UNIT 12 LAND DEGRADATION

Structure

12.1 INTRODUCTION

In the previous units of this block you have studied about air pollution and water pollution. In this unit, we will study factors responsible for the degradation of land.

Soil erosion and land degradation together constitute the most extensive ecological hazard to the world in general and India in particular. It has aptly been observed that silt and salt are the two reasons for the fall of many prosperous civilisations that be traced over the six thousand year long history of mankind. This is because land is a pre-requisite not only to all primary production systems but also for meeting every social priority and for pursuing necessary as well as desirable economic activities.

In this unit, we will discuss causes of land degradation both natural and those resulting from human activities. We will also discuss the effects of land degradation in terms of surface runoff and floods, loss of nutrients and land productivity. Finally, some measures have been suggested to stem soil erosion and land degradation.

Objectives

After reading this unit, you should be able to:

- define soil erosion and land degradation
- describe the causes of land degradation and its extent giving specific case studies
- describe the effects of land degradation
- outline remedial measures for stemming land degradation.

12.2 SOIL DEGRADATION

Soil is a complex entity and is represented by the land surface and the operative soil profile depth. It functions physically, chemically as well as biologically. Therefore, its health and also its utility for various land uses has to be judged from these three angles. The extensive limitation of Indian soils is their low inherent fertility level through exhaustion over centuries. In addition, there has been a steady depletion of supporting vegetation for regeneration of the soil fertility through organic recycling and transportation of nutrients from lower reaches to productive top layers. Due to acute shortage of fuel and fodder, even agricultural crop residues are not

incorporated into the soil. Cowdung is used mostly as fuel, while forest humus is simply not there, with deforestation going unabated. Another limitation is extensive water stress, due to extended dry season and drought. This is because supply of water is limited in time, whereas demand for various purposes is stretched throughout the year. Though India, is fortunate in terms of average annual rainfall, larger parts of India receive low to very low rainfall. In places receiving heavy or medium rainfall, much of it flows out and causes problems of flood elsewhere. Since water becomes available to users like men, animals, and plants only after it has routed through land surface and soil profile. Land and water cycle have a close relationship. This relationship becomes all the more important because surface runoff and floods are some of the main causes of nutrient depletion and loss of productivity. Now, we will study about soil erosion which is one of the phenomena that causes degradation of the soil.

12.2.1 Soil Erosion

Soil erosion refers to all physical processes that loosen or tear-off soil particles and displace the detached particles from the parent sites. Much of the erosion is due to instability of land mass vis-a-vis gravity and the balance is directly lost due to excessive moisture or water in the earth mass. Many times this is referred to as gravity erosion, such as, fall, slide or flow. Land slides, torrents or river erosion entail mass movement of fractured rock, other unconsolidated materials and of coarse soil and therefore, is also referred to as mass wasting. The process, as such, is a physical one, and can be understood by analysing the resistance of soil in the form of cohesion and friction against the causative forces of rain drop impact and flow of the eroding agents. The spread of problem areas in different parts of the country can be seen in Figure 12.1.

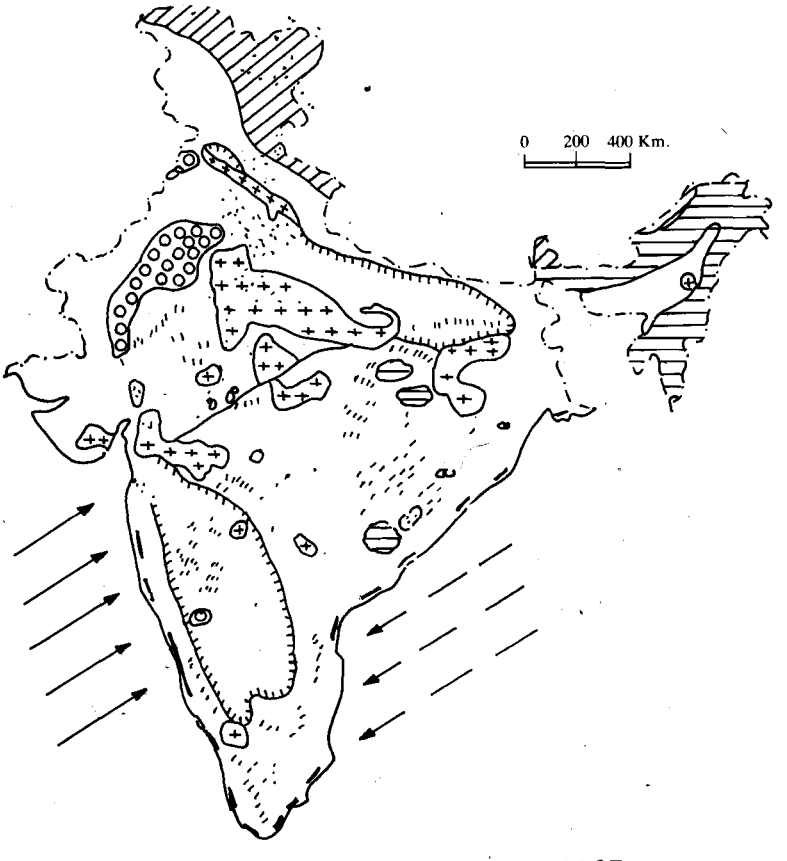


Fig. 12.1 : Soil Erosion Map of India

(This map does not represent political boundries)

Soil erosion is caused by natural processes as well as by human activities. The natural processes can be divided into: I) Geological Erosion, and II) Accelerated Erosion.

