Unit 2

Natural Resources

Let's understand

- What renewable and non-renewable resources are
- About the role of an individual in the conservation of natural resources
- How resources can be used equitably for sustainable lifestyles

2.1 Introduction

The environment provides us with a variety of goods and services necessary for our day-to-day life. These natural resources include air, water, soil and minerals, along with the climate and solar energy, which form the non-living or 'abiotic' part of nature. The 'biotic' or living parts consist of plants and animals, including microbes. Plants and animals can only survive as communities of different organisms, all closely linked to each other in their own habitat, and requiring specific abiotic conditions. Thus, forests, grasslands, deserts, mountains, rivers, lakes and the marine environment all form habitats for specialised communities of plants and animals to live in. The interactions between the abiotic aspects of nature and specific living organisms together form ecosystems of various types. Many of these living organisms are used as food resources. Others are linked to food less directly, like bees as pollinators and dispersers of plants, soil animals like worms which recycle nutrients for plant growth, and fungi and termites that break up dead plant material so that microorganisms can act on the detritus to replenish soil nutrients.

Resource use over time

About ten thousand years ago, when humans changed from hunter–gatherers, living in wilderness areas such as forests and grasslands, into agriculturalists and pastoralists, we began to change the environment to suit our own requirements. As our ability to grow food and use domestic animals developed, these 'natural' ecosystems were converted into agricultural land. Most traditional agriculturists depended extensively on natural sources—rain, streams and rivers—for water. Later, they began to use wells to tap underground water sources, impound water and create irrigated land by building dams. Recently, we have begun to use fertilisers and pesticides to further boost the yield from the same amount of land. However, we now realise that all this has led to several undesirable changes in our environment. Humans have been overusing and depleting natural resources. The over-intensive use of land has exhausted the capability of the ecosystem to support the growing demands of more and more people, all requiring more intensive use of resources. Industrial growth, urbanisation, population growth and the enormous increase in the use of consumer goods have further stressed the environment, as they create great quantities of solid waste. Air, water and soil pollution, in turn, have begun to seriously affect human health.

Historical changes in land and resource use

During the last 100 years, a better healthcare delivery system and improved nutrition has led to rapid population growth, especially in the developing countries. This phenomenal rise has placed great demands on the earth's natural resources. Large stretches of land – forests, grasslands and wetlands – have been put to agricultural and industrial use. These changes have brought about dramatic alterations in land use patterns and the rapid disappearance of valuable natural ecosystems. The need for more water, more food, more energy and more consumer goods is not only the result of a greater population, but also that of an increasing consumerist society.

Industrial development is aimed at meeting growing demands for all consumer items. However, these consumer goods also generate waste in ever larger quantities. As shown in Fig. 2.1, the growth of industrial complexes has also led to a shift of people from their traditional, sustainable, rural way of life to urban centres that developed around industries. During the last few decades, several small urban centres have become large cities; some have even become giant mega cities. This has increased the disparity between what the surrounding land can produce and what the large numbers of people in these areas of high population density

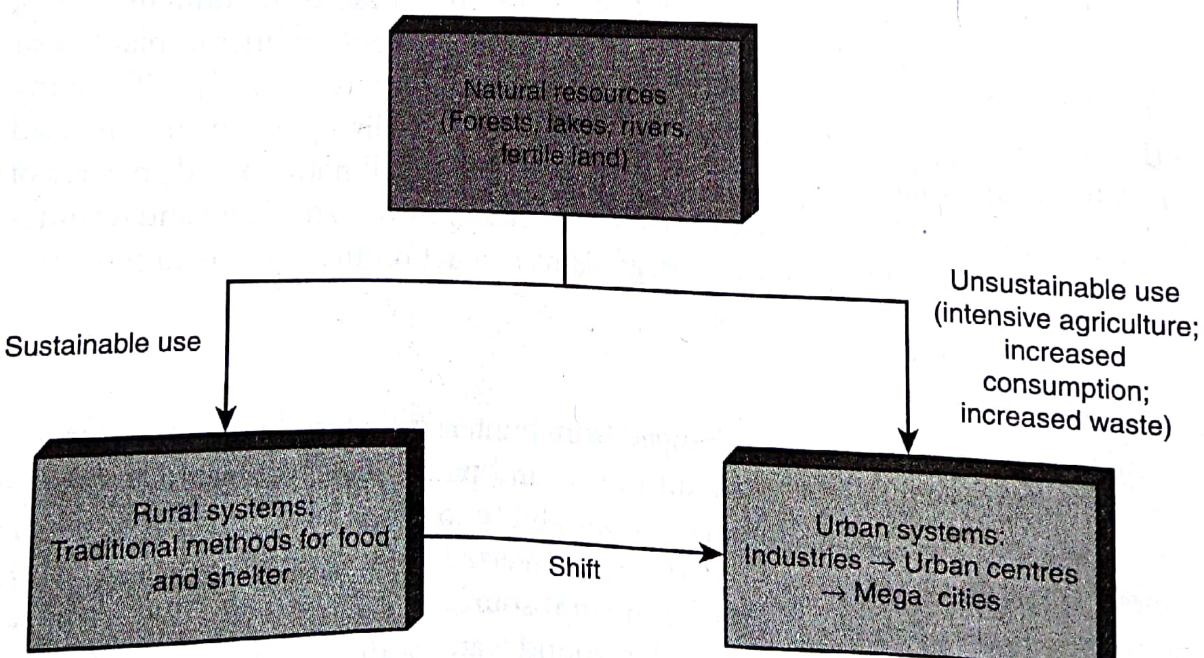


Fig. 2.1 Shift in pressure of natural resources from rural to urban systems

consume. Urban centres cannot exist without resources such as water from rivers and lakes, food from agricultural areas, domestic animals from pasture land and timber, fuelwood, construction material and other resources from forests. Rural agricultural systems are dependent on forests, wetlands, grasslands, rivers and lakes. The resulting movement of natural resources from the wilderness ecosystems and agricultural sector to the urban user has led to a serious inequality in the distribution of resources among human beings, which is both unfair and unsustainable.

Earth's Resources and Humans

The resources on which humans depend are provided by various sources or 'spheres', shown in Fig. 2.2.

(i) The atmosphere

- Oxygen for human respiration (metabolic requirements)
- Oxygen for wild fauna in natural ecosystems and domestic animals used by humans as food
- Oxygen as a part of carbon dioxide, used for the growth of plants (which in turn are used by humans)

The atmosphere forms a protective shell over the earth. The lowest layer or troposphere, the only part warm enough for us to survive in, is only 12 km thick. If the earth were the size of an apple, this lower layer of atmosphere that we breathe would be no thicker than the apple's skin! The stratosphere is 50 km thick and contains a layer of sulphates, which is important for the formation of rain. It also contains a layer of ozone, which absorbs ultraviolet (UV) light known to cause cancer, and without which no life could exist on earth. The atmosphere is not uniformly warmed by the sun. This leads to air flows and variations in climate, temperature and rainfall in different parts of the earth. It is a complex dynamic system; if disrupted, it affects everybody. Most air pollutants have both global and regional effects.

Living creatures cannot survive without air even for a few minutes. To continue to support life, the air must be kept clean. Many of the major pollutants of air are created by industrial units that release gases such as carbon dioxide, carbon monoxide and toxic fumes into the air. The air is also polluted by burning fossil fuels. The build-up of carbon dioxide in the atmosphere,

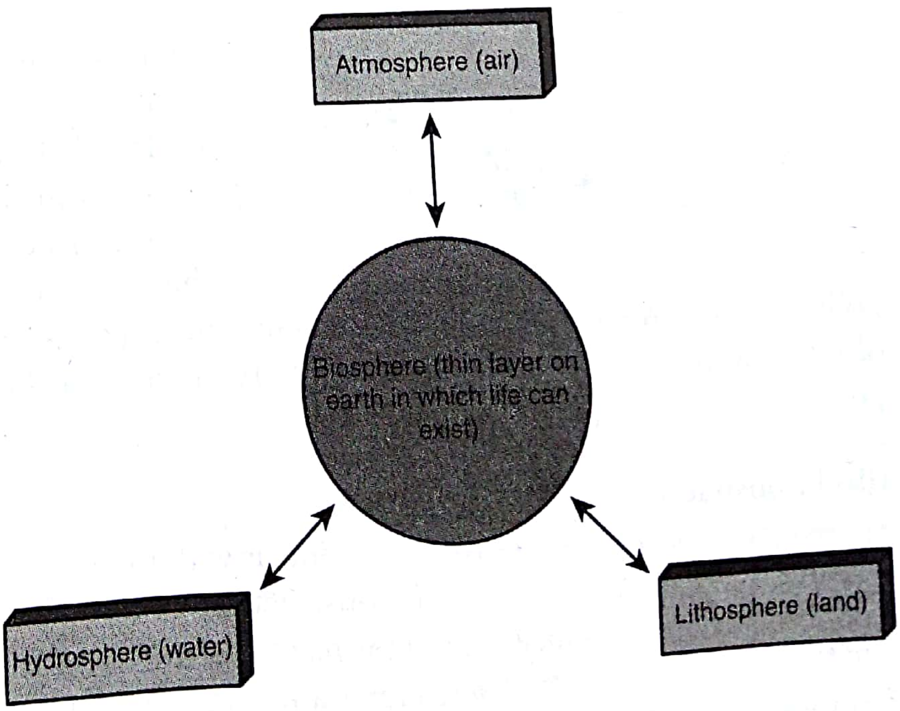


Fig. 2.2 Earth's spheres

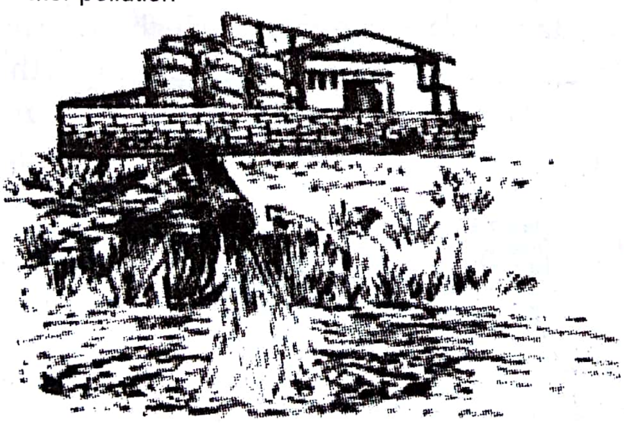
known as the 'greenhouse effect', has led to the current global warming. The growing number of scooters, motorcycles, cars, buses and trucks, which all run on fossil fuel (petrol and diesel), is a major cause of air pollution in cities and along highways.

Air pollution severely affects human health; it leads to acute and chronic respiratory diseases such as lung infections, asthma and even cancer.


Burning garbage

(ii) Hydrosphere

- Clean water for drinking (a metabolic requirement for all living processes)
- Water for washing and cooking
- Water used in agriculture and industry
- Food resources from the sea, including fish, crustaceans and seaweed
- Food from freshwater sources, including fish, crustaceans and aquatic plants
- Water flowing down from mountain ranges, harnessed to generate electricity in hydroelectric projects

Water pollution


The hydrosphere covers three-quarters of the earth's surface. A major part of the hydrosphere is the marine ecosystem in the ocean, while only a small part is freshwater. The freshwater in rivers, lakes and glaciers is perpetually being renewed by a process of evaporation and rainfall; some of this freshwater is stored in underground aquifers. Human activities, like deforestation, create serious changes in the hydrosphere. Once the land is denuded of vegetation, the rain erodes the soil, which is then washed into the sea.

Chemicals from industry and sewage find their way into rivers and into the sea. Water pollution thus threatens the health of communities, as all our lives depend on the availability of clean water. This once plentiful resource is now becoming rare and expensive due to pollution.

(iii) Lithosphere

- Soil, the basis for agriculture to provide us with food
- Stone, sand and gravel, used for construction
- Micronutrients in soil, essential for plant growth
- Microscopic flora, small soil fauna and fungi in soil, important living organisms of the lithosphere, which break down plant litter as well as animal waste to provide nutrients for plants

- A large number of minerals on which our industries are based
- Oil, coal and gas, extracted from underground sources. They provide power for vehicles, agricultural machinery, industry and for our homes

The lithosphere began as a hot ball of matter which formed the earth about 4.6 billion years ago. About 3.2 billion years ago, the earth cooled down considerably and a very special event took place—life began on our planet. The crust of the earth is 6–7 km thick and lies under the continents. Of the 92 elements in the lithosphere, only eight are common constituents of crystal rocks. Of these, 47% is oxygen, 28% is silicon, 8% is aluminum, and 5% is iron, while sodium, magnesium, potassium and calcium constitute 4% each. Together, these elements form about 200 common mineral compounds. Rocks, when broken down, form soil on which humans are dependent for agriculture. Their minerals are also the raw material used in various industries.

(iv) Biosphere

- Food, from crops and domestic animals, providing human metabolic requirements
- Food for all forms of life, which live as interdependent species in a community, and form food chains in nature on which humans are dependent
- Energy needs: Biomass fuelwood collected from forests and plantations, along with other forms of organic matter, used as a source of energy
- Timber and other construction materials

This is the relatively thin layer on the earth in which life can exist. Within it the air, water, rocks and soil and the living creatures form structural and functional ecological units, which together can be considered as one giant global living system, that of our earth itself. Within this framework, those characterised by broadly similar geography and climate, as well as communities of plant and animal life can be divided for convenience into different biogeographical realms. These occur on different continents. Within these, smaller biogeographical units can be identified on the basis of structural differences and functional aspects into distinctive recognisable ecosystems, which give a distinctive character to a landscape or waterscape. Their easily visible and identifiable characteristics can be described at different scales, such as those of a country, a state, a district or even an individual valley, hill range, river or lake.

The simplest of these ecosystems to understand is a pond. It can be used as a model to understand the nature of any other ecosystem and to appreciate the changes that are seen over time in any ecosystem. The structural features of a pond include its size, depth and the quality of its water. The periphery, the shallow part and the deep part of the pond, each provide specific conditions for different plant and animal communities. Functionally, a variety of cycles like the amount of water within the pond at different times of the year and the quantity of nutrients flowing into the pond from the surrounding terrestrial ecosystem, all affect the 'nature' of the pond.

Natural cycles between the spheres: All these four spheres are closely interlinked systems and are dependent on the integrity of each other. Disturbing one of these spheres affects the others.

