

Human Impacts on Environment

2.1 INTRODUCTION

Human beings evolved about 40,000 years ago on the 4.6 billion year old earth. In the initial one thousand years, when human population was small and man was basically a hunter gatherer with limited requirements, his interference with natural cycles and harmony was negligible. However, with development of agricultural activities followed by industrial revolution, there were tremendous changes in the population size of human beings along with rise in quality and standards of living. Due to technological development and rapid economic growth our civilisation has reached its zenith, but at the same time it has led to serious environmental degradation. Development has changed the attitude of human beings towards nature, which has further aggravated the problems.

Let us see how our life style, consumerism, agriculture, food, shelter, economic development and industrialisation have affected our environment including air, water, land, materials, biological diversity and also the human beings and their social security.

While early human societies used to consume much less resources, with the dawn of industrial era, consumerism has shown an exponential rise. It has been related both to the increase in the population size as well as increase in our demands due to change in lifestyle. Earlier we used to live a much simpler life and used to have fewer wants. In the modern society our needs have multiplied and so consumerism of resources has also multiplied.

Our population was less than 1 million for thousands of years ever since we evolved on this earth. Today we have crossed the six billion mark and are likely to reach 11 billion by 2045, as per World Bank estimates.

2.2 MAJOR ASPECTS OF HUMAN ACTIVITIES

Consumerism has increased enormously with growing human population and growing needs in the modern era of development, which has raised our standard of living. Some important aspects associated with human activities are discussed here.

2.2.1 Food

There are thousands of edible plants and animals over the world, of which only about three dozen types constitute the major food of human beings. With increasing population, the demand for crops has increased at a rate that has laid a lot of stress on our land resources. As a result, forests have been cleared to create agricultural lands.

The Food and Agriculture Organization (FAO) of the United Nations estimated that on an average minimum caloric intake on a global scale is 2500 calories/day. People receiving 2000–2200 calories/day are said to be **undernourished**, who suffer from various deficiencies and health problems. People having deficiency of proteins are said to suffering from **malnutrition**.

About 15–20 million deaths occur annually due to malnutrition.

During the last 50 years world grain production has increased almost three times, thereby increasing per capita production by about 50%. But, at the same time population growth increased at such a rate in LDCs (Less developed countries) that it outstripped food production. Every year 40 million people (fifty per cent of which are young children between 1 to 5 years) die of undernourishment and malnutrition. This means that *every year our food problem is killing as many people as were killed by the atomic bomb dropped on Hiroshima during World War II*. These startling statistical figures more than emphasize the need to increase our food production, equitably distribute it and also to control population growth.

2.2.2 Shelter

With increasing population, there is also increasing pressure on finite land resources for housing. Shelter for humans or habitat development on this earth has largely taken place within about 5% of land area, which supports more than half of global population.

Both overcrowded unplanned urban settlements and unhygienic, underdeveloped rural settlements pose big challenges for the present and future generations.

Fast depletion of natural resources, shrinking land, rising pollution levels and associated health problems have forced us to re-look at the structure and design of buildings by introducing environmental approach to buildings. There is an urgent need to apply the principles of sustainability to **'built environment'**. An integrated approach is thus required with inputs from various fields including architecture, engineering, science, technology, ecology and economics. Built environment should not just be viewed as structures created for providing shelter for humans, rather these are to be viewed as dynamic interplay of spaces with judicious use for multiple purposes, which provide physical comfort and psychological satisfaction to the inhabitants, along with balanced ecological elements.

2.2.3 Economic Growth

Economic growth is required for raising the quality of life of human beings. Technological advancement leading to rapid industrialization and urbanisation have raised the standard of living in modern era, but have also led to depletion of natural resources, energy crisis and pollution of the air, water and soil. Economic growth over the world has been such that it has led to wide disparity between the developed and developing nations. The U.S.A. with just 4.7% of global population consumes 25% of the total

energy and produces 25% of total pollutants/wastes and 22% of total chlorofluorocarbons (CFC's), responsible mainly for ozone depletion.

The developing nations, still struggling with their population of teeming billions and poverty are not even able to provide basic amenities like food, safe drinking water, hygienic shelter and a livable life to millions of its people.