I) **Geological Erosion :** Geological soil erosion is a natural process that tends to bring the earth's surface to a uniform level. The first phase of this process is weathering which is essentially physico-chemical in nature. This leads to simplification of substances through disintegration and is aided by certain biological influences causing further disintegration. The process leads to the development of complex soil bodies with definite physical, chemical and biological properties. Therefore, as a part of geological process, erosion takes place through various weathering processes. You will read more about geological erosion in Section 12.3.1.

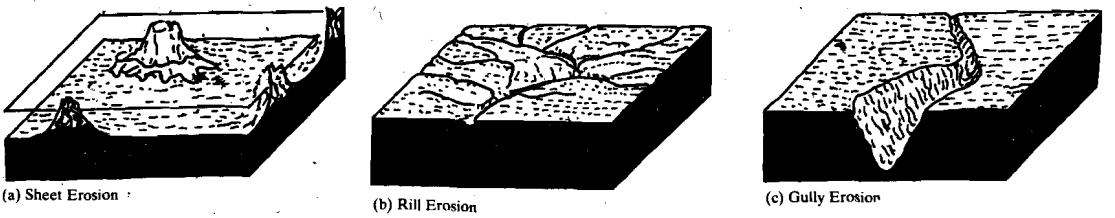
II) **Accelerated Erosion :** Under cultivation, the land experiences a lot of pressure from outside and consequently the balance between vegetation cover and climate is disturbed. Thus, removal of surface soil by natural agencies takes place at a faster rate than it can be built up by soil forming process. Erosion occurring under these conditions is referred to as accelerated erosion. Its rate and magnitude are higher than those in normal geological erosion.

Depending upon the agency causing it, erosion is classified as follows:

Water Erosion : Water is an important force causing transport of soil. Erosion of soil by water can take place by means of rain drops, waves or ice. The erosion of soil by rain water including melted snow is raindrop erosion. Raindrops falling on the land surface cause detachment of soil particles which are subsequently transported away with the flowing water. A thin film of soil layer is detached and transported by the rain water flowing on the land surface. This type of erosion is known as wash-off or sheet erosion (Fig. 12.2a). Sheet erosion may not be evident significantly, but lands subjected to sheet erosion loose a thin layer of top fertile soil every year. The second stage of sheet erosion in which finger like rills appear on the landscape is known as **rill erosion**. (Fig. 12.2b). These rills are usually smoothened out every year by normal farm operations. But each year rills slowly increase in their number as well as in their shape and size. They become wider and deeper and affect crop production adversely.

Ravines annually ravage 3,000 ha throughout the country where approximately 0.5% of the ravine catchment area is being eroded. The ravines are mostly found along rivers such as Yamuna, Chambal, Sabarmati, Mahi, Gomati.

Gully erosion is an advanced stage of rill erosion. (Fig. 12.2c). Rills when neglected develop in size and become gullies. Gullies could also be caused by runoff concentrating at a point on the agricultural land. Gullies when not controlled expand year after year. **Ravines** are a form of gullies. The erosion of the stream banks by flowing water is known as **stream bank erosion.** In certain areas where the rivers or streams change course stream banks are eroded at an accelerated pace. Stream bank erosion damages adjoining agricultural lands, highways, railroads and bridges.



(a) Sheet Erosion (b) Rill Erosion (c) Gully Erosion

Fig. 12.2 : Types of Soil Erosion

Coastal Erosion is caused on the sea-shore due to wave action and the advance of the sea at some places. Coastal erosion is more difficult to control than other forms of water erosion.

Wind Erosion : Soil erosion by winds is very common in areas where vegetation is not enough to cover and protect the soil. Such conditions are found in arid lands and along the sand shores of oceans, lakes and rivers. The fine loose soil particles are blown from the surface of the land and transported by the winds. Soil transported in a series of short bounces is termed as **siltation.** The tiny soil particles are carried to long distances in the form of suspension. Such a movement of soil is termed as **suspension movement.** Heavier soil particles are transported at the ground level as a result of high velocity of wind, this is defined as **surface creep.**

The sand is constantly blown away from one place to another. Agricultural fields, orchards, etc., whatever comes in the way, is covered with sand and becomes unproductive in the course of time. Plants get buried in the sand and are destroyed forever. As sand moves forward deserts expand in size.

