors make use of nuclear chain reaction. In order to control the rate of fission, only 1 neutron released is allowed to strike for splitting another nucleus. 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 (1 billion °C) until they fuse to form a heavier nucleus releasing enormous energy in the process. It is difficult to initiate the process but it releases more energy than nuclear fission. (Fig. 2.5.7 (*b*))

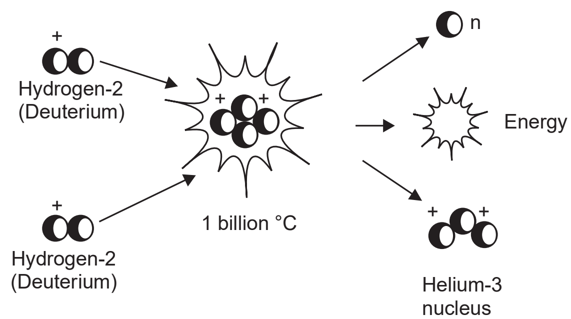

Fig. 2.5.7. (*b*) Nuclear fusion reaction between two hydrogen-2 nuclei, which take place at a very high temperature of 1 billion °C; one neutron and one fusion nucleus of helium-3 is formed along with a huge amount of energy.

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

Two hydrogen-2 (Deuterium) atoms may fuse to form the nucleus of Helium at 1 billion °C and release a huge amount of energy. Nuclear fusion reaction can also take place between one Hydrogen-2 (Deuterium) and one Hydrogen-3 (Tritium) nucleus at 100 million °C forming Helium-4 nucleus, one neutron and a huge amount of 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.

Nuclear power in India is still not very well developed. There are four nuclear power stations with an installed capacity of 2005 MW.

These are located at Tarapur (Maharashtra), Rana Pratap Sagar near Kota (Rajasthan), Kalpakkam (Tamil Nadu) and Narora (U.P.).

2.6. 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 for arable 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 as discussed above 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.

■ 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-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. If we look at the world situation, we find that one third of the world's cropland is getting eroded. Two thirds of the seriously degraded lands lie in Asia and Africa.

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

(*i*) **Normal erosion or geologic erosion:** caused by the gradual removal of top soil by natural processes which bring an equilibrium between physical, biological and hydrological activities and maintain a natural balance between erosion and renewal.

(*ii*) **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 torrential 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 are kicked up and taken away to distant places.
- ***Surface creep:*** Here larger particles (5-10 mm diameter) creep 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 devoid of vegetation cover. So the land 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. Unsustainable methods of farming cause 28% of soil erosion.

Deforestation without reforestation, overgrazing by cattle, surface mining without land reclamation, irrigation techniques that lead to salt build-up, water-logged soil, farming on land with unsuitable terrain, soil compaction by agricultural machinery, action of cattle trampling 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:

(*i*) **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). Conservational till farming, popularly known as **no-till-farming** causes minimum disturbance to the top soil. Here special tillers break up and loosen the subsurface soil without turning over the topsoil. The tilling machines make slits in the unploughed soil and inject seeds, fertilizers, herbicides and a little water in the slit, so that the seed germinates and the crop grows successfully without competition with weeds.

(*ii*) **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 acts as a small dam to help hold soil and slow down loss of soil through run-off water.

(*iii*) **Terracing:** It is used on still steeper slopes are converted into a series of broad terraces which run across the contour. Terracing 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 (Plate I, *a*).

(*iv*) **Strip cropping:** Here strips of crops are alternated with strips of soil saving covercrops 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. Nitrogen fixing legumes also help in restoring soil fertility (Plate I, *b*).

Plate I(a) Terrace farming

Plate I(b) Strip cropping

(*vi*) **Alley cropping:** It is a form of inter-cropping in which crops are planted between rows of trees or shrubs. This is also called **Agro forestry.** 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 (Plate I, *c*).

Wind breaks or shelterbelts: They help in reducing erosion caused by strong winds. The trees are planted in long rows along the cultivated land boundary so that wind is blocked. The wind speed is substantially reduced which helps in preventing wind erosion of soil (Plate I, *d*).

Plate I(c) Alley cropping

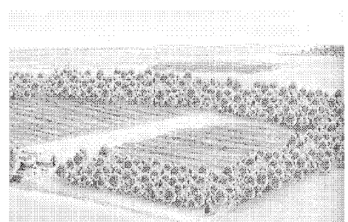

Plate I(d) Shelter belt

Thus, soil erosion is one of the world's most critical problems and, if not slowed, will seriously reduce agricultural and forestry production, and degrade the quality of aquatic ecosystems as well due to increased siltation. Soil erosion, is in fact, a gradual process and very often the cumulative effects becomes visible only when the damage has already become irreversible. The best way to control soil erosion is to maintain adequate vegetational cover over the soil.

Water Logging

In order to provide congenial moisture to the growing crops, farmers usually apply heavy irrigation to their farmland. Also, in order to leach down the salts deeper into the soil, the farmer provides more irrigation water. However, due to inadequate drainage and poor quality irrigation water there is accumulation of water underground and gradually it forms a continuous column with the water table. We call these soils as waterlogged soils which affect crop growth due to inhibition of exchange of gases. The pore-spaces between the soil particles get fully drenched with water through the roots.

Water logging is most often associated with salinity because the water used for irrigation contains salts and the soils get badly degraded due to erroneous irrigation practices. The damages caused by some major irrigation projects is shown is Table 2.6.1.