The links between them are mainly in the form of cycles. For instance, the atmosphere, hydrosphere and lithosphere are all connected through the hydrological cycle. The water evaporating from the hydrosphere (the seas and freshwater ecosystems) forms clouds in the atmosphere. On condensing, this falls as rain, which provides moisture for the lithosphere, on which life depends. The rain also acts on rocks as an agent of erosion and over millions of years has created soil, on which plants grow. Atmospheric movements in the form of wind also break down rocks into soil. The most sensitive and complex links are those between the atmosphere, the hydrosphere and the lithosphere, on the one hand, with the millions of living organisms in the biosphere on the other. All living organisms which exist on earth live only in the relatively thin layer of the lithosphere and hydrosphere present on the surface of land and in the water. The biosphere which they form has countless associations with different parts of the three other 'spheres'.

It is, therefore, essential to understand the inter-relationships of the separate entities soil, water, air and living organisms, and to appreciate the value of preserving intact ecosystems in their entirety.

Let's do it!

Observe a nearby pond in different seasons and document the seasonal changes that take place in it. One can also observe changes in a river or the seasonal changes in a forest or grassland.

Let's do it!

Take a simple object in daily use and track its components back to each of its spheres.

Example: This textbook:

- Paper from wood—the biosphere
- Water for pulping wood—the hydrosphere
- Bleach to whiten the paper—a mineral from the lithosphere

2.2 Renewable and Non-Renewable Resources

A renewable resource is a natural resource which, if harvested sustainably, can be regenerated after its use. Ecosystems act as resource producers and processors. Solar energy is the main driving force of ecological systems, providing energy for the growth of plants in forests, grasslands and aquatic ecosystems. A forest recycles its plant material slowly by continuously returning its dead material, leaves and branches to the soil. Grasslands recycle material much faster than forests, as the grass dries up after the rains every year. All the aquatic ecosystems also depend on solar energy and have cycles of growth when plant life spreads and aquatic animals breed; the sun also drives the water cycle.

It is important to understand that although water and biologically living resources such as forests, grasslands and wetlands are considered renewable, they are, in fact, renewable only within a certain limit. If over-utilised and/or degraded beyond that limit, they lose their capacity to regenerate.

Non-renewable resources on the other hand are natural resources that take millions of years to regenerate and are therefore irreplaceable after consumption. They are often present in only a fixed amount and are often consumed at a faster rate than the environment's capacity to regenerate them. Fossil fuels such as coal, petroleum and natural gas are some examples of non-renewable resources.

2.2.1 Natural Resources and Associated Problems

Natural resources include those resources that are derived from the environment. Water, air, minerals, oil and products gained from forests are some examples of natural resources.

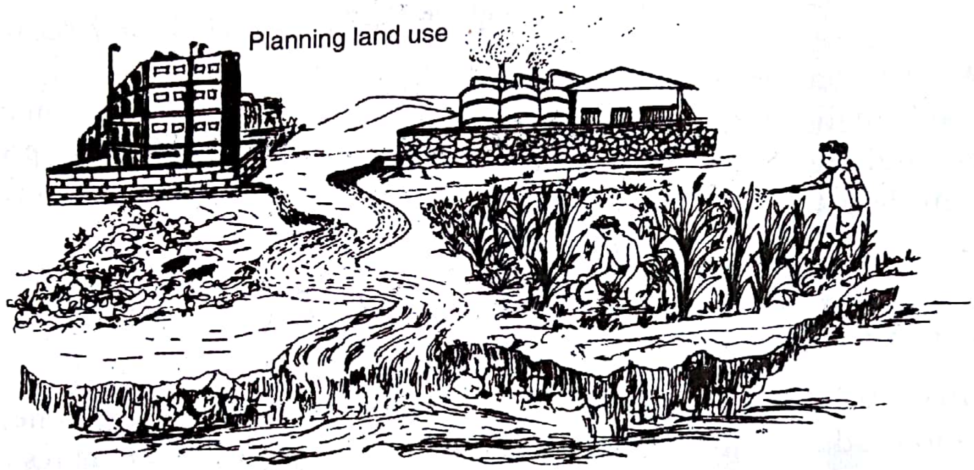
The unequal consumption of natural resources

Currently, a major part of our natural resources are consumed in the technologically advanced or 'developed' world, usually termed as 'the North'. The 'developing nations' of 'the South', including India and China, also overuse many resources because of their greater human population. However, the consumption of resources per capita (per individual) of the developed countries is up to 50 times greater than in most developing countries. Advanced countries also produce over 75% of the global industrial waste and greenhouse gases (GHGs).

Energy from fossil fuels is consumed in much greater quantities in developed countries. Their per capita consumption of food and other products is also much greater, resulting in larger quantities of waste, such as packaging material used in the food industry. Producing animal food for human consumption requires more land than that required for growing crops. Thus, countries that are highly dependent on meat-based diets need much larger areas for pasture than those where the people are mainly vegetarian. This consumption pattern can also be measured in terms of a nation or city's *Ecological Footprint* (EF), which is a measure of human demand on the earth's resources in relation to the earth's capacity to regenerate those resources. Thus, the per capita EF provides a means to compare consumption and lifestyles while checking this against the earth's ability to provide for this consumption. As of 2006, the US footprint per capita was 9.0 global hectares (gha), while India's was 0.8 gha. While India's footprint is much smaller than the world average of 2.2 gha, it is important to know that our footprint has doubled since the 1960s due to population growth. This accelerated degradation of our natural capital is unsustainable.

Planning land use

Land itself is a most important resource; it is necessary for food production, animal husbandry, industry and for our growing human settlements. These forms of intensive land use are frequently extended at the cost of 'wild lands'—our remaining forests, grasslands, wetlands and deserts. Thus, it is essential to evolve a rational land use policy that examines how much land must be made available for different purposes and where it must be situated. For instance, there are usually alternate sites at which industrial complexes or dams can be built, but a natural wilderness cannot be recreated artificially. Scientists today believe that at least 10% of the land and water bodies of each ecosystem must be kept as wilderness for the long-term needs of protecting nature and natural resources.



Land as a resource is now under serious pressure due to an increasing 'land hunger'—to produce sufficient quantities of food for an exploding human population. It is also affected by degradation due to misuse. Land and water resources are also polluted by industrial waste and rural and urban sewage, apart from being diverted for short-term economic gains to agriculture and industry. Natural wetlands of great value are being drained for agriculture and other purposes and semi-arid land is being irrigated and overused.

The most damaging change in land use is demonstrated by the rapidity with which forests have vanished in recent times, both in India and in the rest of the world. In the long term, the loss of forests and the services they provide is far greater than the short-term gains produced by converting forested lands to other uses.

The need for sustainable lifestyles

The quality of human life and the quality of ecosystems on earth are indicators of the sustainable use of resources. There are some clear indicators of sustainable lifestyles in human life, such as:

- increased longevity,
- an increase in knowledge, and
- an enhancement of income.

These three together are known as the 'Human Development Index'.

The indicators of the quality of the ecosystems are more difficult to assess. They are:

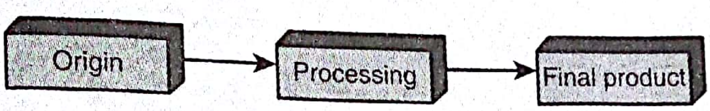
- a stabilised population or the percentage of species loss,
- species diversity in ecosystems, and
- the state of 'naturalness' of ecosystems.

Let's do it!

Utilisation of Resources

The use of a resource begins with its collection, its processing into a useable product, and transport through a delivery system to the consumer who uses it. It also involves disposal of the waste products produced at each step. Each step in resource use can affect the environment for better or worse. Control of these steps is known as environmental management.

Think of a resource you use and track it through these steps.



Example: The cotton in the clothes you are wearing. At each step, note:

- What other resources are needed at this step to move the resource you chose to the next?
- What waste products are generated at that step?
- How are they likely to be disposed of?
- What pollutants are generated in the process?

2.2.2 Renewable Resources

(i) Forest Resources

People who live in or near forests know the value of forest resources first-hand, because their lives and livelihoods depend directly on these resources. However, the rest of us also derive great benefits from the forests, which we are rarely aware of. The water we use depends on the existence of forests on the watersheds around river valleys. Our homes, furniture and paper are made from wood from the forest. We use many medicines that are based on forest produce and we depend on plants for the oxygen they emit and to remove the carbon dioxide we breathe out from the air.

Once upon a time, forests extended over large tracts of our country. People have used forests in our country for thousands of years. With the spread of agriculture, however, the forests were left in patches which were controlled mostly by tribal people. They hunted animals and gathered plants and lived entirely on forest resources. Deforestation became a major concern in British times when a large amount of timber was extracted for building ships. This led the British to develop scientific forestry in India. They, however, alienated local people by creating *Reserved* and *Protected Forests*, which curtailed access to the resources. This led to a loss of stake in the conservation of the forests and to the gradual degradation and fragmentation of forests along the length and breadth of the country.

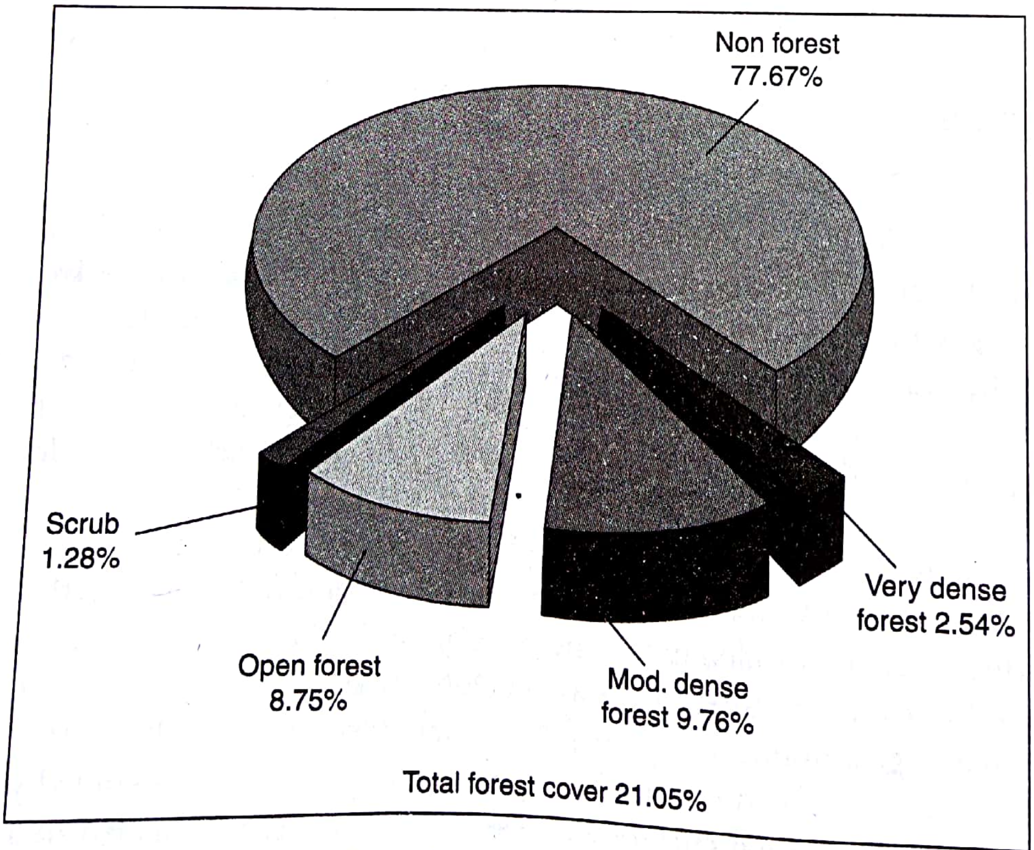
The data in Table 2.1 is represented by a pie chart for easier comprehension (Fig. 2.3).

Another period of over-utilisation and forest degradation occurred soon after India gained independence, as state sponsored agricultural expansion became a priority. The following years saw India's residual forest wealth dwindle sharply.

Table 2.1 Forest and tree cover of India in 2011

Class	Area (km²)	Geographical area (%)
Forest cover		
Very dense forest	83,471	2.54
Moderately dense forest	320,736	9.76
Open forest	287,820	
Total forest cover (includes 4662 km² under mangroves)	**692,027**	**21.05**
Tree cover	**90,844**	**2.76**
Total forest cover and tree cover	**782,871**	**23.81**
Scrub	42,177	1.28
Non-forest	2,553,059	77.67
Total geographical area	**3,287,263**	**100.0**

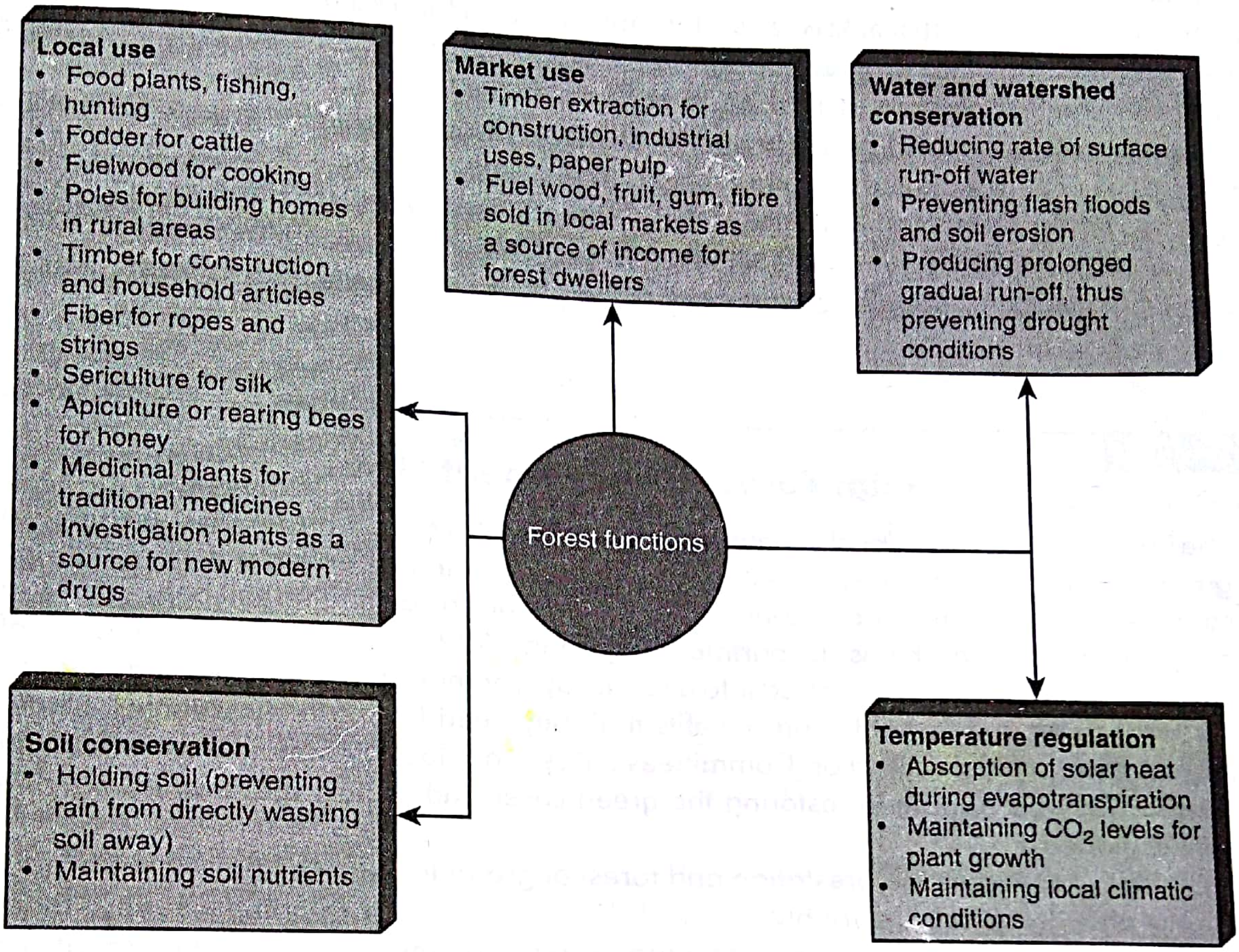
Source: India state of forest report 2011



- Very dense forest: All lands with tree canopy density of 70% and above
- Moderately dense forest: All lands with tree canopy density between 40% and 70%
- Open forest: All lands with tree canopy density between 10% and 40%
- Scrub: Degraded forest lands with canopy density less than 10%
- Non-forest: Area not included in any of the above classes.