SAQ 1

Fill in the blanks using appropriate words:

a) ..... refers to all physical processes that loosen or tear-off soil particles and displace the detached particles from the parent sites.

b) Three stages of soil erosion by rain water are i)..... erosion, ii)..... erosion, and iii)..... erosion.

c) Coastal erosion on the sea coast is caused by..... action and advance of sea.

d) Siltation, suspension movement and surface creep are the phenomena of..... erosion.

12.3 CAUSES OF LAND DEGRADATION

Degradation of the soil is caused by natural processes as well as by human activities. Now let us briefly study about both of these.

12.3.1 Natural

Soil is a complex body and forms the thin outer layer of the earth. It is directly or indirectly developed from the mineral constituents of the rocks. The first phase of this process is weathering which is essentially physico-chemical in nature. Weathering leads to simplification of complex substances forming rocks through disintegration. The second phase is soil formation through the process of consolidation. This is bio-geo-chemical in nature. The process encompasses certain biological influences which result in the synthesis of many substances leading to the development of complex soil bodies with definite physical, chemical and biological properties. This natural process of weathering is slow and is a part of the evolutionary cycle.

The intensity of this natural erosion process can be realised from the rate of denudation or the rate of lowering of land surface. Denudation rates vary widely in India, particularly in the Himalayan belt. For Sutlej basin it is 0.21 mm per year, while it is 20 mm per year in Darjeeling. But the general estimate for the earth, as a whole, is between 0.1 to 1.0 mm per year. Much of the natural erosion is neutralised by the uplift or rise of land surface. The estimated range is from 1 mm per year to 9 mm per year. However, analysis of available information on soil losses, sedimentation rates and other related data from India, leads to the conclusion that estimated uplift rate is lower than 5 mm per year.

The estimated geological erosion rate in the present times has been at 100 cm/1000 years, which is about five times that of the past forty million years. There seem to be no evidence of any unusual geological upheaval in extensive areas in the recent past. Whereas, there has been phenomenal increase in population and attendant activities in the last two or three centuries, which points to the role of man's intervention in aggravating land degradation.

12.3.2 Human Activities

Among all the life forms that have lived and are living on this earth, human beings have caused serious transformation of natural resource base to subserve various requirements of human society. The interventions are manifold. Often these are intended to obtain maximum from the mother earth, and in the process, have wrought severe disturbances to the balance in the bio-geo-physical systems. These have reduced the earth's capacity to absorb adverse effects and have impaired its regenerative ability to restore the losses suffered through exploitation. On the other hand, there have been deliberate destructive actions, such as those during the world wide wars which have caused serious damages to the natural defences of this planet. More important interventions are as follows:

a) Deforestation
b) Farming

c) Economic activities : Mining, etc.
d) Developmental works : Settlements, Transport and Communication

We will briefly describe the effects of these on land quality.

a) **Deforestation**

Physically the process of deforestation includes repeated lopping, felling, removal of forest litter, browsing and trampling of livestock, fire, etc. Examination of the annual rate of deforestation between 1976 to 1985 reveals that in India annually 0.174Mha of forests are being deforestated. As you know from Section 8.3.1, between 1951 and 1972, an area of 3.4Mha of forests has been lost for different purposes.

A number of studies in India and Nepal have established that the increased demand for food, livestock and firewood is the direct cause of deforestation. These well intended efforts to increase food production are often unsuccessful and usually result in great environmental damage. The consequences of deforestation in terms of soil erosion, land degradation, nutrient loss, and the disruption of the delicate equilibrium among soil, plants and atmosphere can be seen in the vast tracts of barren and unproductive land where lush green forest once grew.

Another important reason for forest conversion is to meet the fuel wood demand. The rural population in the tropics depends almost exclusively on fuel wood as their primary sources of energy. It is estimated that the per cent energy requirements met by fuel wood in rural areas is 90% in Kenya, 88% in Zambia, and 95% each in Nepal, Sri Lanka, and Thailand. The estimated fuel wood consumption ranges from 0.8 to 2.0 m^3/capita/year, with an average consumption of 1.5 m^3/capita/year. Deforestation will continue unabated unless alternative, equally reliable, and economic sources of fuel are made available to the rural population.

You have read in Unit 8 that the recent studies carried out by the Indian Institute of Sciences, Bangalore, North East Hill University, Shillong, Centre for Environmental Studies, New Delhi, and others revealed that the increasing rate of deforestation cannot be attributed to the community residing within and around forests and those who depend very significantly on forest produce for their sustenance. In fact, analysis of the traditional flow of forest produce indicates that these people use minor forest produce without damaging the forest cover. On the other hand, with the advent of centralised management of forest resources, much of the community forests were lost to the community and it had to look for alternatives. This may have accelerated exploitation by the community from limited areas accessible to them. In fact, much of the extensive deforestation is now going on, more to meet off-site resource flow or demands than the unavoidable pressure from the local community to meet their sustenance needs. In place of the traditional rapport between the forests and the community, increasing alienation, or at least indifference, has become widespread. The possible ecological implications of large scale deforestation now taking place in humid and sub-humid tropics has caused much concern among scientists, environmentalists, and planners around the world. In order to assess the environmental changes, local and global impact on climate, and degradation of fragile soil resources, it is necessary that solid data is collected from well-designed and adequately equipped long-term studies, planned to quantify the effects of deforestation. Some effects of forest conversion are described in Table 12.1.