2.2.4 Social Security

The ultimate goal of development is to improve the quality of life, so that all humans throughout the world enjoy long, healthy, purposeful and fulfilling lives. But unfortunately the developed nations, with just 20% of global population control about 80% of global economy. At present, about 1.4 billion people (*i.e.*, about 1/4th global population) live on less than \$ 1 per day. About 12% of the global population living in poor countries is suffering from undernutrition or malnutrition. Such poor people suffer from acute social insecurity because life for them is an endless struggle for survival, centred around fulfilment of basic amenities of life like drinking water, fire-wood and food. While economic development is on its zenith in developed nations, it is an irony that even now 35,000 babies die every day due to unavailability of adequate food, safe drinking water and medical facilities. It is very important to improve the quality of life in poor nations and ensure adequate food, nutrition, hygienic dwelling and education, particularly for the disadvantaged women.

Intra-generational equity has emerged as a new concept in sustainable development to ensure equitable share of resources for economic growth of the poor and their social security.

2.3 EFFECTS OF HUMAN ACTIVITIES ON ENVIRONMENT

For about 75 per cent duration of their existence on this earth, human beings have acted as hunter-gatherers. It was about 10,000 to 12,000 years ago, when a cultural shift known as 'Agricultural revolution' took place in several regions of the world, which changed the life style of humans from wandering nomadic life to a settled life. People started domesticating animals and cultivating the plant species that were useful. Gradually, population increased and so did the demands for more food production. There was a need to increase the cropped land area and increase crop yield by using technological advancements. In order to feed the livestock there was increasing demand for more grazing land. Intensive agricultural practices and overgrazing led to several offshoots that influenced our environment. In the present section we would discuss about these impacts.

Rapid development activities have been associated with more and more exploitation of various natural resources. Technological development has resulted in fast depletion of non-renewable energy resources, mainly coal and petroleum, and also various minerals. Mining activities, dam, building, urbanisation and industrialisation have all interfered with the ecological balance of nature due to large scale impacts.

2.3.1 Impacts of Agriculture

In primitive times human beings used the practice of **slash and burn cultivation or shifting cultivation**. This practice in which a forest land was cleared by burning, used for cultivation of a crop for a few

years, and as the productivity declined the land was abandoned and a fresh piece of forest land was cleared for cropping is still prevalent in many tribal areas, as in the North East Hills of India. The type of agriculture practised these days is very different from the traditional ones and their outputs in terms of yield as well as their impacts on the environment show lots of differences, as shown in Fig. 2.1.

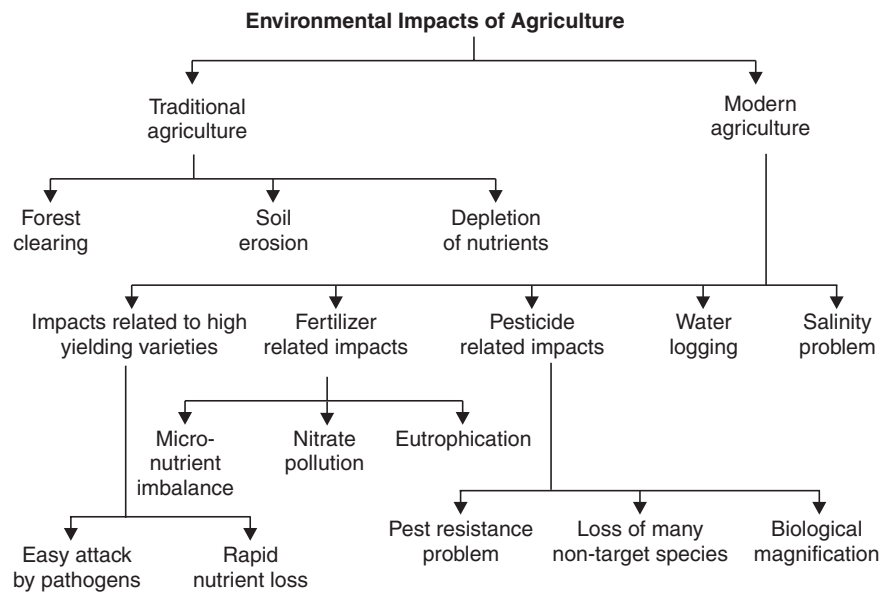


Fig. 2.1. Chain of side effects on environment due to intensive practices for increased food production

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

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

- (i) **Deforestation:** The slash and burn of trees in forests to clear the land for cultivation and frequent shifting result in loss of forest cover.
- (ii) **Soil erosion:** Clearing of forest cover exposes the soil to wind, rain and storms, thereby resulting in loss of top fertile layer of soil.
- (iii) **Depletion of nutrients:** During slash and burn the organic matter in the soil gets destroyed and most of the nutrients are taken up by the crops within a short period, thus making the soil nutrient poor which forces the cultivators shift to another area.