Fig. 2.3 Forest cover in India

Forest functions include:



Threats on forest resources: Scientists estimate that India should ideally have 33% of its land under forests. Today, we only have about 12%. Thus, we need to not only protect our existing forests but also to increase our forest cover.

Deforestation and degradation: Deforestation involves a loss in the area covered by forests. Degradation, on the other hand, refers to the condition of a forest involving a reduction in its quality. One or more of the components such as soil, vegetation and/or fauna of a forest are affected, thereby impacting the overall functioning of a forest ecosystem.

Those civilisations that looked after forests by using forest resources cautiously have prospered, whereas those that destroyed forests have gradually become impoverished. Today, expansion of agricultural land, rapid industrialisation, urbanisation, illegal logging and mining are serious causes of loss and degradation of forests in our country and all over the world. Furthermore, dams built for hydroelectric power or irrigation have submerged large tracts of forests and have displaced tribal people whose lives are closely knit to the forest. Realising this, the Ministry of Environment and Forest (MoEF) formulated the National Forest Policy of 1988 to give added importance to Joint Forest Management (JFM), which co-opts local village communities and the Forest Department to work together to sustainably manage our forests. Another resolution in 1990 provided a formal structure for community participation through the formation of

Village Forest Committees (VFCs). Based on these experiences, new JFM guidelines were issued in 2000. This stipulates that at least 25% of the income from the area must go to the community. From the initiation of the programme until 2002, there were 63,618 JFM Committees managing over 140,953 sq km of forest in 27 states in India.

Various states have tried a variety of approaches to JFM. The share of profits for the VFCs ranges from 25% in Kerala to 50% in Gujarat, Maharashtra, Orissa and Tripura and 100% in Andhra Pradesh. In many states, 25% of the revenue is used for village development. In many states, non-timber forest products (NTFPs) are available to the people free of cost. Furthermore, some states have stopped grazing while others have rotational grazing schemes that have helped in forest regeneration.

CASE STUDY I

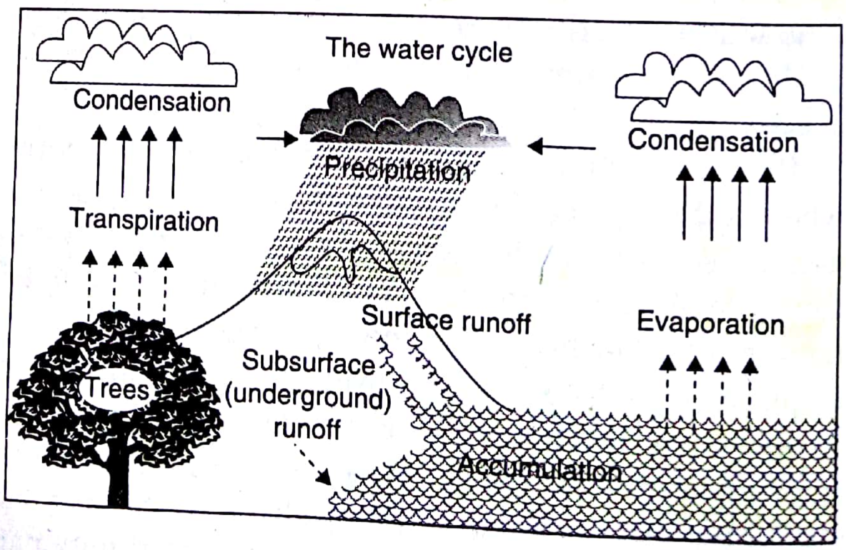
Joint Forest Management (JFM)

The need to include local communities in Forest Management has become a growing concern. Local people will only support greening of an area if they can see some economic benefit from conservation. An informal arrangement between local communities and the Forest Department began in 1972, in the Midnapore District of West Bengal. JFM has now evolved into a formal agreement which identifies and respects the local community's rights and benefits that they need from forest resources. Under JFM schemes, Forest Protection Committees (FPCs) from local community members are formed. They participate in restoring the green cover and protect the area from being over-exploited.

While the causes of deforestation and forest degradation such as timber extraction, mining and dams are invariably some of the needs of a developing country, there needs to be a strategy that looks at long-term ecological gains that cannot be sacrificed for short-term economic gains.

(ii) Water Resources

Fresh water (even after being used) evaporates due to the sun's energy, forms water vapor and is re-formed in clouds, which fall to earth as rain.



The water cycle, through evaporation and precipitation, maintains hydrological systems which form rivers and lakes and supports a variety of aquatic ecosystems. Wetlands are the intermediate forms between terrestrial and aquatic ecosystems and contain species of plants and animals that are highly moisture-dependent. All aquatic ecosystems are used by a large number of people for their daily needs such as drinking water, washing, cooking, watering animals and irrigating fields. However, the world depends on a limited quantity of freshwater. Water covers 70% of the earth's surface, but only 3% of this is fresh water. Of this, 2% is present as polar ice caps and only 1% is usable water in rivers, lakes and subsoil aquifers. Only a fraction of this can be actually used. At a global level, 70% of the water is used for agriculture, about 22% for industry and only 8% for domestic purposes. However, this varies in different countries, and industrialised countries use a greater percentage for industry. India uses 87% of its water for agriculture, 8% for industry and 5% for domestic purposes (National Commission for Water Resources Development Plan, Ministry of Water Resources, 1999).

One of the greatest challenges facing the world this century, is the need to rethink the overall management of water resources. Water sources can be overused or wasted to such an extent that they locally run dry. Water sources can also become so heavily polluted by sewage and toxic substances that it becomes impossible to use the water.

The world population has passed the 6 billion mark. Based on the proportion of young people in developing countries, this will continue to increase significantly during the next few decades. This places enormous demands on the world's limited freshwater supply. The total annual freshwater withdrawals today are estimated at 3800 cubic kilometres, twice as much as just 50 years ago (World Commission on Dams, 2000). Studies indicate that a person needs a minimum of 20–40 litres of water per day for drinking and sanitation. However, more than one billion people worldwide have no access to clean water, and to many more, water supplies are unreliable. Local water conflicts are already spreading to states; for example, Karnataka and Tamil Nadu are fighting over the waters of the Cauvery River and Karnataka and Andhra Pradesh over the Krishna waters.

India is expected to face critical levels of water stress by 2025. At the global level, 31 countries are already short of water and by 2025 there will be 48 countries facing serious water shortages. The UN has estimated that by the year 2050, 4 billion people will be seriously affected by water shortages. This will lead to multiple conflicts between countries over the sharing of water. Around 20 major cities in India face chronic or interrupted water shortages. There are 100 countries that share the waters of 13 large rivers and lakes. The upstream countries could starve the downstream nations, leading to political instability across the world. Examples are Ethiopia, which is upstream on the Nile, and Egypt, which is downstream and highly dependent on the Nile. International accords that will look at a fair distribution of water in such areas will become critical to world peace. India and Bangladesh already have a negotiated agreement on the use of the Ganges River.

Mismanagement and pollution of water resources: With the growth of human population, there is an increasing need for larger amounts of water to fulfil everyone's needs. Today, in many areas, this requirement cannot be met. The mismanagement of water resources has meant an inequitable distribution of water—some use more water than they need while others do not have access to clean water at all.

Agriculture also pollutes surface water and underground water stores by the excessive use of chemical fertilisers and pesticides. Methods, such as the use of biomass as fertiliser and non-toxic pesticides such as neem products, and using integrated pest management systems, all help reduce the agricultural pollution of surface and ground water. There are many ways in which farmers can use less water without reducing yield, such as by using the drip irrigation system.

Industries also tend to overlook their environmental impact while maximising their short-term economic gains. Industrial liquid waste is often released into streams, rivers and the sea unchecked. Public awareness may increasingly put pressure on industry to produce products in a manner which minimises the impact on the environment. In the longer term, as people become more conscious of using 'green products', ecosensitive industries will gain a greater competitive market compared with industries that continue to pollute. As people begin to learn about the serious health hazards caused by pesticides in their food, public awareness can begin putting pressure on farmers to reduce the use of chemicals that are injurious to health.

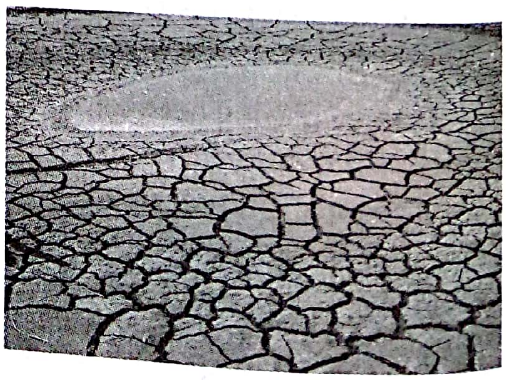
Global climate change: Changes in climate at a global level, caused by increasing air pollution, have now begun to affect our climate. In some regions, global warming and the *El Niño* winds have created unprecedented storms. In other areas, they lead to long droughts. Everywhere, the 'greenhouse effect' due to atmospheric pollution is leading to increasingly erratic and unpredictable climatic effects. This has seriously affected regional hydrological conditions.

Floods: Floods have been a serious environmental hazard for centuries. However, the havoc caused by rivers overflowing their banks has become progressively more damaging, as people have deforested catchments and intensified the use of river flood-plains that once acted as safety valves. The wetlands in flood-plains are nature's flood control systems into which overfilled rivers could spill and they act like a temporary sponge holding the water and preventing fast-flowing water from damaging the surrounding land.


Floods

Deforestation in the Himalayas causes floods that year after year kill people, damage crops and destroy homes along the Ganges and Brahmaputra and their tributaries. Rivers change their course during floods and tons of valuable soil is lost to the sea. As the forests are degraded, rainwater no longer percolates slowly into the subsoil but runs off down the mountainside, bearing large amounts of topsoil. This blocks or 'silts' up the rivers temporarily, but eventually gives way as the pressure mounts, allowing enormous quantities of water to suddenly wash down into the plains below. There, the rivers swell, burst their banks and flood waters spread to engulf peoples' farms and homes.

Drought: In most arid regions of the world, the rains are very unpredictable. This leads to periods when there is a serious scarcity of water to drink, use in farms or provide for urban and industrial use. Drought-prone areas are thus faced with irregular periods of famine. Agriculturists have no income in these years and as they have no steady income, they have a constant fear of droughts. India has 'Drought-Prone Areas Development Programmes', which are used in such areas to buffer the effects of drought. Under these schemes, people are given wages in years of water scarcity to build roads, minor irrigation works and plantation programmes.


Drought

Drought has been a major problem in our country, especially in arid and semi-arid regions. It is an unpredictable climatic condition and occurs due to the failure of one or more monsoons. It varies in frequency in different parts of the country. While it is not feasible to prevent the monsoon from failing, good environmental management can reduce its ill-effects. The scarcity of water during drought years affects homes, agriculture and industry. It also leads to food shortage and malnutrition which especially affects children.

Several measures can be taken to minimise the serious impacts of a drought. However, this must be done as a preventive measure so that if the monsoon fails, its impact on local peoples' lives is reduced. In years when the monsoon is adequate, we often use up the supply of water without trying to conserve it or use it judiciously. Thus, in a year when the rains are poor, there is no water even for drinking in the drought areas.

One factor that aggravates the effect of drought is deforestation. Once the hill-slopes are denuded of forest cover, the rainwater rushes down the rivers and is lost. Forest cover permits water to be held in the area and gradually seep into the ground. This charges the underground stores of water in natural aquifers. This can be used in drought years if the stores have been filled during a good monsoon. If water from the underground stores is overused, the water table drops and vegetation suffers. This soil and water management and afforestation are long-term measures that reduce the impact of drought.

Water for agriculture and power generation: India's increasing demand for water for intensive irrigated agriculture, for generating electricity and for consumption in urban and industrial centres, has been met by creating large dams. The area under irrigation has increased from 40 million ha in 1900 to 100 million ha in 1950 and to 271 million ha by 1998. Dams support 30%–40% of this area.

Although dams ensure a year-round supply of water for domestic use and provide extra water for agriculture, industry and hydropower generation, they are also accompanied by several serious environmental problems. They alter river flows, change nature's flood-control mechanisms, such as wetlands and flood-plains, and destroy the lives of local people and the habitats of wild plant and animal species. Intensive irrigation to support water-hungry cash crops like sugarcane produces an unequal distribution of water. Large landholders on the canals get the lion's share of water, while smaller farmers get less and are adversely affected.