Table 12.1 : Alterations in Soil and Micro-climate by Deforestation and Intensive Cultivation of Tropical Soils.

Hydrologic Cycle
Decrease in interception by vegetation
Decrease in the water transmission and retention characteristics of the soil
Decrease in water uptake from subsoil below 50cm depth
Increase in evaporation
Increase in surface runoff
Increase in the interflow component
Micro-Climate
Increase in temperature amplitude
Decrease in the mean relative humidity
Increase in the incoming radiation reaching soil surface

Energy Balance
Increase in the fluctuations in soil temperature
Change in the heat capacity of the soil
Change in the phase angle, periodicity, and damping depth

Soil Flora and Fauna
Decrease in biological activity of macro and micro-organisms, notably earthworms
shift in the vegetation type from broad leaves to grasses and from perennials to annuals
Shift in climatic climax

b) Farming

Agriculture in its multiple dimensions has been a major human intervention to cause soil erosion and loss of bio-diversity. It has interfered with the natural means to regenerate land productivity and replenish available moisture storage. It has also opened the means to contaminate both soil as well as moisture sources with the application of bio-chemicals and irrigation water. The worst form of erosion on farm lands is wash-off or sheet erosion. It is slow and not so spectacular. As described earlier, this is followed by formation of rills due to development of erosive over-land flow and subsequent formation of gullies and ravines. On the arid and semi-arid areas, sand blows and sand shifts act in a similar fashion as sheet erosion does, where water is the chief agent. Consequently, a creeping effect of desertification sets in and steadily destroys land productivity and its supporting capacity.

Uncontrolled cultivation of mountain slopes without appropriate land treatment measures such as bunding, terracing, trenching, jacketing and rivetting, etc., leads to loss of nutrients. Similarly, due to increasing population, continuous cropping of the same land or enlargement of cultivation over marginal and sub-marginal lands, there is little time for the natural ecosystem to revive and protect the land from erosion. In the areas subject to shifting cultivation, the population pressure shortens the fallow cycle and thus prevents natural regeneration of the multiple plant species as present in a multitiered forest cover. On the other hand, increased number of livestock, particularly goats and sheep, besides stray cattle, have been increasingly grazing the decreasing community lands and other grazing grounds. One of the most important consequences of this is the increased erosion and decreased growth of plants.

c) Economic Activities

Besides land based communities, minerals and metals as well as fossil fuel are other natural resources that the society needs to meet its energy requirement and for other activities. The extraction of such natural resources demand deforestation and changes in landscape, causing irreversible changes in the natural land resource base. Mined area and mine spoils are a major source of erosion and land degradation with resultant loss of water resources and land productivity. Mining from greater depth such as for oil, gas, etc., cause subsidence and accompanied erosion. In Unit 7 you have already studied that excessive mining degrades the land quality.

d) Developmental Works

Human society has many social priorities, such as, shelter, transport, communication, recreation, etc. For all these items, land and land based commodities are needed. Human settlements are a major threat to the soil and land, as during the construction in the developmental phase, much accelerated erosion takes place. Subsequently, settlements put the land to irreversible non-productive use. Roads, railways, etc. are required to be aligned, cutting across the natural divides such as ridges, valleys, streams and rivers. The construction of such facilities cause voluminous dislocation of earth mass and rock material associated with heavy erosion, disruption of natural drainage system, resulting in accumulation of water at various locations and cause land slides and slips over extensive area.

12.3.3 Extent of Soil Erosion

Neither a comprehensive survey for the country as a whole, nor any rapid survey for a reasonable extent of the country, has been made on the extent of soil erosion. Till 15 years ago, no attempt was made to collect available information from different sources and correlate it with other statistics with a view to assess the magnitude and extent of various soil-related problems in the country. In the early 1970s, the National Commission on Agriculture (NCA), carried out such an exercise for the country as a whole and indicated that about 175 Mha or nearly 53% of the country's geographical area is subjected to problems of soil erosion and different types of land degradation. The widespread problem of erosion in different parts of the country has

been given in Fig. 12.1. Let us study below, two case studies: one from India and the other from America.