B. Modern Agriculture and its Impacts: It makes use of hybrid seeds of selected and single crop variety, high-tech equipments and lots of energy subsidies in the form of fertilizers, pesticides and irrigation water. The food production has increased tremendously, evidenced by “green revolution”. However, it has also given rise to several problematic off-shoots as discussed below:

1. **Impacts Related to High Yielding Varieties (HYVs):** The uses of HYVs encourage monoculture *i.e.*, the same genotype (variety) is grown over vast areas. In case of an attack by some pathogen, there is total devastation of the crop by the disease due to exactly uniform conditions, which help in rapid spread of the disease.

2. Fertilizer related problems:

- (a) **Micronutrient imbalance:** Most of the chemical fertilizers used in modern agriculture have nitrogen, phosphorus and potassium (N, P, K) which are essential macronutrients. Farmers usually use these fertilizers indiscriminately to boost up crop growth. Excessive use of fertilizers cause *micronutrient imbalance*. For example, excessive fertilizer use in Punjab and Haryana has caused deficiency of the micronutrient zinc in the soils, which is affecting productivity of the soil.
- (b) **Nitrate pollution:** Nitrogenous fertilizers applied in the fields often leach deep into the soil and ultimately contaminate the ground water. The nitrates get concentrated in the water and when their concentration exceeds 25 mg/L, they become the cause of a serious health hazard called “**Blue Baby Syndrome**” or methaemoglobinemia. This disease affects the infants to the maximum extent causing even death. In Denmark, England, France, Germany and Netherlands this problem has been faced frequently. In India also, problem of nitrate pollution exists in many areas.
- (c) **Eutrophication:** Excessive use of N and P fertilizers in the agricultural fields leads to another problem, which is not related to the soil, but relates to water bodies like lakes. A large proportion of nitrogen and phosphorus used in crop fields is washed off and along with runoff water reach the water bodies causing over nourishment of the lakes, a process known as **Eutrophication** (eu = more, trophic = nutrition).

Due to eutrophication the lakes get invaded by algal blooms. These algal species grow very fast by rapidly using up the nutrients. They are often toxic and badly affect the food chain. The algal species quickly complete their life cycle and die, thereby adding a lot of dead organic matter. The fishes are also killed and there is a lot of dead matter that starts getting decomposed. Oxygen is consumed in the process of decomposition and very soon the water gets depleted of dissolved oxygen. This further affects aquatic fauna and ultimately anaerobic conditions are created where only anaerobic bacteria can survive many of which are known to be pathogenic. Thus, due to excessive use of fertilizers in the agricultural fields the lake ecosystem gets degraded. This shows how an unmindful action can have far reaching consequences.

3. **Pesticide related problems:** Thousands of types of pesticides are used in agriculture. The first generation pesticides include chemicals like sulphur, arsenic, lead or mercury to kill the pests. DDT (Dichlorodiphenyl trichloroethane) whose insecticidal properties were discovered by Paul Mueller in 1939 belongs to the second generation pesticides. After 1940, a large number of synthetic pesticides came into use. Although these pesticides have gone a long way in protecting our crops from huge losses occurring due to pests, yet they have a number of side-effects, as discussed below:

- (a) **Creating resistance in pests and producing new pests:** Some individuals of the pest species usually survive even after pesticide spray. The survivors give rise to highly resistant generations. About 20 species of pests are now known which have become immune to all types of pesticides and are known as “**Super pests**”.