Dams: Managing a river system is best done by leaving its course undisturbed. Dams and canals lead to major floods during the monsoons and drainage of wetlands seriously affects the areas that get flooded when there is high rainfall.

Today there are more than 45,000 large dams around the world, which play an important role in communities and economies that harness these water resources for their economic development. Current estimates suggest that about 30%–40% of the irrigated land worldwide relies on dams. Hydropower, another contender for the use of stored water, currently supplies 19% of the world's total electric power supply and is used in over 150 countries. The world's two most populous countries, China and India, have built around 57% of the world's largest dams (World Commission on Dams, International Rivers Organization, 2008).

Problems caused by dams

- The fragmentation and physical transformation of rivers
- Serious impact on riverine ecosystems
- Social consequences of large dams due to the displacement of people
- Water-logging and salinisation of the surrounding lands
- Dislodging animal populations, damaging their habitat and cutting off their migratory routes

- Disruption of fishing and waterway traffic
- The emission of greenhouse gases from reservoirs due to rotting vegetation and carbon inflows from the catchment is a recently identified impact

Large dams have had a serious impact on the lives, livelihoods, cultures and spiritual existence of indigenous and tribal people. They have suffered disproportionately from the negative impact of dams and have often been excluded from sharing the benefits. In India, of the 16–18 million people displaced by dams, 40%–50% are tribal people, who account for only 8% of our nation's one billion people.

Conflicts over dams have heightened over the last two decades because of their social and environmental impact and failure to achieve targets for adhering to costs as well as achieving promised benefits. Recent examples show how the failure to provide a transparent process that includes the effective participation of local people has prevented these people from playing an active role in debating the pros and cons of the project and its alternatives. The loss of traditional and local controls over equitable distribution remains a major source of conflict.

In India, a national assessment of dam projects cleared in the 1980s and '90s shows that in 90% of the cases, the project authorities have not fulfilled the environmental conditions under which environmental clearance was given by the GOI under the EPA of 1986.

CASE STUDY 2

Sardar Sarovar project

This project is a multi-purpose dam project built in the Narmada River Valley. It has impacted millions of people living in the river valley. The farmers downstream will get water for agriculture at the cost of the tribal folk, farmers and fishermen at the estuary who have lost their homeland and their means of livelihood. The question is why should the local tribals be rendered homeless, displaced and relocated to benefit other people? Why should the less fortunate be made to bear the costs of development for wealthier farmers? It is a question of social and economic equity as well as the enormous environmental losses, including loss of the biological diversity of the inundated forests in the Narmada Valley.

'Save water' campaigns are essential to make people everywhere aware of the dangers of water scarcity. A number of measures need to be taken for better management of the world's water resources. These include measures such as:

- building several small reservoirs instead of a few mega projects,
- developing small catchment dams and protecting wetlands,
- soil management, micro-catchment development and afforestation, which enables recharging of underground aquifers, thus reducing the need for large dams,
- treating and recycling municipal waste water for agricultural use,
- preventing leakages from dams and canals,
- preventing loss in municipal pipes,
- effective rainwater harvesting and recharging of groundwater in urban environments,
- water conservation measures in agriculture, such as using drip irrigation,
- pricing water at its real value, which makes people use it more responsibly and efficiently and reduces wastage, and

- in deforested areas where land has been degraded, soil management, by making *bunds* along the hill-slopes and making *nalla* plugs, can help retain moisture and make it possible to revegetate degraded areas.

Sustainable water management is a crucial step towards the world's looming water crisis situation.

Let's do it!

How much water does one person need a day? Several international agencies and experts have proposed that 50 litres per person per day covers the basic human water requirements for drinking, sanitation, bathing and food preparation. Estimate your average daily consumption.

(iii) Mineral Resources

A mineral is a naturally occurring substance of definite chemical composition and identifiable physical properties. An ore is a mineral or combination of minerals from which a useful substance, such as a metal, can be extracted and used to manufacture useful products.

Minerals are formed over a period of millions of years in the earth's crust. Iron, aluminum, zinc, manganese and copper are important raw materials for industrial use. Important non-metallic resources include coal, salt, clay, cement and silica. Stone used for building material, such as granite, marble and limestone, constitute another category of minerals. Minerals with special properties that humans value for their aesthetic and ornamental value are gems such as diamonds, emeralds and rubies. The lustrous metals such as gold, silver and platinum are used for ornaments. Minerals in the form of oil, gas and coal were formed when ancient plants and animals were converted into underground fossil fuels.


Iron ore mine

Minerals and their ores need to be extracted from the earth's interior so that they can be used; this process is known as mining. Mining operations generally progress through four stages.

- Prospecting: Searching for minerals.
- Exploration: Assessing the size, shape, location and economic value of the deposit.
- Development: The work of preparing access to the deposit so that the minerals can be extracted from it.
- Exploitation: Extracting the minerals from the mines.

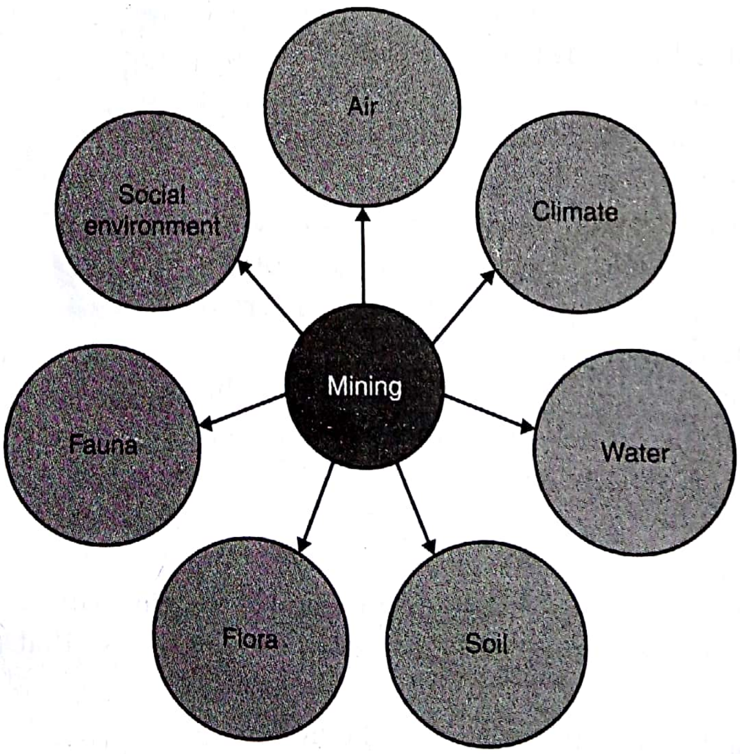
In the past, mineral deposits were discovered by prospectors in areas where deposits in the form of veins were exposed on the surface. Today, however, prospecting and exploration is done by teams of geologists, mining engineers, geophysicists, and geochemists, who work together to discover new deposits. Modern prospecting methods include the use of sophisticated instruments, like GIS, to survey and study the geology of the area and discover placers. The method of mining has to be determined depending on whether the ore or mineral deposit is nearer the surface or deep within the earth. The topography of the region and the physical nature of the ore deposit are also studied.

Mines are of two types—surface (open-cast or strip mines) or deep (or shaft) mines. Coal, metals and non-metalliferous minerals are all mined differently depending on the above criteria. The method chosen for mining will ultimately depend on how the maximum yield may be obtained under existing conditions at the minimum cost, with the least danger to the mining personnel.

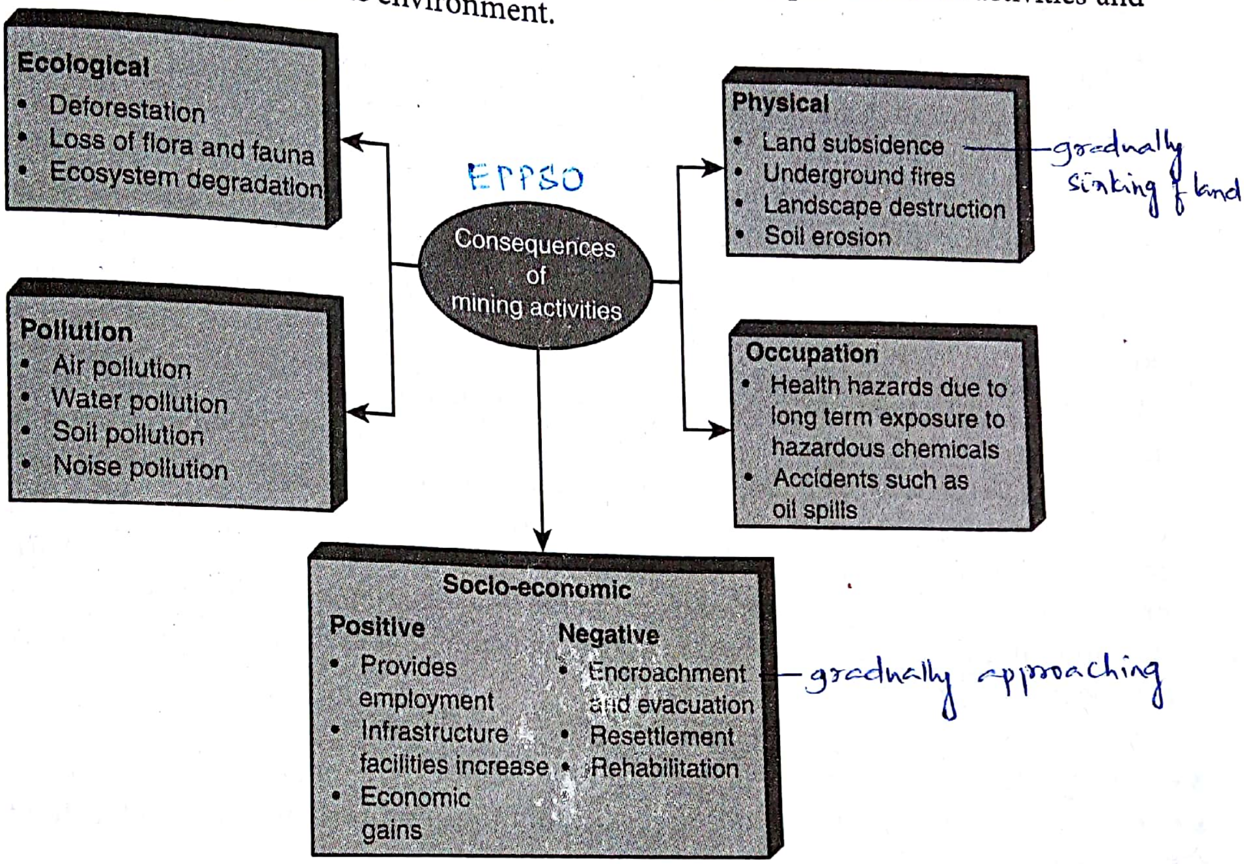
Most minerals need to be processed before they become usable. Thus, 'technology' is dependent on both the presence of resources and the energy necessary to make them 'usable'.

Mine safety: Mining is a hazardous occupation, and the safety of mine workers is an important environmental consideration. Surface mining is less hazardous than underground mining, and metal mining is less hazardous than coal mining. In all underground mines, rock- and roof-falls, flooding and inadequate ventilation are the greatest hazards. Large explosions have occurred in coal mines, killing many miners. More miners have suffered from disasters due to the use of explosives in metal mines.

Mining poses several long-term occupational hazards to the miners. The dust produced during mining operations is injurious to health and causes a lung disease known as 'black lung' or pneumoconiosis. The fumes generated by incomplete dynamite explosions are extremely poisonous. Methane gas, emanating from coal strata, is hazardous to health, although not poisonous in the concentrations usually encountered in mine air. Radiation is a life-threatening hazard in uranium mines.



Environmental problems: Mining operations are considered one of the main sources of environmental degradation. The extraction of all these products from the lithosphere has a variety of side effects. The depletion of available land due to mining, waste from industries, conversion of land to industry and pollution of land, water and air by industrial waste are the environmental side effects of the use of these non-renewable resources. There is global public awareness of this problem and government actions to stem the damage to the natural environment have led to numerous international agreements and laws directed toward the prevention of activities and events that may adversely affect the environment.



CASE STUDY 3

Sariska Tiger Reserve, Rajasthan

The Forest Department leased land for mining in the Sariska Tiger Reserve area by denotifying the protected forest areas. The local people fought against the mining lobby, and filed a Public Interest Litigation (PIL) in the Supreme Court in 1991. As a result, the Supreme Court banned mines in the core zone of the reserve. However, more recently, the Sariska Tiger Reserve has been faced with threats of illegal poaching. This is further discussed in Unit 4.

Let's do it!

A coal mining company is to commence operations in a small farming town in Maharashtra. Form two discussion groups in your class: Group A is the mining company that will list out the positive impacts of having this operation in town. Group B represents the concerned public that will list out the negative impacts of having this operation. Discuss and come up with a decision/solution.

(iv) Food Resources

Today our food comes almost entirely from agriculture, animal husbandry and fishing. India is self-sufficient in food production; however, this has come at a cost. The modern practice of intensive agriculture pollutes our waterways and land with excessive use of fertilisers and pesticides.

The FAO (Food and Agricultural Organization) defines sustainable agriculture as that which conserves land, water and plant and animal genetic resources, does not degrade the environment and is economically viable and socially acceptable. Most of our large farms grow single crops (monoculture). If this crop is hit by a pest, the entire crop can be devastated, leaving the farmer with no income during the year. On the other hand, if the farmer uses traditional varieties and grows several different crops, the chance of complete failure is lowered considerably. Many studies have shown that one can use alternatives to inorganic fertilisers and pesticides. This is known as Integrated Crop Management.

World food problems: In many developing countries where populations are expanding rapidly, the production of food is unable to keep pace with the growing demand. Food production in 64 of the 105 developing countries is lagging behind their population growth levels. These countries are unable to produce more food, or do not have the financial means to import it. India is one of the countries that has been able to produce enough food by cultivating a large proportion of its arable land through irrigation. The Green Revolution of the '60s reduced starvation in the country. However, many of the technologies we have used to achieve this are now being questioned.

- Our fertile soils are being exploited faster than they can recuperate.
- Forests, grasslands and wetlands have been put to agricultural use, which has led to serious ecological consequences.
- Our fish resources, both marine and inland, show evidence of exhaustion.
- There is great disparity in the availability of nutritious food. Some communities such as tribal people still face serious food problems leading to malnutrition, especially among women and children.