Doon Valley is an exquisite region full of diverse flora and fauna. It is bounded by Shivalik and Himalayan ranges on one side and Ganga and Yamuna on the other. But, today this scenic valley is in danger of being ruined because of uncontrolled quarrying for limestone, and also because of deforestation. The tree cover in the valley is reported to be only 12% as against officially recommended 60%. Doon Valley is a good example of erosion caused by human activities, such as, mining and deforestation. According to the report commissioned by the Department of Environment, mine debris allowed to fall into river and canal beds, is impeding water flow and affecting irrigation supplies. Further, the limestone belts used to act as a mechanism for capturing, retaining and releasing water perennially. All the important rivers and streams, such as the Yamuna, Bindal, Song, Suswa and Sahashdhara, etc., originate from the same area where the limestone deposits exist. Limestone quarrying has also led to deforestation and loss of grazing lands. Quarrying operations have destroyed forests and natural springs, creating ecological havoc in the area. Mining operations have loosened the hills, giving way to landslides and silting of the rivers.

Several cost-benefit analysis made by the Government have pointed out that limestone industry would not suffer even if all the operations were shut down in the area. The Government could, therefore, issue an ordinance declaring the Valley as an ecologically fragile zone.

In the above case study you have learnt how mining enhances erosion and destroys the land fertility.

We may now study how agricultural activities affect lands, farmers and productivity. A related issue, however, is the effect of agricultural pollution on non-agricultural ecosystems. When the soils are eroded from farmlands, not only the farm but the air is also filled with dust; silt may collect in beds of streams. In addition to various nutrients, pesticides pour into streams and leach into groundwater supplies. In many agricultural regions, well water contains such a high concentration of nitrate that it is unfit to drink. To illustrate, we give below this case study from the United States of America.

The early European settlers found millions of hectares of virgin land in America. The eastern coast was heavily forested and so it was natural that they set their eyes on the West. It was the rich topsoil and rockless, treeless expanses, promising easy plowing, sowing and reaping, which attracted them. In 1889, the Oklahoma Territory was opened for homesteading. A few weeks later, the non-Indian population there rose from almost nil to close to 60,000. By 1900, the population was 390,000 people living off the wealth of the soil. However, over a period of 20 to 35 years, improper farming practices led to a decline in soil fertility. Poor fertilisation and loss of soil due to wind and water erosion took their toll. Finally, when a drought struck, the seeds failed to sprout and that resulted in a disaster. In 1934, a summer wind stripped entire country of their topsoil and even flew some of this dust more than 1500 km eastward into the Atlantic Ocean. Altogether, 3.5 Mha of farmland were destroyed, and productivity of an additional 30 Mha was seriously reduced. Dangerous wind erosion continues to this day and some agronomists fear that another major Dust Bowl is in the making.

SAQ 2

State whether the following statements are true or false.

a) Man's intervention has caused greater denudation of soil than natural causes; this is evident from the fact that there has been no unusual geological upheaval in extensive areas in the recent past, whereas, human activities have assumed staggering proportions during this period.

b) The increasing rate of deforestation cannot be attributed to the community residing within the forest who depend on it for their sustenance but to those who try to exploit forests in order to meet offsite demand, such as contractors, etc.

c) Continuous cropping of the land and cultivation of marginal lands leaves no time for natural process of ecosystems to revive the fertility of land.

d) Construction of houses, roads, railways, bridges, dams, etc., leads to dislocation of weight on earth. This results in occurrence of land slides and land slips over extensive areas.

12.4 EFFECTS OF LAND DEGRADATION

Soil erosion is one of the most destructive phenomena of land degradation. There is loss of not only water and plant nutrients but ultimately soil itself is lost, which, in turn, affects crop productivity. The soil finds its way into beds of streams and rivers, thus reducing their capacity to contain water which causes floods. We will consider the effects of land degradation one by one.

12.4.1 Surface Runoff and Floods

Most of the soil is lost through the surface runoff. Let us find out what surface runoff means. The precipitation or rainfall of the area, that is discharged from the area through stream channels and is thus lost without entering the soil, is called surface runoff. Surface runoff reduces or even prevents percolation of water into the ground. Runoff levels vary greatly from region to region and from soil to soil. In some humid regions, losses are as high as 50-60% of the annual rainfall. While annual runoff losses are much lower in semi-arid and arid regions, high rates of loss are not unusual during heavy storms, which are common in these regions. Runoff also increases sedimentation and flooding.

In India the core of the problem of flooding lies in the Indo-Gangetic basin accounting for 60 Mha of cultivated land and 60% of the total flood prone area in the country. The basin also supports 40% of India's population and vital industries and provides mineral resources of the country. On the other hand, the Brahmaputra basin is critical due to the fact that the floods there are more frequent and seriously affect all developmental activities. It is interesting to note that the cause of floods in the Indo-Gangetic basin is not only the excessive rainfall and snowmelt on the hills but also the inability of the right bank tributaries of the Ganges to drain in time and the inability of the vast alkaline area to absorb and use the onsite rainfall.

Floods may basically be due to unusually heavy rainfall over short durations. However, many of the human interventions, that adversely affect the ability of land surface and soil profile to absorb, hold and utilise rain water and make its delayed release as sub-surface runoff or interflows, are also the main contributory factors.