- (b) **Death of non-target organisms:** Many insecticides are broad spectrum poisons which not only kill the target species but also several non-target species that are useful to us.
- (c) **Biological magnification:** Many of the pesticides are non-biodegradable and keep on accumulating in the food chain, a process called biological magnification. Since human beings occupy a high trophic level in the food chain, they get the pesticides in a bio-magnified form which is very harmful.
4. **Waterlogging:** Over irrigation of croplands by farmers for good growth of their crop usually leads to waterlogging. Inadequate drainage causes excess water to accumulate underground and gradually forms a continuous column with the water table. Under water-logged conditions, pore-spaces in the soil get fully drenched with water and the soil-air gets depleted. The water table rises while the roots of plants do not get adequate air for respiration. Mechanical strength of the soil declines, the crop plants get lodged and crop yield falls.

In Punjab, extensive areas have become water-logged where adequate canal water supply or tube-well water encouraged the farmers to use it over-enthusiastically leading to waterlogging problem.

Preventing excessive irrigation, sub-surface drainage technology and bio-drainage with trees like *Eucalyptus* are some of the remedial measures to prevent waterlogging.

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

A major cause of salinization of soil is excessive irrigation with poor quality (saline) water. About 20% of the world's croplands receive irrigation with canal water or ground water which unlike rainwater often contains dissolved salts. Under dry climates, the water evaporates leaving behind salts in the upper soil profile (Fig. 2.2).

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

The most common method for getting rid of salts is to flush them out by applying more good quality water to such soils. Another method is laying underground network of perforated drainage pipes for flushing out the salts slowly known as subsurface drainage.

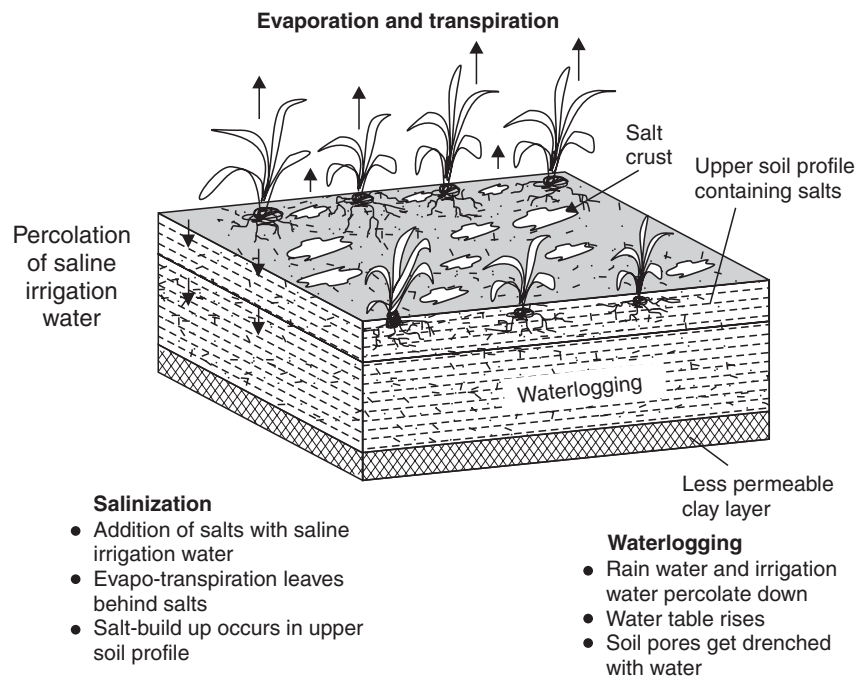


Fig. 2.2. Salinization and waterlogging.

2.3.2 Effect of Housing

With increasing population growth, there has been a global shift of population from rural to urban centres. According to population Reference Bureau, 48% of the world population lives in urban areas now. Generally, towns with populations of 2000 or more are considered urban. Urban population is much higher (75%) in developed nations and about 38% of total population of developing nations lives in urban areas. Housing and infrastructure facilities is a major challenge in urban areas, where space is limited. Provision of water, sewage system, educational and medical facilities, transportations and housing to the influx of people from rural to urban areas is a big task.

Production and usage of practically all types of building materials during construction and demolition have some impact on the environment in one way or the other. Extraction and processing of building material is associated with energy consumption and waste generation, which vary depending upon the type of the building. Local materials used for building have less environmental implications in terms of energy use and waste production. The quality of building material chosen for construction needs to be assessed from the point of view of environmental impacts. Production and use of building materials have the following environmental impacts:

- (i) Energy consumption and related impacts.
- (ii) Physical degradation of environment and loss of top fertile soil.
- (iii) Depletion of natural resources and biodiversity due to deforestation.