These issues raise new questions as to how demands will be met in the future, even with a slowing down of population growth. Today, the world is seeing a changing trend in dietary habits. As living standards are improving, people are eating more meat-based food. As people change from eating grain to meat, the world's demand for feed for livestock, based on agriculture, increases as well. This uses more land per unit of food produced and the result is that the world's poor do not get enough to eat.

Women play a vital role in food production as well as in cooking meals and feeding children. In most rural communities, they have the least exposure to technical training and to health workers trained in teaching/learning on issues related to nutritional aspects. Women and girls frequently receive less food than the men. These disparities need to be corrected.

In India there is a shortage of cultivable productive land. Thus, farms are too small to support a family on farm produce alone. With each generation, farms are being subdivided further. Poor environmental agricultural practices such as slash-and-burn, shifting cultivation or *rab* (woodash) cultivation degrade the forests. Globally, 5–7 million ha of farmland is degraded each year. The loss of nutrients and the overuse of agricultural chemicals are major factors in land degradation. Water scarcity is an important aspect of poor agricultural output. Salinisation and water-logging has affected a large amount of agricultural land worldwide.

Food security: It is estimated that 18 million people worldwide, most of whom are children, die each year due to starvation or malnutrition, and many others suffer a variety of dietary deficiencies. The earth can only supply a limited amount of food. If the world's carrying capacity to produce food cannot meet the needs of a growing population, anarchy and conflict will follow. Thus, food security is closely linked with population control through the family welfare program. It is also linked to the availability of water for farming. Food security is only possible if food is equitably distributed to all. Many of us waste a large amount of food carelessly. This eventually places great stress on our environmental resources.

Another major concern is the support needed for small farmers so that they remain farmers rather than shifting to urban centres as unskilled industrial workers. International trade policies with regard to an improved flow of food across national borders from those who have surplus to those who have a deficit in the developing world is another issue that is a concern for planners who deal with international trade concerns. 'Dumping' of under-priced foodstuff produced in the developed world onto markets in undeveloped countries undermines crop prices and forces farmers there to adopt unsustainable practices in order to compete.

Fisheries: Fish is an important source of protein for many people. This includes both marine and freshwater fish. While the supply of food from fisheries has increased phenomenally between 1950 and 1990, in several parts of the world, the fish catch has dropped due to overfishing. In 1995, the FAO reported that 44% of the world's fisheries are fully or heavily exploited—16% are already overexploited, 6% are depleted and only 3% are gradually recovering. Canada had to virtually close down cod fishing in the 1990s due to the severe depletion of its fish reserves.

Modern fishing technology using mechanised trawlers and small meshed nets have lead directly to overexploitation, which is not sustainable. It is evident that fish have to breed successfully and need to have time to grow if the yield has to be used sustainably. The small traditional fishermen, who are no match for organised trawlers, are the worst affected by these developments.

Loss of genetic diversity: There are 50,000 known edible plants documented worldwide. Of these, only 15 varieties produce 90% of the world's food. Modern agricultural practices have resulted in a serious loss of genetic variability of crops. India's distinctive traditional varieties of rice alone are said to have numbered between 30 and 50,000. Most of these have been lost to the farmer during the last few decades, as multinational seed companies aggressively push a few commercial genotypes.

This creates a risk to our food security, as farmers can lose all their produce due to a rapidly spreading disease. On the other hand, a cereal that has multiple varieties growing in different locations does not permit the rapid spread of a disease.

The most effective method to introduce desirable traits into crops is by using characteristics found in the wild relatives of crop plants. As the wilderness shrinks, these varieties are rapidly disappearing. Once they are completely lost, their desirable characteristics cannot be introduced when found necessary in the future. Ensuring long-term food security may depend on conserving the wild relatives of crop plants in national parks and wildlife sanctuaries.

If plant genetic losses worldwide are not slowed down, some estimates show that as many as 60,000 plant species, which account for 25% of the world's total, will be lost by the year 2025. The most economical way to prevent this is by expanding the network and coverage of our protected areas. Collections in germplasm, seed banks and tissue culture facilities are other possible ways to prevent extinction, but these are extremely expensive.

Scientists now believe that the world will soon need a second Green Revolution to meet our future demands of food, based on a new ethic of land and water management that must incorporate values which include environmental sensitivity, equity, biodiversity conservation of cultivars and *in-situ* preservation of wild relatives of crop plants. This must not only provide food for all, but also enable a more equitable distribution of both food and water, reduce agricultural dependence on the use of fertilisers and pesticides (which have long-term ill-effects on human wellbeing) and provide increasing support for preserving wild relatives of crop plants in protected areas. The pollution of water sources, land degradation and desertification must be rapidly reversed. Adopting soil conservation measures, using appropriate farming techniques, especially on hill-slopes, enhancing the soil with organic matter, rotating crops and managing watersheds at the micro-level are the keys to agricultural production to meet future needs. Most importantly, food supply is closely linked to the effectiveness of population control programs worldwide. The world needs better and more sustainable methods of food production, which is an important aspect of land use management.

Alternate food sources: Food can be innovatively produced if we break out of current agricultural patterns. This includes working on new avenues to produce food, such as using forests for their multiple non-wood forest products, which can be used for food if harvested sustainably. This includes fruits, mushrooms, sap, gum and others. This will, of course, take time, as people must develop a taste for these new foods.

Medicines, both traditional and modern, can be harvested sustainably from forests. Madagascar's Rosy Periwinkle used for childhood leukemias and Taxol obtained from Western Yew from the American North-west as an anti-cancer drug are examples of forest products used extensively in modern medicine. Without due care, commercial exploitation can lead to the early extinction of such plants.

CASE STUDY 4

Using wastewater

In India, some traditional communities in urban and semi-urban towns used to grow their own vegetables in backyards, using wastewater from their own homes. Kolkata releases its wastewater into surrounding lagoons in which fish are reared and the water is also used for growing vegetables.

Using unfamiliar crops such as *Nagli*, which are grown on poor soil on hill-slopes, is another option. This crop, found in the Western Ghats, has no market at present and is thus rarely grown. Only local people use this nutritious crop. Therefore, it is not as extensively cultivated as in the past. Popularising this crop could add to food availability from marginal lands. Several crops can be grown in urban settings, including vegetables and fruit, which can be grown on waste household water and fertilisers from vermicomposting pits.

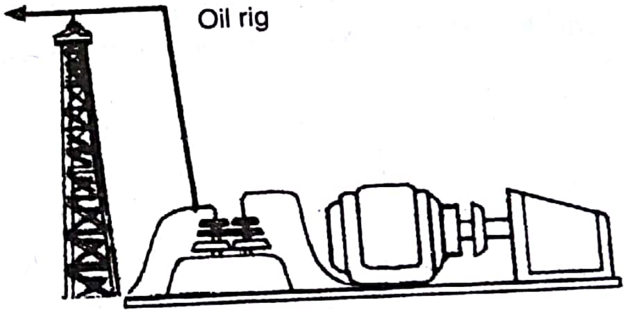
Several foods can be popularised from yet unused seafood products like seaweed, as long as this is done at sustainable levels. Educating women, who are more closely involved with feeding the family, about nutrition is an important aspect of supporting the food needs of many developing countries.

Integrated Pest Management which includes preserving pest predators, using pest-resistant seed varieties and reducing the use of chemical fertilisers, should also be adopted for sustainable food production.

(v) Energy Resources

Energy is defined by physicists as the capacity to do work. Energy is found on our planet in a variety of forms, some of which are immediately useful, while others require a process of transformation.

The sun is the primary source of energy. We use it directly for its warmth and through various natural processes that provide us with food, water, fuel and shelter. The sun's rays power the growth of plants, which form our food material, give off oxygen which we breathe in and take up carbon dioxide that we breathe out. The sun's energy evaporates water from oceans, rivers and lakes, to form clouds that turn into rain. Today's fossil fuels were once the forests that grew in prehistoric times due to the energy of the sun.



The chemical energy present in chemical compounds is released when they are broken down by animals in the presence of oxygen. In India, manual labour is still extensively used to get work done in agricultural systems, and domestic animals used to pull carts and ploughs. Electrical energy is produced in several ways—power transport, artificial lighting, agriculture and industry. This comes from hydel power based on the water cycle that is powered by the sun's energy that supports evaporation, or from thermal power stations powered by fossil fuels. Nuclear energy is held in the nucleus of an atom and is now harnessed to develop electrical energy.

We use energy for household purposes, agriculture, production of industrial goods and for transportation. Modern agriculture uses chemical fertilisers, which require large amounts of energy for their manufacture. Industry uses energy to power manufacturing units and the urban complexes that support it. Energy-demanding roads and railway lines are built to transport products from place to place and to reach raw materials in mines and forests.

No energy-related technology is completely 'risk free' and unlimited demands on energy increase this risk factor many-fold. All energy use creates heat and contributes to atmospheric temperature. In addition, many forms of energy release carbon dioxide and lead to global warming.

At present, almost 2 billion people worldwide have no access to electricity at all. While more people will require electrical energy, those who do have access to it continue to increase their individual requirements. In addition, a large proportion of energy from electricity is wasted during transmission as well as at the user level. It is broadly accepted that long-term trends in energy use should be towards a cleaner global energy system that is less carbon intensive and less reliant on finite non-renewable energy sources. It is estimated that the current methods of using renewable energy and non-renewable fossil fuel sources together will be insufficient to meet foreseeable global demands for power generation beyond the next 50–100 years.

Thus, when we use energy wastefully, we are contributing to the environmental deterioration of our planet. We all need to become responsible energy users. Remember that even a single electrical light that is burning unnecessarily is a contributor to environmental degradation!

Growing energy needs: Energy has always been closely linked to man's economic growth and development. The present strategies for development, focussed on rapid economic growth, have used energy utilisation as an index of economic development. This index, however, does not take into account the adverse long-term effects of excessive energy utilisation on society.

Between 1950 and 1990, the world's energy needs increased four-fold. The world's demand for electricity has doubled over the last 22 years! The world's total primary energy consumption in 2000 was 9096 million tons of oil; a global average per capita that works out to be 1.5 tons of oil. Electricity is at present the fastest growing form of end-use energy worldwide. By 2005, the Asia–Pacific region is expected to surpass North America in energy consumption, and by 2020 is expected to consume some 40% more energy than North America.

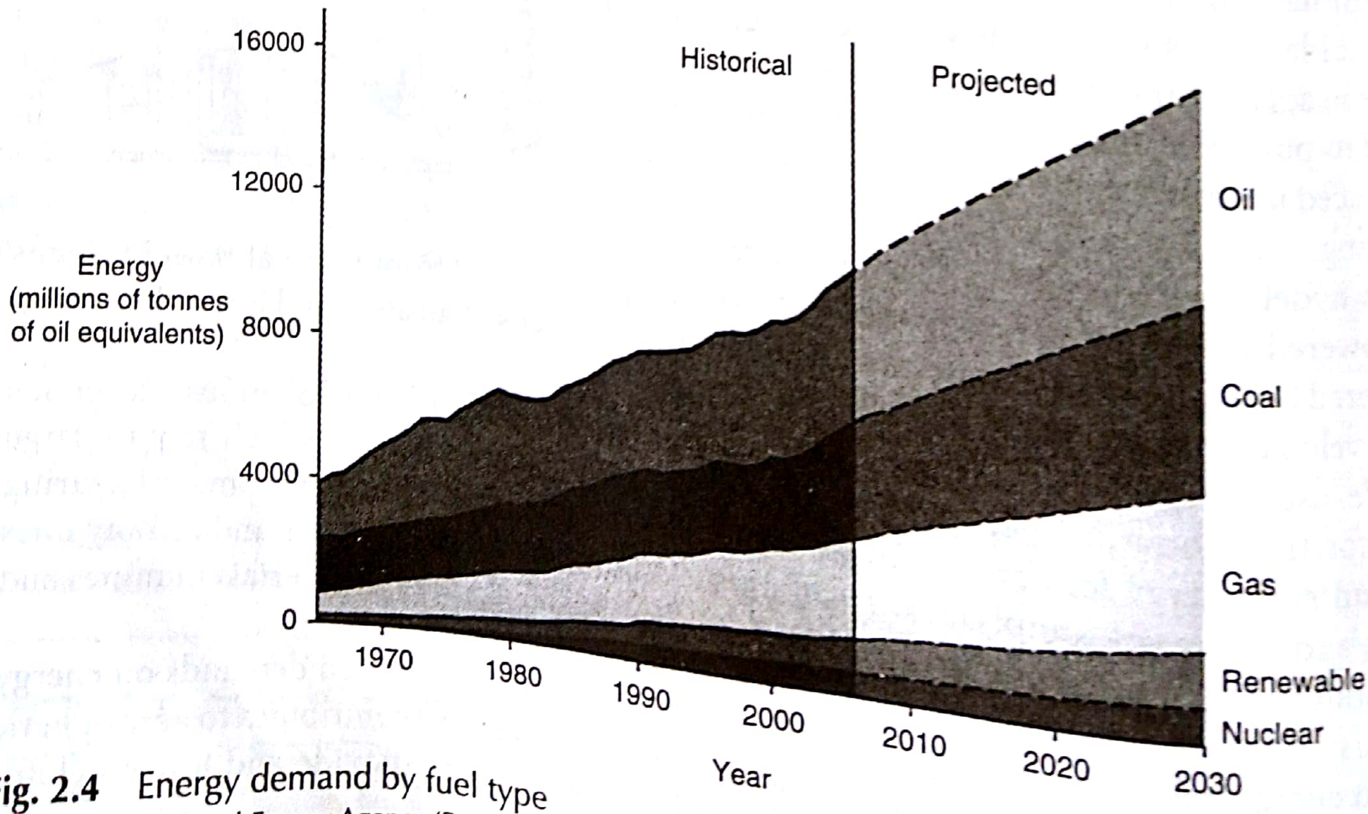


Fig. 2.4 Energy demand by fuel type
Source: International Energy Agency (Power generation from coal) 2011