12.4.2 Desertification

Desertification is a problem generally associated with arid lands of the country. While water stress and drought are experienced over larger areas including arid deserts, semi-arid and even areas having moderate annual rainfall, both for productivity as well as sound environment, the problem of these two categories would have to be looked into critically. The problem of desertification is the diminution or degradation of biological potential of land which ultimately may lead to desert like conditions. The process results in widespread deterioration of ecosystems with the loss of plant and animal production. The areas subject to wind erosion and arid conditions is estimated at about 38.73 Mha including 7.03 Mha of cold arid areas. The hot deserts and arid areas are located in 7 states, namely, Rajasthan, Gujarat, Haryana, Punjab, Andhra Pradesh, Karnataka, and Maharashtra. The erodible nature of soils coupled with strong winds and decreased natural vegetal cover has set in more degradation within the area already subject to desertification, even though danger of extension of desert may not be there.

You have already studied the causes and effects of desertification in detail in Unit 7. We will now discuss the effects of land degradation on productivity.

12.4.3 Loss of Nutrients and Land Productivity

The most significant effect of soil erosion is in the form of loss of soil as washoff. An estimated 6,000 Mt of soil is lost annually from the Indian subcontinent. Annual rate of soil loss into the sea through erosion is 5 mm. This eroded material carries

several valuable nutrients along with it, which are lost forever. Estimates about the quantum of such losses in terms of major plant nutrients (NPK) is reported to be ranging from 5.37 to 8.4 Mt per year. Several nutrients are lost during floods due to surface runoff and also due to leaching. In the regions where water percolation is high, the potentiality for leaching is also high. Soil properties also have a definite effect on nutrient-leaching losses. There is a greater nutrient loss in sandy soil than clay, because of higher rate of percolation and lower nutrient absorbing power of the sandy soil. Thus, in sandy soil, the nutrients in the top soil are lost due to wind erosion and also due to more rapid leaching.

Intensive land management under any of the primary production system, except multi-tiered forest, invariably leads to exhaustion of the land. Definite care is needed to put back the lost energy through organic sources. Soil erosion and land degradation through various means further affect the physical viability of the soil profile and the environment in terms of solid, water, air ratio as well as chemical and biological balances. These, in turn diminish the availability of nutrients and water to the plants and ultimately the productivity of the land.

A study of the potential population-supporting capacity of an area indicates that continuing soil erosion would render nearly 33% of the area insignificant in terms of productivity; while production in such eroded areas will fall by about 36%. Therefore, inspite of the increasing total productivity of the irrigated lands in 16 countries, including India, as studied, our country's overall production is likely to drop by about 12%.

When soil conservation is allowed to proceed in excess of permissible soil loss (here 12 t/ha/year) over the years, the lands are relegated to lower productivity and finally to zero productivity. The land is classified into eight productivity classes on their capability of cultivation and need for conservation. The eight productivity classes are: I. Suitable for cultivation, II. Requires good soil management practice, III. Moderate conservation practice necessary, IV. Intensive conservation practice necessary, V. Unsuitable for cultivation, VI. No restrictions in use, VII. Moderate restrictions in use, and VIII. Severe restrictions in use.

Class I is flat or nearly flat land suited for cultivation but a few conservation practices are necessary. For II, III and IV lands artificial fertilisation will be required, but special measures of conservational management must be added. Class V, VI, VII are grazing or forestry lands with varying degrees of restrictions on use. The eighth class is suited for wildlife and recreation. Table 12.2 gives the relationship between the rate of soil erosion and long-term decline on land productivity.

Table 12.2 : Relationship Between Rate of Soil Erosion and Long-Term Decline in Land Productivity

Rate of Soil loss (Tonnes per ha per annum)	Anticipated long-term productivity losses
Less than 12	No change in land productivity
12 — 15	50 per cent of the area of very productive land downgrades to productive land, the rest remains unchanged
50 — 100	100 per cent of all productive land downgrades by one productivity class
101 — 200	50 per cent of the area of all productive land downgrades to not suitable (non-productive land); the remainder downwards by one productivity class
More than 201	All extents of productive land downgrades to not suitable (non-productive land).

12.4.4 Cost of Soil Erosion

Soil erosion is economically the most destructive phenomenon in the world. Not only is the productivity of the eroded land destroyed but the eroded soil reaches the productive land, which also loses its productivity. Expansion of the deserts is a prime example. The productivity of crop land lost annually is given in the following Table 12.3.

Table 12.3 : Annual Loss of Land Productivity (India)

	Source	Loss ha/year
1)	**Loss of Crop Land by**	
a)	Encroachment of gullies and ravines in productive land	8,000
b)	Areable land becoming unsuitable for production	22,50,000
c)	Diversion to settlements; towns, cities, etc.	15,00,000
d)	Flood damage average for (1953-1988)	38,20,000
e)	Loss through mining activities as in 1989*	500
	TOTAL	75,78,500
* may increase to 1440 ha/year by the year 2000 AD		
2)	**Loss of forest land by**	
a)	Deforestation for all purposes	1,47,000
b)	Slashing and burning under shifting cultivation	1,00,000
c)	Submergence in dams and reservoirs till now	12,500
	TOTAL	2,59,500
	GRAND TOTAL	78,38,000

Thus a total of 7.84 Mha is estimated to be adversely affected in terms of productive uses. In some cases, the loss is irreversible while in others it is gradual and can be restored. However, we will try to illustrate it with some examples.