- (iv) Gaseous emissions causing global warming and acid rains.
- (v) Toxic emissions and health effects.
- (vi) Occupational health hazards.

The major environmental implications of housing/building are discussed here.

- (i) **Energy consumption during building and construction:** Energy consumption is an important aspect of construction. Energy is required for extraction of minerals such as iron ores, bauxite etc. Energy is also required for transportation, processing, fabrication and installation during construction, refurbishment and demolition of buildings.

The most important measure of environmental impact of a building material is ‘**embodied energy**’ or ‘**capital energy**’. **Embodied energy is defined as the amount of energy used to produce a unit weight of the material.**

Based upon the impacts, environmental profiles of various types of building materials are now available. In relative environmental performance rating system, simple grades like A, B, C... etc., are assigned based on their associated variety of environmental impacts like mineral and water extraction, fossil fuel depletion, emissions of pollutants, toxicity, role in climate change etc.

The embodied energy of a material increases with increase in the number of processes it undergoes. The associated waste production also increases accordingly. For this reason, the choice of such eco-friendly materials is necessary which are as close to nature as possible and also nearer to the construction site; so that energy consumption for transportation, processing and transforming is minimal. The cost and eco-friendliness could also be improved by using recycled material. For instance, embodied energy of an aluminium-framed window will be different if made from the recycled metal or from its ore. The type of the material used is also equally important. Embodied energy of an aluminium-framed window would be definitely higher than that of a timber-framed window, as the latter involves less processing and is natural. Also, the latter would be more eco-friendly as it does not give CO₂ emissions for processing.

Transportation of the building material from production to sale, and from market to construction site adds to the embodied energy of the material. Emissions arising from the use of fuels in vehicles add to global warming and various noxious gases emitted lead to serious health problems. Another important factor for consideration of eco-friendly material is the maintenance requirement and life-span of the building.

Building materials that contribute to embodied energy are cement, concrete, bricks, steel, aluminium, timber, glass, plaster etc., which are generally used in all types of buildings. Metals and plastics have very high embodied energy. Their use in small quantities like that in joints or fixtures may, however, be useful. Thus, selection of a proper building material must be given due consideration. The embodied energy of plastics is very high as these are derived from petroleum involving energy intensive processing.

- (ii) **Resource depletion and loss of biodiversity:** Timber, is an eco-friendly building material. But, indiscriminate cutting of forests for timber production has far reaching environmental consequences. It is therefore necessary that timber production should be based on a sustainable strategy of forest management. Timber production based on ‘*selective cutting practice*’,

ensuring replacement of cut trees by fresh plantations, can take care of forest sustainability. There should also be a scheme to certify that the wood being used for building has been obtained from a sustainable forest.

An important point worth mentioning here is that if timber is produced by cutting down rainforests, it would not be possible to substitute the cut trees by similar species. The tropical rainforests have evolved over a period of millions of years with complex biodiversity, which has intricate mechanism of ecosystem stability and regulation. Loss of biodiversity or replacement of a complex heterogeneous rainforest by some simple fast growing tree species will cause irreparable damage to the ecosystem and the environment. While selecting an eco-friendly building material, like timber from a rainforest, such important issues must be considered.

Even when timber is otherwise obtained from a far-off place, its eco-friendliness diminishes because of the energy used in transportation, thereby enhancing its embodied energy. Many a times timber is treated with chemicals to prevent its rotting and decay. Use of such a timber as a building material will reduce its eco-friendliness due to toxic nature of the chemicals used in the treatment. Use of synthetic organic paints are environmentally more harmful. These can be substituted by water-based natural pigments, stains or waxes. Thermal insulators (like recycled paper, wool or cork), earth wall, straw bale construction should be preferred if space permits and rough finishes are not inhibitive. Glazed coatings too save energy.

(iii) **Pollution aspects of building:** Several building materials continue to affect the indoor air quality. These materials used as solvents, finishes and cleansers for maintenance and protection of building materials can cause 'sick building syndrome'.

Production of plastics is also associated with generation of the greenhouse gas namely, carbon dioxide (CO_2), volatile organic compounds (VOCs) and polyvinyl chloride (PVC), which are harmful because of global warming potential of CO_2 and health related problems of the latter two. Disposal of PVCs is a major problem. However, plastics have a positive aspect that these are derived from wastes of petroleum production.