Table 2.6.1. Water logging and salinisation caused due to some irrigation projects in India

Irrigation Project	State	Area affected (thousand hectares)	
		Water logging	Salinity
Indira Gandhi Canal	Rajasthan	43	29
Gandak	Bihar, Gujarat	211	400
Chambal	M.P., Rajasthan	98	40
Ram Ganga	U.P.	195	352
Sri Ram Sagar	Andhra Pradesh	60	1

Source : B.K. Garg and I.C. Gupta (1997).*

An estimated loss of Rs. 10,000 million per annum occurs due to water-logging and salinity in India. It is a startling fact because the cost of development of the irrigation projects is very high and in the long run they cause problems like water logging and salinity thereby sharply reducing soil fertility.

■ 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,

*Saline Wastelands, Environment and Plant Growth. Sci. Publ., India.

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.

DESERTIFICATION

Desertification 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 and usually creates huge gullies and sand dunes. Desertification leads to the conversion of rangelands or 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. Desertification is not the literal invasion of desert into a non-desert area. It includes degradation of the ecosystems within as well as outside the natural deserts. The Sonoran and Chihuahuan deserts are about a million years old, yet they have become more barren during the last 100 years. So, further desertification has taken place within the desert.

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. Even the climate change is linked in many ways to human activities. The major anthropogenic activities responsible for desertification are as follows:

(*a*) **Deforestation:** The process of denuding and degrading a forested land initiates a desert producing cycle that feeds on itself. Since there is no vegetation to hold back 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.

(*b*) **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 as a result denude the land area. When the earth is denuded, the microclimate near the ground becomes inhospitable to seed germination. The dry barren land becomes loose and more prone to soil erosion. The top fertile layer is also lost and thus plant growth is badly hampered in such soils. The dry barren land reflects more of the sun's heat, changing wind patterns, driving away moisture laden clouds leading to further desertification.

(*c*) **Mining and quarrying:** These activities are also responsible for loss of vegetal cover and denudation of extensive land areas leading to desertification. Deserts are found to occur in the arid and semi-arid areas of all the continents . During the last 50 years about 900 million hectares of land have undergone desertification over the world. This problem is especially severe in Sahel region, just south of the Sahara in Africa. It is further estimated that if desertification continues at the present rate, then by 2010, it will affect such lands which are presently occupied by 20% of the human population.

Amongst the most badly affected areas are the sub Saharan Africa, the Middle East, Western Asia, parts of Central and South America, Australia and the Western half of the United States.

It is estimated that in the last 50 years, human activities have been responsible for desertification of land area equal to the size of Brazil. The UNEP estimates suggest that if we don't make sincere efforts now then very soon 63% of rangelands, 60% of rain-fed croplands and 30% of irrigated croplands will suffer from desertification on a worldwide scale, adding 60,000 Km^2 of deserts every year.

■ 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. However, overuse of these resources in our modern society is resulting in fast depletion of these resources and several related problems. If we want our mankind to flourish there is a strong need to conserve these natural resources.

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. 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. Let us see how can individuals help in conservation of 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.
- Reuse the soapy water of washings from clothes for washing off the courtyards, driveways etc.
- 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 capture rain water and collect normally wasted used water from sinks, cloth-washers, bath-tubs 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.
- Build your house with provision for sunspace which will keep your house warmer and will provide more light.
- 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. A big tree is estimated to have a cooling effect equivalent to five air conditioners. The deciduous trees shed their leaves in winter. Therefore they do not put any hindrance to the sunlight and heat.
- Drive less, make fewer trips and use public transportations whenever possible. You can share by joining a car-pool if you regularly have to go to the same place.

- Add more insulation to your house. 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.
- Instead of using the heat convector more often wear adequate woolens.
- Recycle and reuse glass, metals and paper.
- Try riding bicycle or just walk down small distances instead of using your car or scooter.
- Lower the cooling load on an air conditioner by increasing the thermostat setting as 3-5 % electricity is saved for every one degree rise in temperature setting.

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.
- 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.
- Use green manure and mulch in the garden and kitchen-garden which will protect 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.
- 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 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 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 and command 85% of its income. In turn, they contribute a very big proportion to its pollution. 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. Their income is merely 15% of global income. 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.

As the rich nations are developing more, they are also leading to more pollution and sustainability of the earth's life support system is under threat. The poor nations, on the other hand, are still struggling hard with their large population and poverty problems. Their share of resources is too little leading to unsustainability.

As the rich nations continue to grow, they will reach a limit. If they have a growth rate 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. A global consensus has to be reached for more balanced distribution of the basic resources like safe drinking water, food, fuel etc. so that 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.

QUESTIONS

1. What are renewable and non-renewable resources ? Give examples.
2. Discuss the major uses of forests. How would you justify that ecological uses of forests surpass commercial uses ?
3. What are the major causes and consequences of deforestation ?
4. Discuss with the help of a case study, how big dams have affected forests and the tribals.
5. What is an aquifer ? Discuss its types.
6. What are the environmental impacts of ground water usage ?
7. Briefly discuss droughts and floods with respect is their occurrence and impacts.
8. What are the major causes for conflicts over water ? Discuss one international and one inter-state water conflict.
9. Should we build big dams ? Give arguments in favour of your answer.
10. What are the uses of various types of minerals ?
11. Discuss the major environmental impacts of mineral extraction.
12. What is overgrazing ? How does it contribute to environmental degradation ?
13. What do your mean by (*a*) eutrophication (*b*) super pest (*c*) shifting cultivation (*d*) water logging ?
14. Give a brief account of non-renewable energy resources.

15. What are solar cells ? Draw a diagram and enumerate its applications.

16. Discuss the merits and demerits of wind energy.

17. Comment upon the types of energy harnessed from oceans.

18. What is biogas ? Discuss the structure and function of biogas plants.

19. What is nuclear energy ? Discuss its two types.

20. What its soil erosion ? How can it be checked ?

21. How can you as an individual conserve different natural resources ?