The productive land lost due to advancement of ravines and gullies are mostly in command areas. At least 50% of these are highly productive crop land, each hectare costing between Rs. 10,000-20,000. If we take an average of Rs. 15,000 ha for half of 8,000 ha lost annually, the total amount lost will be $4,000 \times 15,000 = 60 \times 10^6$ or Rs. 60 million 10^4/year. Due to coal mining it is 500×10^4 or Rs. 5 million/year.

The most severe damage is caused by floods, which on an average for the period between 1953 and 1988, is of the order of Rs. 886 crore for all the losses, i.e., crop land, human lives and livestock and productivities, etc. The average crop land damage of 3.82 Mha/year at the rate of Rs. 1,000 Mha comes to an economic loss of Rs. 3820 million or Rs. 382 crore.

Sedimentation of various reservoirs is one of the most disastrous consequences of soil erosion. An estimated 480 Mt out of 5,344 Mt of the eroded materials ends up being deposited in various water reservoirs of India and drastically reduce their irrigation and hydro-power generation capacities. The annual cost of erosion in terms of reservoir sedimentation is estimated to be at least Rs. $10,000 \times 100$ Mha—m or Rs. 10,00,000 (Rs. 1 million/year). The eroded soil takes out the major plant nutrients such as NPK which is estimated to be between 5.37 to 8.4 Mt. Although, estimates vary widely, the loss almost equals the amount of fertilisers that is being applied throughout the country. Nearly 0.03 kg/ha of nutrients are lost every year.

There are several other things lost during erosion and it is difficult to assess their economic value. These are:

i) Loss of fodder and forage production, decline in production of timber.

ii) Loss of natural species of flora and fauna and a consequent decrease in bio-diversity.

iii) Loss of water resource points as evident by drying up of springs and nalas, and lowering of water level in wells.

iv) When the land is lost due to wind erosion or water erosion, apart from physical, chemical and biological degradation, there is loss of employment opportunities. This leads to migration towards cities and towns, causing social problems related to unplanned urbanisation.

Thus, the costs of soil erosion include a wide variety of components of importance to man.

SAQ 3

I) Fill in the blank spaces using appropriate words:

a) A total of 7.84 Mha land is estimated to be adversely affected in terms of productive uses, in various human activities. The most severe damage was caused by ..... wherein 3.82 Mha of good land was rendered unproductive.

b) Sedimentation of ..... is one of the most disastrous consequences of soil erosion, costing about Rs. 1 million/year.

c) If the rate of soil loss in erosion ranges between 100-200 tonnes per ha per annum; it is anticipated that ..... per cent of the total area will be rendered unproductive.

d) There is greater nutrient loss in sandy soil than in clay, because rate of ..... is higher while nutrient ..... power is lost in the sandy soils.

II) The land is classified into eight productivity classes based on their capability of cultivation and need for conservation. What are the eight productivity classes? Mention in the space given below.

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12.5 REMEDIAL MEASURES

In the earlier sections you had studied about the causes and the effects of land degradation. Now we will study the remedial measures that if practised would prevent the land from degradation.

Measures designed to reduce soil erosion have been known since at least ten centuries. One of the most important of the ancient measures on agricultural land was terrace construction, representing remarkably impressive efforts of the ancient man. This ancient technique has been considerably refined and has undergone many transformations. Today, an integrated approach towards techniques of soil moisture conservation is practised.

At first, the capability of a plot of land is determined, i.e., the type of land use and economic production to which a plot is suited considering its slope, soil type, drainage, precipitation, wind exposure and other ecological attributes. Once the capability of the plot has been determined, specific measures of soil erosion control come into play. Based on the capability of the land, it is classified into eight classes, about which you have studied in Section 12.4.3.

For Class I land, remedial practices are not needed. After the natural nutrient minerals begin to decline under cultivation, the addition of organic and inorganic fertilisers becomes necessary. Preventive remedial measures for soil erosion control are required on Class II, III and IV lands. These lands are collectively called as degraded cultivable lands. The remedial measures are of two types: 1) Preventive Remedial Measures,and 2) Rehabilitation of Degraded Land. Now let us study about these.

12.5.1 Preventive Remedial Measures

To prevent wind erosion, trees are planted to break the force of the wind. The trees not only cover soil from the sun, they also help to hold the soil particles. Cultivation at right angles to the direction of the wind further serves to prevent wind erosion.

Fig. 12.3 : Contour farming.