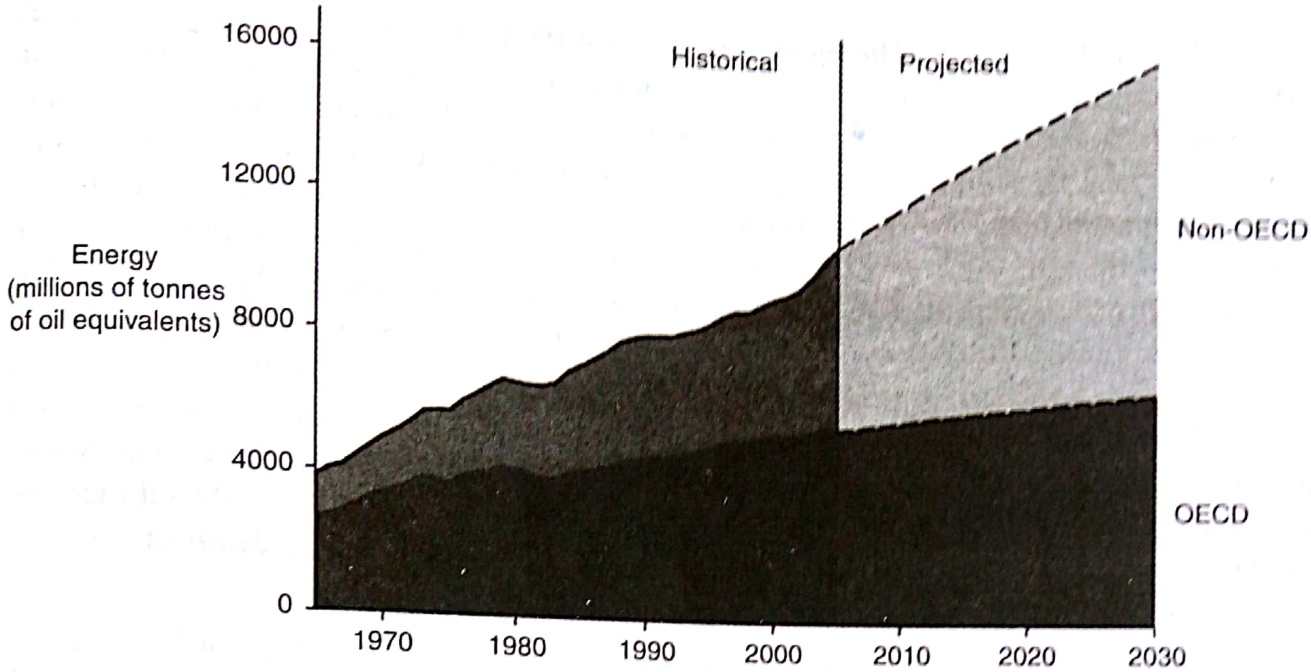


Fig. 2.5 World energy consumption: OECD vs. non-OECD
Source: International Energy Agency (Power generation from coal) 2011
OECD: Organisation for Economic Co-operation and Development is an international organisation of 34 countries to help economic progress and world trade. Some of the OECD countries include Australia, New Zealand, Belgium, Austria, Germany, South Korea, Japan, United Kingdom, United States of America. Some of the non-OECD countries include Brazil, China, Colombia, India, South Africa.

For almost 200 years, coal was the primary energy source, fuelling the Industrial Revolution in the 19th century. At the close of the 20th century, oil accounted for 39% of the world's commercial energy consumption, followed by coal (24%) and natural gas (24%), while nuclear (7%) and hydro/renewable power sources (6%) accounted for the rest.

Among the commercial energy sources used in India, coal is a predominant source, accounting for 55% of energy consumption estimated in 2001, followed by oil (31%), natural gas (8%), hydro (5%) and nuclear power (1%). In India, biomass (mainly wood and dung) accounts for almost 40% of the primary energy supply. While coal continues to remain the dominant fuel for electricity generation, nuclear power has been used increasingly since the 1970s and 1980s, and the use of natural gas increased rapidly in the '80s and '90s.

Types of energy: There are three main types of energy: those classified as non-renewable; those that are said to be renewable; and nuclear energy, which uses such small quantities of raw material (uranium) that supplies are, to all effect, limitless. However, this classification is inaccurate because several of the renewable sources, if not used 'sustainably', can be depleted more quickly than they can be renewed.

Non-renewable energy

To produce electricity from non-renewable resources, the material must first be ignited. The fuel is placed in a secured area and set on fire. The heat thus generated turns water to steam, which moves through pipes, to turn the blades of a turbine. This converts magnetism into electricity, which we use in various appliances.

Non-renewable energy sources: These consist of the mineral-based hydrocarbon fuels – coal, oil and natural gas – that were formed from ancient prehistoric forests. These are called 'fossil fuels', because they are formed after plant life is fossilised. At the present rate of extraction, there is enough coal for a long time to come. Oil and gas resources, however, are likely to be used up within the next 50 years. When these fuels are burnt, they produce waste products that are released into the atmosphere as gases such as carbon dioxide, oxides of sulphur, nitrogen, and carbon monoxide—all causes of air pollution. These have led to respiratory tract problems in an enormous number of people all over the world, have also affected historic monuments like the Taj Mahal and destroyed many forests and lakes due to acid rain. Many of these gases contribute to the greenhouse effect, letting sunlight in and trapping the heat inside. This leads to global warming, a rise in global temperature, increased drought in some areas, floods in other regions, the melting of icecaps and a rise in sea levels, which is slowly submerging coastal belts all over the world. The warming of the seas also leads to the death of sensitive organisms like coral.

Oil and its impact on the environment: India's oil reserves, which are being used at present, lie off the coast of Mumbai and in Assam. Most of our natural gas is linked to oil and, because there is no distribution system, it is just burnt off. This means that nearly 40% of available gas is wasted. The processes of oil and natural gas drilling, processing, transport and utilisation have serious environmental consequences, such as leaks in which air and water are polluted and accidental fires that may go on burning for days or weeks before they are put out. While refining oil, solid waste like salts and grease are produced, which also damage the environment. Oil slicks are caused at sea from offshore oil wells, cleaning of oil tankers and shipwrecks. The most well-known disaster occurred when the huge oil-carrier, the *Exxon Valdez* sank in 1989 and birds, sea otters, seals, fish and other marine life along the coast of Alaska was seriously affected.

Oil-powered vehicles emit carbon dioxide, sulphur dioxide, nitrous oxide, carbon monoxide and particulate matter that are a major cause of air pollution, especially in cities with heavy traffic density. Leaded petrol leads to neurological damage and reduces attention span. Petrol vehicles can be run with unleaded fuel by attaching catalytic converters to all new cars, but unleaded fuel contains benzene and butadiene which are known to be carcinogenic compounds. Delhi, which used to have a serious smog problem due to traffic, has been able to reduce this health hazard by changing a large number of its vehicles to CNG, which contains methane.

This high dependence on dwindling fossil fuel resources, especially oil, results in political tension, instability and war. At present, 65% of the world's oil reserves are located in the Middle East.

Coal and its impact on the environment: Coal is the world's largest single contributor of greenhouse gases and is one of the most important causes of global warming. Many coal-based power generation plants are not fitted with devices such as electrostatic precipitators to reduce emissions of suspended particulate matter (SPM), which is a major air polluter. Burning coal also produces oxides of sulphur and nitrogen which, combined with water vapour, lead to 'acid rain'. This destroys forest vegetation, damages architectural heritage sites, pollutes water and affects human health.

Thermal power stations that use coal produce waste in the form of 'fly-ash'. Large dumps are required to dispose of this waste material; some efforts have been made to use it for making bricks. The transport of large quantities of fly-ash and its eventual dumping are costs that have to be included in calculating the cost benefits of thermal power.

Renewable energy

Renewable energy systems use resources that are constantly replaced and are usually less polluting. Some examples are: hydropower, solar, wind and geothermal (energy from the heat inside the earth). We also get renewable energy from burning trees and even garbage as fuel and processing other plants into biofuels.

One day, all our homes may get their energy from the sun or the wind. Your car's fuel tank will probably use biofuel, and your garbage might contribute to your city's energy supply. Renewable energy technologies will improve the efficiency and cost of energy systems. We may reach the point when we may no longer rely mostly on fossil fuel energy.

CASE STUDY 5

Oil-related disasters

The Deepwater Horizon oil spill, also known as the Gulf of Mexico oil spill or the BP oil spill, is considered amongst the largest oil spills in history. On 10 April 2010, an oil well blowout occurred about 5,000 feet below the ocean surface causing a catastrophic explosion on the Deepwater Horizon offshore oil drilling platform. Hundreds of millions of litres of oil have been spilled to date. Work to drill relief wells to permanently close the oil well continues. The best estimate of the spill so far is approximately 12,000 to 19,000 barrels of oil per day. Petroleum toxicity is expected to affect the habitats of thousands of marine and bird species. This ongoing environmental disaster has already impacted the Gulf of Mexico fishing industry and tourism industry.

Hydroelectric power

This uses water flowing down a natural gradient to turn turbines to generate electricity known as 'hydroelectric power' by constructing dams across rivers. Between 1950 and 1970, hydropower generation worldwide increased seven times. The long life of hydropower plants, the renewable nature of the energy source, very low operating and maintenance costs, and absence of inflationary pressures, as in fossil fuels, are some of its advantages.

Drawbacks: Although hydroelectric power has led to economic progress around the world, it has created serious ecological problems.

- To produce hydroelectric power, large areas of forest and agricultural lands are submerged. These lands traditionally provided a livelihood for local tribal people and farmers. Conflicts over land use are inevitable.
- The silting of the reservoirs (especially as a result of deforestation) reduces the life of the hydroelectric power installations.

CASE STUDY 6

Hydel power in the Western Ghats

In 1882, the first hydroelectric power dam was built in Appleton, Wisconsin. In India, the first hydroelectric power dams were built in the late 1800s and early 1900s by the Tatas in the Western Ghats of Maharashtra. Jamshedji Tata, a great visionary who developed industry in India in the 1800s, wished to have a clean source of energy to run cotton and textile mills in Bombay as he found people were getting respiratory infections due to coal-driven mills. He therefore asked the British Government to permit him to develop dams in the Western Ghats to generate electricity. The four dams are the Andhra, Shirowata, Valvan and Mulshi hydel dams. An important feature of the Tata power projects is that they use the high rainfall areas in the hills as storage areas. While the rivers flowing eastwards from the Western Ghats are dammed in the foothills near the Deccan Plateau, the water is tunnelled through the crest of the Ghats to drop several hundred metres to the coastal belt. Large turbines in the power plants generate electricity for Mumbai and its giant industrial belt. However, the damming has inundated large forest areas of the Western Ghats. It is important to note that there are several biological and social implications to damming rivers.

- Water is required for many purposes besides power generation. These include domestic, agricultural and industrial requirements. This also gives rise to conflicts over the equitable allocation of water.
- The use of rivers for navigation and fisheries becomes difficult once the water is dammed to generate electricity.
- The resettlement of displaced persons is a problem for which there is no ready solution. The opposition to large hydroelectric schemes is growing, as most dam projects have been unable to resettle or adequately compensate the affected people.
- In certain seismically sensitive regions, large dams can induce increased seismic activity, resulting in earthquakes and the consequent loss of lives and property. There is a great possibility of this occurring around the Tehri Dam in the Himalayan foothills. Shri Sunderlal Bahuguna, the initiator of the Chipko Movement, has fought against the Tehri Dam for several years.

With large dams causing so many social problems, an attempt has made to develop small hydroelectric generation units. Multiple small dams have less impact on the environment. China has the largest number of these—60,000, generating 13,250 megawatts, that is 30% of China's electricity. Sweden, the US, Italy and France have also developed small dams for electrical power generation. The development of small hydroelectric power units could become a very important resource in India, which has rivers traversing steep gradients as well as the economic capability and technical resources to exploit them.

Solar energy: In one hour, the sun pours as much energy onto the earth as we use in a whole year. If it were possible to harness this colossal quantum of energy, humanity would need no other source. Today, we have developed several methods of collecting this energy for heating water and generating electricity.

Solar heating for homes: Modern houses that use air conditioning and/or heating are extremely energy dependent. A passive solar home or building is designed to collect the sun's heat through large, south-facing glass windows. In solar-heated buildings, *sunspaces* are built on the south side of the structure and act as large heat absorbers. The floors of sunspaces are usually made of tiles or bricks that absorb heat throughout the day and then release heat at night when it is cooler.

In energy-efficient architecture, the sun, water and wind are used to heat a building when the weather is cold and to cool it in summer. This is mostly based on design and building material. Thick walls of stone or mud were used in traditional architecture as insulators. Small doors and windows kept direct sunlight and heat out. Deeply-set glass windows in colonial homes, on which direct sunlight could not reach, permitted the use of glass without creating a greenhouse effect; verandahs also served a similar purpose. Traditional bungalows also had high roofs and ventilators that permitted the hot air to rise and leave the room. Cross-ventilation where wind can drive the air in and out of a room keeps it cool. Large overhangs or eaves over windows prevent the glass from heating the room inside. Double walls are used to prevent heating, and shady trees around the house help reduce the temperature.

Solar water heating: Most solar water-heating systems have two main parts—the solar 'collector' and the 'storage tank'. The solar energy collector heats the water, which then flows to a well-insulated storage tank. A common type of collector is the 'flat-plate collector', a rectangular box with a transparent cover that faces the sun, usually mounted on a flat roof. Small tubes run through the box, carrying the water or any other fluid such as antifreeze, to be heated. The tubes are mounted on a metal 'absorber plate', which is painted black to absorb the sun's heat. The back and sides of the box are insulated to hold in the heat. Heat builds up in the collector and as the fluid passes through the tubes, it too heats up.

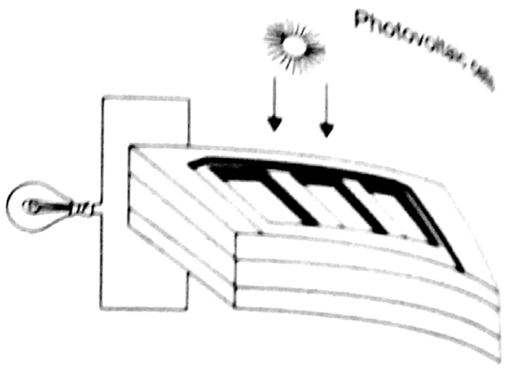
Solar water-heating systems cannot heat water when the sun is not shining. Thus, homes must also have a conventional backup system. About 80% of homes in Israel have solar water heaters.

Solar cookers: The heat produced by the sun can be harnessed directly for cooking using solar cookers. A solar cooker is a metal box, which is black on the inside to absorb and retain heat. The lid has a reflective surface to reflect the heat from the sun into the box. The box contains black vessels in which the food to be cooked is placed.