Manufacturing of metals from their ores has several environmental impacts. In the recycling of metals harmful chemicals dioxins are produced, which are carcinogenic (cancer causing) in nature.

Some insulating materials are made from non-renewable petroleum resources, while some use chlorofluorocarbons (CFCs). During demolition, their safe recovery is difficult. Release of CFCs in the atmosphere would enhance the global warming problem. Asbestos, which has been quite in use in buildings is now known to be very harmful for our health and not recommended now. Even during demolition of existing buildings, recovery of asbestos should be carried out very carefully.

2.3.3 Environmental Impacts of Mining

The fact that reserves of mineral resources in our earth's crust or in the ocean are limited is not so significant as compared to the environmental concern arising from the impacts of extraction and processing of these minerals during mining and smelting.

Mining is done to extract minerals (or fossil fuels) from deep deposits in soil by using **sub-surface mining** or from shallow deposits by **surface mining**. The former method is more destructive, dangerous and expensive including risks of occupational hazards and accidents.

Surface mining can make use of any of the following three types:

- (a) *Open-pit mining* in which machines dig holes and remove the ores (e.g., copper, iron, gravel, limestone, sandstone, marble, granite).
- (b) *Dredging* in which chained buckets and draglines are used which scrap up the minerals from under-water mineral deposits.
- (c) *Strip mining* in which the ore is stripped off by using bulldozers, power shovels and stripping wheels (e.g., phosphate rocks).

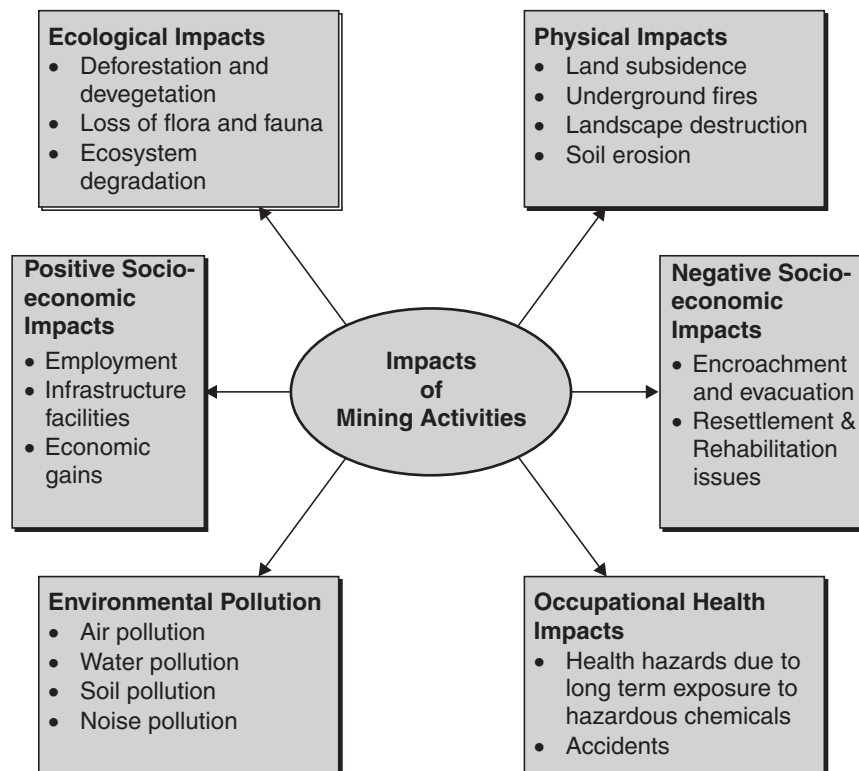


Fig. 2.3. Impacts of mining activities.

The environmental damage caused by mining activities depicted in Fig. 2.3 are discussed below:

- (i) **Devegetation and defacing of landscape:** The topsoil as well as the vegetation are removed from the mining area to get access to the deposit. While large scale deforestation or devegetation leads to several ecological losses, the landscape also gets badly affected. Huge quantities of debris and tailings along with big scars and disruptions spoil the aesthetic value of the region and make it prone to soil erosion.
- (ii) **Subsidence of land:** This is mainly associated with underground mining. Subsidence of mining areas often results in tilting of buildings, cracks in houses, buckling of roads, bending of rail tracks and leaking of gas from cracked pipe-lines leading to serious disasters.