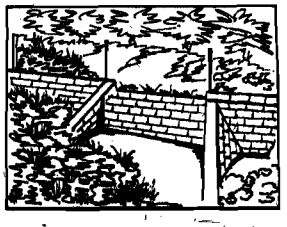

Fig. 12.4 : Concrete dam built to protect field from erosion

Water erosion on sloping ground may be prevented by **terracing** on steep slopes or by **contour cultivation** on more gentle slopes. In contour cultivation a slope is plowed along horizontal lines of equal elevation. (Fig. 12.3). Another technique for reducing water erosion is **strip-cropping** in which a close-growing crop is alternated with the one that leaves a considerable amount of exposed ground. The soil washed from the bare areas is held by the closer growing vegetation. In tropics, a shelter of trees or canopy over the ground serves as a means for breaking the force of raindrops and thus reducing their erosive power. The tree shelter also screens out direct sunlight. The sunlight, in addition to causing damage to certain crops, can accelerate the breakdown of organic materials in the soil at a rate that is faster than is desirable.

12.5.2 Rehabilitation of Degraded Land

The measures described in the previous section can be considered preventive. There are also measures of rehabilitation where possibilities are provided for restoration of fields which have already suffered erosion. For the Classes V, VI, VII and VII whos principal feature is that these soils can be used for purposes other than cultivation, rehabilitative methods for control of soil erosion are required. These methods are more of an effort to condition degraded soils. One of the chief principle is maximum production of wood and other produce while maintaining continuous soil cover. Grading the soil with the help of construction of small check dams or bunds across former gullies using mechanical equipment is one such example (Fig. 12.4).

Another rehabilitative erosion control measure aims at minimising stream bank erosion. This is done through revetments, retaining wall and jetties which slow down undercutting of banks and hold sand and silt across the corners. Soil binding vitex, lantana, impomea or other vegetation may become established in these revetments. Sediment detention reservoirs also reduce the erosive power of the current. Catchment passive or flood control storage help reduce high flows. These measures are costlier and can recover land capability only very slowly.

For eroded range lands and grass lands, use of forage plants should be adjusted. Grazing must be tolerated only to the extent that the forage plants still retain sufficient vitality in withstanding a period of drought which may arrive at any time.

SAQ 4

Fill in the blanks with suitable words.

a) To prevent wind erosion .....are planted to break the force of the wind.

b) ..... not only cover soil from the sun, they also help to hold the soil particles.

c) Water erosion on sloping ground may be prevented by ..... on steep slopes or by .....cultivation. In.....cultivation a slope is plowed along horizontal lines of equal elevation.

d) The soil washed from the bare areas is held by the ..... growing cultivation.

e) The sunlight, in addition to causing damage to certain crops can accelerate the ..... of organic materials in the soil at a rate that is faster than is desirable.

12.6 SUMMARY

In this unit you have studied that:

- Land degradation is caused by natural processes as well as by human activities. Soil erosion is one of the phenomena of land degradation, caused by water and wind.
- Major human activities which accelerate the rate of soil erosion include deforestation, intensive cultivation, mining and other developmental activities.
- Mining in Doon Valley has caused silting in rivers, instability of land mass resulting in reduction in irrigation water supply and loss of grazing land.
- The results of land degradation are surface runoff and floods, desertification, loss of nutrients and land productivity.

- Soil erosion is economically the most destructive phenomenon. Not only is the productivity of the eroded land destroyed, but the eroded soil reaches the productive land destroying it also.
- Degradation of the soil can be prevented by practising preventive measures. The degraded land can also be restored by following suitable rehabilitative techniques.

12.7 TERMINAL QUESTIONS

1) Briefly comment on the following.
   a) Sheet erosion

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   b) Rill erosion

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   c) Gully erosion

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   d) Coastal erosion

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   .....

2) Briefly describe the effects of deforestation.

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3) What are the effects of land degradation? Describe briefly in the space given below.

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4) Briefly describe about two preventive remedial measures for the conservation of soil.

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12.8 ANSWERS

Self Assessment Questions

1) a) Soil erosion
   b) sheet, rill, gully
   c) wave
   d) wind

2) a) T b) T c) T d) T

3) I a) floods
   b) Reservoirs
   c) 50
   d) percolation, absorbing

   II) Class I. Suitable for cultivation
   Class II. Requires good soil management practice
   Class III. Moderate conservation practice necessary
   Class IV. Intensive conservation practice necessary
   Class V. Unsuitable for cultivation
   Class VI. No restrictions in use
   Class VII. Moderate restrictions in use
   Class VIII. Severe restrictions in use

4) a) trees
   b) trees
   c) terracing
   d) closer growing
   e) breakdown

Terminal Questions

1) a) Please refer Section 12.2.1
   b) Please refer Section 12.2.1
   c) Please refer Section 12.2.1
   d) Please refer Section 12.2.1

2) Please refer Section 12.3.2

3) Please refer Section 12.4

4) Please refer Section 12.5.2