India has the world's largest solar cooker programme and an estimated 2 lakh families that use solar cookers. Although solar cookers reduce the need for fuelwood and pollution from smoky wood fires, they have not yet become popular in rural areas as it is felt that they are not suitable for traditional cooking practices. However, they have great potential if marketed well.

Other solar-powered devices: Solar desalination systems (for converting saline or brackish water into pure distilled water) have been developed. In future, they should become important alternatives for our future economic growth in areas where freshwater is not available.

Photovoltaic energy: The solar technology that has the greatest potential for use throughout the world is that of solar photovoltaic cells, which directly produce electricity from sunlight using photovoltaic (PV) (also called solar cells or solar panels). PV cells use the sun's light,



not its heat, to make electricity. PV cells require little maintenance, have no moving parts and essentially no environmental impact. They work cleanly, safely and silently. They can be installed quickly in small modules, in any place where there is sunlight. Solar cells are made up of two separate layers of silicon, each of which contains an electric charge. When light hits the cells, the charges begin to move between the two layers and electricity is produced. PV cells are wired together to form a module. A module of about 40 cells is enough to power a light bulb. For more power, PV modules are wired together into an array. PV arrays can produce enough power to meet the electrical needs of a home. Over the past few years, extensive work has been done in decreasing PV technology costs, increasing efficiency and extending cell lifetimes. Many new materials, such as amorphous silicon, are being tested to reduce costs and automate manufacturing.

PV cells are commonly used today in calculators and watches. They also provide power to satellites, electric lights, small electrical appliances such as radios, for water pumping, highway lighting, weather stations and other electrical systems located away from power lines. Some electric utility companies are building PV systems into their power supply networks.

PV cells are environmentally benign; that is, they do not release pollutants or toxic material into the air or water, there is no radioactive substance and no possible catastrophic accidents. Some PV cells, however, do contain small quantities of toxic substances such as cadmium, and these can be released into the environment in the event of a fire. PV cells are made of silicon which, although the second most abundant element in the earth's crust, has to be mined. Mining creates environmental problems. PV systems, of course, only work when the sun is shining and thus need batteries to store the electricity.

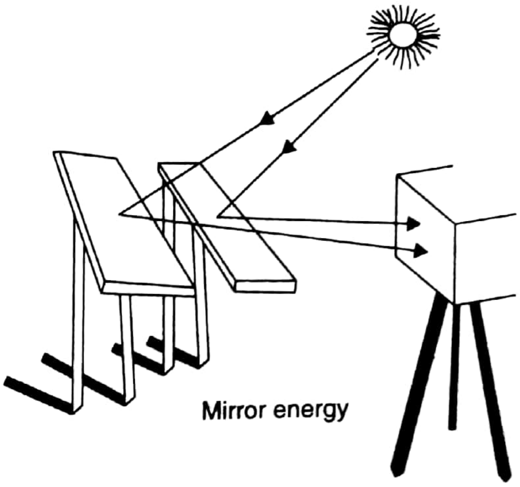
CASE STUDY 7

Solar power

- In 1981, a plane called 'The Solar Challenger' flew from Paris to England in 5 hours, 20 minutes. It had 16,000 solar cells glued to its wings and tail, and they produced enough power to drive a small electric motor and propeller. Since 1987, every three years there is a World Solar Challenge for solar-operated vehicles in Australia, where the vehicles cover 3000 km!
- The world's first solar-powered hospital is in Mali in Africa. Situated at the edge of the Sahara desert, Mali receives a large amount of sunlight. Panels of solar cells supply the power needed to run vital equipment and keep medical supplies cool in refrigerators.
- Space technology requires solar energy and the space race spurred the development of solar cells. Only sunlight can provide power for long periods of time for a space station or long-distance spaceship.
- Japanese farmers are substituting PV-operated insect killers for toxic pesticides.
- In recent years, the popularity of Building Integrated Photovoltaics (BIPVs) has grown considerably. In this application, PV devices are designed as part of the building materials (that is, roofs and siding) both to produce electricity and reduce costs by replacing the costs of normal construction materials. There are more than 3,000 BIPV systems in Germany and Japan has a programme that will build 70,000 BIPV buildings.

Solar thermal electric power (STE): Solar radiation can produce high temperatures, which can generate electricity. Areas with low cloud cover with little scattered radiation, as in the desert, are considered the most suitable sites. According to a UNDP assessment, STE is about 20 years behind the wind energy market exploitation, but is expected to grow rapidly in the near future.

Mirror energy: During the 1980s, a major solar thermal electrical generation unit was built in California, containing 700 parabolic mirrors, each with 24 reflectors, 1.5 m in diameter, which focussed the sun's energy to produce steam to generate electricity.


Mirror energy

Biomass energy: When a log of wood is burned, we are using biomass energy. Because plants and trees depend on sunlight to grow, biomass energy is a form of stored solar energy. Although wood is the largest source of biomass energy, we also use agricultural waste, sugarcane waste and other farm byproducts to make energy.

There are three ways to use biomass. It can be burned to produce heat and electricity, changed to a gas-like fuel such as methane or changed to a liquid fuel. Liquid fuels, also called *biofuels,* include two forms of alcohol—*ethanol* and *methanol.* Because biomass can be changed directly into liquid fuel, it could someday supply much of our transportation fuel needs for cars, trucks, buses, airplanes and trains with diesel fuel replaced by *biodiesel* made from vegetable oils. In the US, this fuel is now being produced from soybean oil. Researchers are also developing algae that produce oils, which can be converted to biodiesel, and new ways have been found to produce ethanol from grasses, trees, bark, sawdust, paper and farming wastes.

Organic municipal solid waste includes paper, food waste and other organic non-fossil fuel-derived materials such as textiles, natural rubber and leather, that are found in the waste of urban areas. Currently, in the US, approximately 31% of organic waste is recovered from municipal solid waste via recycling and composting programmes, 62% is deposited in landfills and 7% is incinerated. Waste material can be converted into electricity by combustion boilers or steam turbines.

Note that like any fuel, biomass creates some pollutants, including carbon dioxide, when burned or converted into energy. In terms of air pollutants, biomass generates less in comparison to fossil fuels. Biomass is naturally low in sulphur and therefore, when burned, generates low sulphur dioxide emissions. However, if burned in the open air, some biomass feedstock would emit relatively high levels of nitrous oxides (given the high nitrogen content of plant material), carbon monoxide, and particulates.

Biogas: Biogas is produced from plant material, animal waste, garbage, waste from households and some types of industrial waste such as fish processing, dairies and sewage treatment plants. It is a mixture of gases which includes methane, carbon dioxide, hydrogen sulphide and water vapour. In this mixture, methane burns easily. From 1 ton of food waste, one can produce 85 cu m of biogas. Once used, the residue is used as an agricultural fertiliser.

Denmark produces a large quantity of biogas from waste and 15,000 mW of electricity from 15 farmers' cooperatives. London has a plant which makes 30 mW of electricity a year from

420,000 t of municipal waste, which supplies power to 50,000 families. In Germany, 25% of landfills for garbage produce power from biogas; Japan uses 85% of its waste in a similar way and France about 50%.

Biogas plants have become increasingly popular in India in the rural sector. The biogas plants use cowdung that is converted into a gas which is used as a fuel. It is also used for running dual fuel engines. The reduction in kitchen smoke by using biogas has reduced lung problems in thousands of homes.

The fibrous waste of the sugar industry is the world's largest potential source of biomass energy. Ethanol produced from sugarcane molasses is a good automobile fuel and is now used in a third of the vehicles in Brazil. The National Project on Biogas Development (NPBD) and Community/Institutional Biogas Plant Programme promote various biogas projects. In 1996, there were already 2.18 million families in India that used biogas. However, China has 20 million households using biogas!

Let's do it!

What you throw out in your garbage today could be used as fuel for someone else. Municipal solid waste has the potential to be a large energy source. Garbage is an inexpensive energy resource. Unlike most other energy resources, someone will collect garbage, deliver it to the power plant and even pay to get rid of it. This helps cover the cost of turning garbage into energy. Garbage is also a unique resource because we all contribute to it.

Keep a record of all the garbage that you and our family produce in a day. What proportion of it is in the form of biomass? Weigh this. How long would it take you to gather enough waste biomass to make a tank-full (0.85 cu m) of biogas? (Remember 1 t of biomass produces 85 cu m of biogas.)

Wind power: Wind was the earliest energy source used for transportation by sailing ships. About 2000 years ago, windmills were developed in China, Afghanistan and Persia to draw water for irrigation and to grind grain. Most of the early work on generating electricity from wind was carried out in Denmark at the end of the last century. Today, Denmark and California have large wind turbine cooperatives, which sell electricity to the government grid. In Tamil Nadu, there are large wind farms producing 850 mW of electricity. At present, India is the third-largest producer of wind energy in the world.

Wind energy

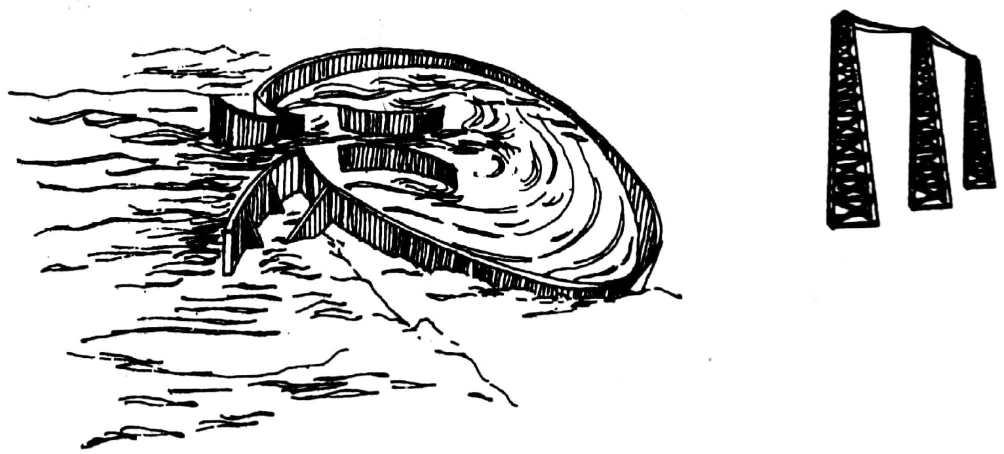
Wind power is a function of the wind speed and therefore, the average wind speed of an area is an important determinant of economically feasible power. Wind speed increases with height. At a given turbine site, the power available 30 m above ground is typically 60% greater than at 10 m. Over the past two decades, a great deal of technical progress has been made in the design, siting, installation, operation and maintenance of power-producing windmills (turbines). These improvements have led to higher wind conversion efficiency and lower electricity production costs.

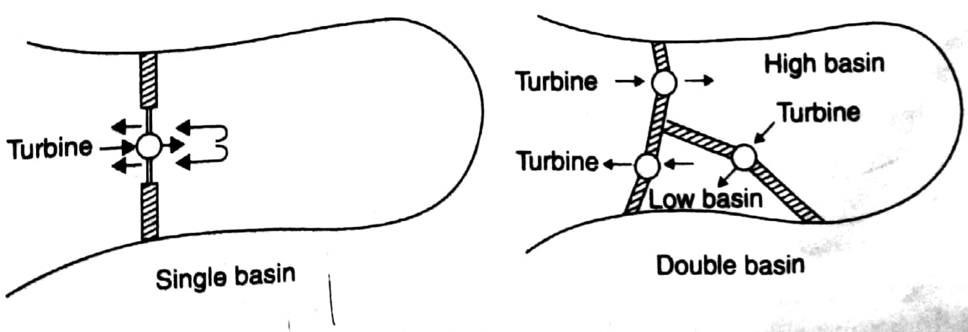
Environmental impact: Wind power has little environmental impact, as there are virtually no air or water emissions, radiation or solid waste production. The principal problems are bird kills, noise, effect on TV reception and aesthetic objections to the sheer number of wind turbines that are required to meet electricity needs. Although large areas of land are required for setting up wind farms, the amount used by the turbine bases, the foundations and the access roads is less than 1% of the total area covered by the wind farm. The rest of the area can also be used for agricultural purposes or for grazing. Siting windmills offshore reduces their demand for land and visual impact.

Wind is an intermittent source and the intermittency of wind depends on the geographic distribution of wind. Wind, therefore, cannot be used as the sole resource for electricity and requires some other backup or standby electricity source.

Tidal and wave power: The energy of waves in the sea that crash on the land of all the continents is estimated at 2–3 million mW of energy. From the 1970s onwards, several countries have been experimenting with technology to harness the kinetic energy of the ocean to generate electricity. Tidal power is tapped by placing a barrage across an estuary and forcing the tidal flow to pass through turbines. In a one-way system, the incoming tide is allowed to fill the basin through a sluice, and the water so collected is used to produce electricity during low tide. In a two-way system, power is generated from both incoming as well as outgoing tides.

Wave power plant



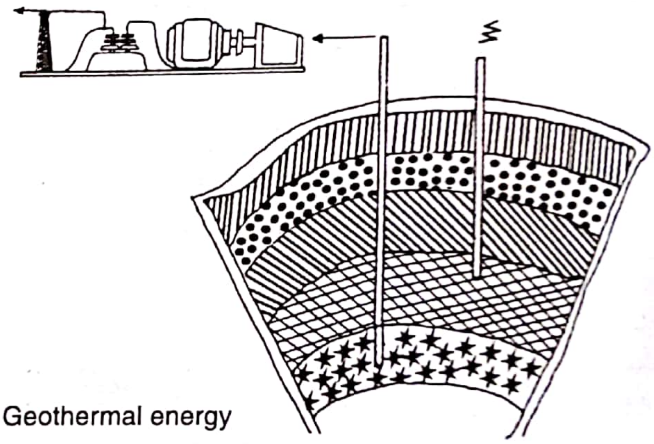


However, tidal power stations bring about major ecological changes in the sensitive ecosystem of coastal regions and can destroy the habitats and nesting places of water birds and interfere with fisheries. A tidal power station at the mouth of a river blocks the flow of polluted water into the sea, thereby creating health and pollution hazards in the estuary. Other drawbacks include offshore energy devices posing navigational hazards. The residual drift current could affect the spawning of some fish, whose larvae would be carried away from the spawning grounds. They may also affect the migratory patterns of surface swimming fish.