- (iii) **Groundwater contamination:** Mining disturbs the natural hydrological processes and also pollutes the groundwater. Sulphur, usually present as an impurity in many ores is known to get converted into sulphuric acid through microbial action, thereby making the water acidic. Some heavy metals also get leached into the groundwater and contaminate it posing health hazards.
- (iv) **Surface water pollution:** The acid mine drainage often contaminates the nearby streams and lakes. The acidic water is detrimental to many forms of aquatic life. Sometimes radioactive substances like uranium also contaminate the water bodies through uranium mine wastes and kill aquatic animals. Heavy metal pollution of water bodies near the mining areas is a common feature causing health hazards.
- (v) **Air pollution:** In order to separate and purify the metal from other impurities in the ore, smelting is done which emits enormous quantities of air pollutants damaging the vegetation nearby and has serious environmental health impacts. The suspended particulate matter (SPM), SO_x, soot, arsenic particles, cadmium, lead etc. shoot up in the atmosphere near the smelters and the public suffers from several health problems.
- (vi) **Occupational health hazards:** Most of the miners suffer from various respiratory and skin diseases due to constant exposure to the suspended particulate matter and toxic substances. Miners working in different types of mines suffer from asbestosis, silicosis, black lung disease etc.

Statistical data show that, on an average, there are 30 non-fatal but disabling accidents per ton of mineral produced and one death per 2.5 tons of mineral produced.

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

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

2.3.4 Effects of Industrialization

The most serious impact of industrialization is environmental pollution that has affected our land, water and air. Major rivers of the world have suffered colossal losses due to water pollution. Many important rivers have been converted into open sewers. Even the groundwater is getting polluted due to illegal drilling of industrial waste water. Toxic gases and particulate matter from industrial emissions and vehicular exhaust have polluted the atmosphere. Release of greenhouse gases into the atmosphere has caused enhanced global warming. Release of CFC's has been responsible for depletion of protective ozone layer in the stratosphere, which makes our earth more prone to exposure of the harmful UV radiations.

Release of oxides of nitrogen and sulphur from power plants and industries is responsible for causing acid rain in many regions of the world. Contamination of the land with toxic heavy metals is

rendering it unproductive. Movement of heavy metals and pesticides through food chain has become a major cause of alarm for human health as well. All pollution aspects are being discussed separately in Chapter 6.

Human behaviour and the technological advances have not only caused regional (localized) impacts as discussed in the preceding section but have also resulted in global environmental disturbances. Technological advancement coupled with improved life style has resulted in production and emission of undesirable substances into the environment which are causing global environmental problems such as acid rain, ozone layer depletion, global warming and climate change.

2.3.5 Effects of Transportation

Movement of materials and human beings are being carried out in several ways using land, water as well as air as the medium of transport. In 1800, the steam engines fitted on to self-propelled vehicles were a major way of transport for both land and water. As 1900s progressed, rail transport gradually gave way to a large extent to airplanes, automobiles, buses and trucks.

In the modern era, private transport, commuting and relatively short distance travel is mainly by automobiles. The widespread use of automobiles has affected our environment in a substantial manner. Some of the major, environmental effects of transport on environment are as follows:

- (i) Conversion of vast areas of agricultural land and wild-life habitats have been converted into sub-urban housing, as greater mobility has been made possible with increased automobile use.
- (ii) Land is being used for building highways and there is loss of fertile top soil during construction of highways.
- (iii) Landslide occurrence has increased as construction of roads clears large forested areas in the fragile mountainous areas.
- (iv) Automobiles lead to air pollution due to vehicular emissions like carbon monoxide, lead (in case of leaded petrol), and volatile organic compounds.
- (v) Noise pollution is a major problem arising due to transport activities.
- (vi) Many aircrafts are releasing oxides of nitrogen that are greenhouse gases, responsible for climate change.
- (vii) Widespread use of private automobiles has enormously increased the consumption of petrol, which has limited reserves.

I. QUESTIONS

1. Discuss how human activities related to food and shelter have affected our environment.
2. What are the major impacts of economic growth on environment?
3. What are different types of mining and how do mining activities influence our environment?
4. Discuss environmental impacts of transportation.