Wave power converts the motion of waves into electrical or mechanical energy. For this, an energy extraction device is used to drive turbo-generators. Electricity can be generated at sea and transmitted by cable to land. This energy source has yet to be fully explored. The largest concentration of potential wave energy on earth is located between 40 and 60 degrees latitude in both the northern and southern hemispheres, where the winds blow most strongly.

Another developing concept that harnesses energy due to the differences in temperature between the warm upper layers of the ocean and the cold deep-sea water is called Ocean Thermal Energy Conversion (OTEC). This is a high-tech installation, which may prove to be highly valuable in the future. At present, the Department of Ocean Development (DOD) has one plant in Tiruchendur in Tamil Nadu, producing 1 mW a day.

Geothermal energy: This is the energy stored within the earth ('geo' for earth and 'thermal' for heat). Geothermal energy starts with hot, molten rock (called *magma*) deep inside the earth, which surfaces at some parts of the earth's crust. The heat rising from the magma warms underground pools of water known as *geothermal reservoirs*. If there is an opening, hot underground water comes to the surface and forms hot springs or it may boil to form geysers. With modern technology, wells are drilled deep below the surface of the earth to tap into geothermal reservoirs. This is called 'direct' use of geothermal energy, and it provides a steady stream of hot water that is pumped to the earth's surface.



Geothermal energy

In the 20th century, geothermal energy has been harnessed on a large scale for space-heating, industrial use and electricity production, especially in Iceland, Japan and New Zealand. Geothermal energy is nearly as cheap as hydropower; there are, however, very few good examples of this. Furthermore, water from geothermal reservoirs often contains minerals that are corrosive and polluting. In addition, geothermal fluids contain contaminants which must be treated before disposal.

Nuclear power

In 1938, two German scientists, Otto Hahn and Fritz Strassman, demonstrated nuclear fission. They found they could split the nucleus of a uranium atom by bombarding it with neutrons. As the nucleus split, some mass was converted to energy. The nuclear power industry, however, was born in the late 1950s. The first large-scale nuclear power plant in the world became operational in 1957, in Pennsylvania, USA.

As of 2008, India and the US have an agreement facilitating nuclear cooperation in energy and satellite technology between the two countries. The US's three-decade suspension of nuclear trade with India has been lifted.

Homi Bhabha is considered the father of nuclear power development in India. The Bhabha Atomic Research Centre (BARC) in Mumbai studies and develops modern nuclear technology. India has ten nuclear reactors at five nuclear power stations that produce 2% of India's electricity. These are located in Maharashtra (Tarapur), Rajasthan, Tamil Nadu, Uttar Pradesh and Gujarat. India has uranium from mines in Bihar. There are also thorium deposits in Kerala and Tamil Nadu.

The nuclear reactors use uranium-235 to produce electricity. The energy released from 1 kg of uranium-235 is equivalent to that produced by burning 3,000 t of coal. U-235 is made into rods that are fitted into a nuclear reactor. The control rods absorb neutrons and thus adjust the fission, which releases energy due to the chain reaction in a reactor unit. The heat energy produced in the reaction is used to heat water and produce steam, which drives turbines that produce electricity. The drawback is that the rods need to be changed periodically. This has an adverse impact on the environment due to the disposal of nuclear waste. Additionally, the reaction releases very hot waste water that potentially damages aquatic ecosystems, even though it is cooled by a water system before it is released.

The cost of nuclear power generation must include the high cost of disposal of its waste and the decommissioning of old plants. These have high economic as well as ecological costs that are not taken into account when developing new nuclear installations. For environmental reasons, Sweden has decided to become a nuclear-free country by 2010.

Although the conventional environmental impact from nuclear power is negligible, what overshadows all the other types of energy sources is that an accident can be devastating and the effects last for long periods of time. While it does not pollute air or water routinely like oil or biomass, a single accident can kill thousands of people, make many others seriously ill, and destroy an area for decades by its radioactivity which leads to death, cancer and genetic deformities. Land, water, vegetation are destroyed for long periods of time. The management, storage and disposal of radioactive waste resulting from nuclear power generation are the biggest expenses of the nuclear power industry. There have been horrifying nuclear accidents at Chernobyl in USSR and at the Three-Mile Island in the USA. The radioactivity unleashed by such accidents can affect humans for generations.

Energy conservation

Conventional energy sources affect nature and human society in different ways. India needs to rapidly move towards a policy to reduce energy needs and use cleaner energy production technologies. Here are some approaches towards energy conservation in India:

- A shift to alternative energy use and renewable energy sources that are used judiciously and equitably would bring about environmentally friendly and sustainable lifestyles. This would also reduce India's dependency on imported oil.
- Electricity losses in India during transmission and distribution are significantly high—approximately 30–45%. And this is before we even turn on our bulbs at home! Minimising these losses is critical to effective energy conservation in India.
- Small hydrogeneration units are environment-friendly. They do not displace people, destroy forests or wildlife habitats or kill aquatic and terrestrial biodiversity. They can be placed on several hill-streams, canals or rivers. The generation depends on flowing water due to gravity. However, this fails if the flow is seasonal. An estimated potential of about 15,000 MW of small hydrogeneration projects exist in India. Andhra Pradesh, Arunachal Pradesh and Assam are examples of some states where small hydro projects have been implemented.

- Enhancing fuelwood plantations and managing them through JFM.
- Using energy-efficient cooking stoves or *chulhas* which help the movement of air through them, making the wood burn more efficiently. Additionally, these stoves have a chimney to minimise air pollution and thus reduce respiratory problems.
- Biomass generated from firewood, cattle dung, crop residue such as rice husk, coconut shells or straw can be converted into biogas or liquid fuels; that is, ethanol and methanol. This can provide a low-cost fuel option for heating purposes such as cooking. Alternatively, biogas can be compressed and used to power motor vehicles.
- Unplanned and inefficient public transport systems, especially in cities, also waste a large amount of energy. Providing for bicycle paths during the town planning stage would encourage more people to conserve energy by using bicycles.
- In the agricultural sector, irrigation pumps to lift water are the most energy intensive; these are either electrical or run on fossil fuels. Alternative energy sources such as solar-powered irrigation pumps should be used instead.
- Large-energy consumers include chemical industries, especially petrochemical units, iron and steel, textiles and paper. Efforts must be made by these industries to be more energy efficient.

It is easy to waste energy but cheaper to save it than generate it. We can conserve energy by preventing or reducing energy waste and by using resources more efficiently. People often waste energy because the government subsidises it. If the real cost was levied, people would not be able to afford to waste it carelessly.

(vi) Land Resources

Land as a resource: Landforms like hills, valleys, plains, river basins and wetlands include different resource-generating areas that the people living in them depend on. Many traditional farming societies had ways of preserving areas from which they used resources. For example, in the 'sacred groves' of the Western Ghats, requests to the spirit of the grove for permission to cut a tree or extract a resource were accompanied by simple rituals. The outcome of a chance fall on one side or the other of a stone balanced on a rock gave or withheld permission. The request could not be repeated for a specified period.

If land is utilised carefully, it can be considered a renewable resource. The roots of trees and grasses bind the soil. If forests are depleted or grasslands overgrazed, the land becomes unproductive and wasteland is formed. Intensive irrigation leads to water-logged and salinised soil, on which crops cannot grow. Land is also converted into a non-renewable resource when highly toxic industrial and nuclear waste is dumped on it.

Land on earth is as finite as any other natural resource. While humans have learnt to adapt our lifestyle to various ecosystems, we cannot live comfortably for instance on polar ice caps, under the sea or in space in the foreseeable future. We need land for building homes, cultivating food, maintaining pastures for domestic animals, developing industries to provide goods and supporting the industries by creating towns and cities. Equally importantly, humans need to protect wilderness areas in forests, grasslands, wetlands, mountains and coasts to protect our critically valuable biodiversity.

Thus, the rational use of land demands careful planning. One can develop most of these different types of land uses almost anywhere, but protected areas (national parks and wildlife sanctuaries) can only be situated where some of the natural ecosystems are still undisturbed. These PAs are important aspects of good land use planning.

Land degradation: Farmland is under threat due to more and more intense utilisation. Every year, between 5–7 mha of land worldwide is added to the existing degraded farmland. When soil is used more intensively for farming, it is eroded even more rapidly by wind and rain. Over-irrigating farmland leads to salinisation as the evaporation of water brings the salts to the surface of the soil on which crops cannot grow. Over-irrigation also creates water-logging of the topsoil, so that crop roots are affected and the crop deteriorates. The use of more and more chemical fertilisers poisons the soil and eventually the land becomes unproductive.

As urban centres grow and industrial expansion occurs, the agricultural land and forests shrink. This is a serious loss and will have unfavourable long-term effects on human civilisations.

Soil erosion: The characteristics of natural ecosystems, such as forests and grasslands, depend on the type of soil. Soil of various types supports a wide variety of crops. The misuse of an ecosystem leads to the loss of valuable soil through erosion by the monsoon rains and, to a smaller extent, by wind. The roots of the trees in the forest hold the soil. Deforestation thus leads to rapid soil erosion. Soil is washed away into streams, transported into rivers and finally lost to the sea. The process is more evident in areas where deforestation has led to erosion on steep hill-slopes as in the Himalayas and in the Western Ghats. These areas are called 'ecologically sensitive areas' or ESAs. To prevent the loss of millions of tons of valuable soil every year, it is essential to preserve what remains of our natural forest cover. It is equally important to reforest denuded areas. The link between the existence of forests and the presence of soil is greater than the forest's physical soil binding function alone. The soil is enriched by the leaf-litter of the forest. This detritus is broken down by soil microorganisms, fungi, worms and insects, which help to recycle nutrients in the system. Further loss of our soil wealth will impoverish the country and reduce its capacity to grow enough food in the future.

2.3 Role of an Individual in the Conservation of Natural Resources

Until fairly recently, humans acted as if we could endlessly exploit the earth's ecosystems and natural resources like soil, water, forests and grasslands and extract minerals and fossil fuels. However, in the last few decades, it has become increasingly evident that the global ecosystem has the capacity to sustain only a limited level of utilisation. Biological systems cannot go on replenishing resources if they are overused or misused. At a critical point, increasing pressure destabilises their natural balance. Even biological resources traditionally classified as 'renewable' – such as those from our oceans, forests, grasslands and wetlands – are being degraded by overuse and may be permanently destroyed. And no natural resource is limitless. Non-renewable resources will be rapidly exhausted if we continue to use them as intensively as at present.

The two most damaging factors leading to the current rapid depletion of all forms of natural resources are increasing consumerism on the part of the affluent sections of society and rapid population growth. Both factors are the result of choices *we make as individuals*. As individuals we need to decide;

- What will we leave to our children? (Are we thinking of short-term or long-term gain?)
- Is my material gain someone else's loss?

In general, acquisitiveness has become a way of life for the majority of people in the developed world. Population growth and the resulting shortage of resources most severely affect people in the developing countries. In nations such as ours, which are both developing rapidly and suffering from a population explosion, both factors are responsible for environmental degradation. We must ask ourselves if we have perhaps reached a critical flashpoint, at which economic 'development' affects the lives of people more adversely than the benefits it provides.

Let's do it!

- Turn off lights and fans as soon as you leave the room.
- Use tubelights and energy efficient bulbs such as CFLs and LEDs that save energy rather than incandescent bulbs. A 40 W tubelight gives as much light as a 100 W incandescent bulb, a 25 W CFL gives as much light for the same incandescent bulb, and finally depending on the level of illumination chosen, a 3 W LED is equivalent in output to a 45 W incandescent bulb.
- Keep the bulbs and tubes clean. Dust on tubes and bulbs decreases lighting levels by 20%–30%.
- Switch off the television or radio as soon as the program of interest is over.
- A pressure cooker can save up to 75% of the energy required for cooking. It is also faster.
- Keeping the vessel covered with a lid during cooking helps to cook food faster, thus saving energy.

CASE STUDY 8

Incentive to conserve

Pune's energy model is a unique Public–Private partnership pattern wherein citizens and the industry work together with Government agencies to conserve energy. All consumers whose monthly energy consumption is less than 300 units a month, do not need to pay 'reliability charges' levied to recover the incremental costs of getting extra power at a higher cost. So small and marginal consumers get the benefit of 24 × 7 electricity without paying a premium price. This further promotes energy conservation as consumers have the incentive to bring down their monthly consumption below 300 units, in order to save themselves the extra charge.

2.4 Equitable Use of Resources for Sustainable Lifestyles

Reducing the unsustainable and unequal use of resources and controlling our population growth are essential for the survival of our nation and indeed, of humans everywhere. Our environment provides a variety of goods and services necessary for day-to-day life, but the soil, water, climate and solar energy, which form the abiotic support that we derive from nature, are not distributed evenly throughout the world or within countries. A new economic order at the global and at national levels must be based on the ability to distribute benefits of natural resources by sharing them more equally among the countries as well as among communities within countries such as our own. It is at the local level where people subsist by the sale of locally collected resources, that the disparity is greatest. Development has not reached them and they are often unjustly accused of exploiting natural resources. They must be adequately compensated for the removal of the sources to distant regions and thus develop a greater stake in protecting natural resources.

There are several principles that each of us can adopt to bring about sustainable lifestyles. This primarily comes from caring for the earth in all respects. A love and respect for nature is the greatest sentiment that helps bring about a feeling for looking at how we use natural resources in a new and sensitive way. Think of the beauty of wilderness, a natural forest in all its magnificence, the expanse of a green grassland, the clean water of a lake that supports so much life, the crystal-clear water of a hill-stream, or the magnificent power of the oceans, and we cannot help but support the conservation of nature's wealth. If we respect this, we cannot commit acts that will deplete our life-supporting systems.

Summary

- A renewable resource is a natural resource which, if harvested sustainably, can be regenerated after its use.
- A non-renewable resource is a natural resource that takes millions of years to regenerate and is therefore irreplaceable after consumption.
- Pressures of an increasing population, changes in land use, over-consumption and pollution are some of the major threats to our fast depleting natural resources.
- Conservation and natural resource use efficiency along with an equitable distribution of natural resources is the key to a sustainable lifestyle.

Questions

1. Write about any two natural renewable resources and describe two problems associated with each of them.
2. What is a non-renewable resource? Give two examples of non-renewable resources.
3. Provide three examples of renewable energy sources. Provide two advantages and two disadvantages for each.
4. In terms of resource use, what are some of the steps we can take to lead a more sustainable lifestyle?