Chapter 6

Soils

INTRODUCTION

The loose material or the upper layer of the mantle rock (regolith—a layer of lose, heterogeneous material covering solid rock) consisting mainly of very small particles and humus which can support the growth of plants is known as soil. Soil mainly consists of mineral/rock particles, a certain proportion of decayed organic matter, soil water, soil air, and living organisms which exist in a complicated and dynamic relationship with each other. The naturally occurring soil is influenced by (i) parent material, (ii) relief, (iii) climate, (iv) physical, chemical and biological agents (micro-organisms) in it, (v) land use practices, and (vi) time. In general, soil is made up of four elements: (a) inorganic or mineral fraction (derived from the parent material), (b) organic matter (decayed and decomposed plants and animals), (c) air, and (d) water.

CHARACTERISTICS OF SOIL

Parent Material

The parent material includes both, hard, resistant rocks such as granite, marble as well as slate, apart from less resistant rocks such as recent volcanic lavas and ashes, and the metamorphic (schist, gneiss) and sedimentary rocks (sandstone, clay, silt, and limestone). The term 'rock' is strictly applied not only to granite, sandstone and the like, but also to gravel, clay, and unconsolidated sand, loess, and alluvium which are less compact and less resistant soils.

Humus

The end product of breakdown of dead organic material is known as humus. It is a structureless, dark-brown or black jelly found beneath or within the soil surface. The humus of ordinary soil is black, and is thus, responsible for making the top soil darker than the subsoil. It helps in the maintenance of soil fertility. The amount of humus in different soils varies considerably.

Soil Texture

A soil is generally characterised by the size of its particles. A clayey soil may thus be described as fine, sandy as coarse, while silt is an intermediate (**Fig. 6.1**). The standard unit for the measurement of soil particles is the millimetre, but a smaller unit is the micron (1 micron = 0.001 mm), which is applicable, for instance, to the measurement of soil colloids. In sandy soil, the size of individual grains varies between 0.05 and 0.2 mm which are visible to the naked eye. The individual grains of clayey soil are 0.002 mm in diameter. Silty soil is finer than sand but coarser than clay. Its particles are found to have a diameter between 0.02 and 0.002 mm.

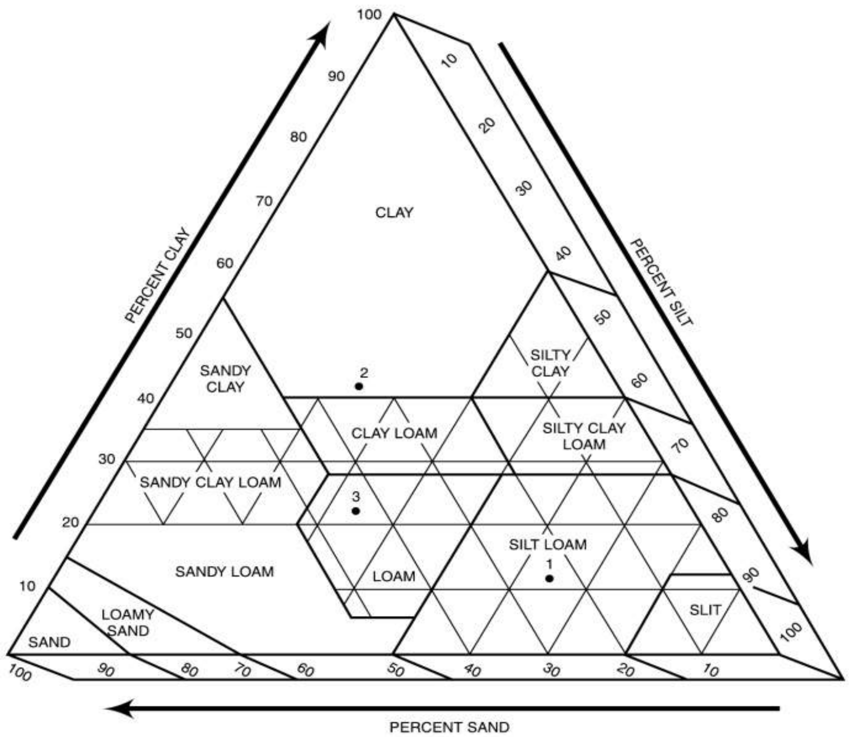


Fig. 6.1 Soil Texture Triangle

Soil Structure

Soil structure refers to the arrangement of soil particles. The way in which sand, silt, clay, and humus bond together to form beds is known as soil structure.

Soil Acidity

The acidity and alkalinity of soils is expressed in the pH value, which is a scale that measures the concentration of hydrogen ion held by the soil colloids (particles). In pure water, one part in 10 million is dissociated to form hydrogen ions, i.e., 10^{-7}, and the pH is thus 7; this is a neutral state on the scale of acidity. If a strong alkali such as caustic soda is dissolved in water, the solution is marked as alkaline (pH 14). By contrast, hydrochloric acid has a pH value of 3. A neutral soil has a pH value of about 7.2, and acid soil less than 7.2 (sometimes as low as 3). A strongly alkaline soil has a pH value of about 8 or higher.

Soil Air

The air content of soil is vital, both to itself and to organic life within it. The air in the soil helps in the process of oxidation which converts nitrogen into a form readily available to the plants. On the other hand, too high degree of oxidation (in the tropical regions) may consume so much organic material that the soil becomes increasingly sterile. Moreover, most bacteria, present in the soil in infinite numbers, require oxygen and are said to be *aerobic*. As these organisms are partly responsible for breaking down plant and animals remains, absence of air limits their activity.

Soil Water

Depending on the texture of the soil, water moves downward by percolation. The amount of water in the soil varies from nil in arid climates, which makes life virtually impossible for organisms, to a state of complete water-logging which excludes air, causes a reduction in bacteriological activity, and limits decomposition.

Soil Horizon

It is a distinct layer within soil which differs chemically and/or physically from the layer below or above. It is a layer of soil which lies more or less parallel to the surface and has fairly distinctive soil properties (**Fig. 6.2**).

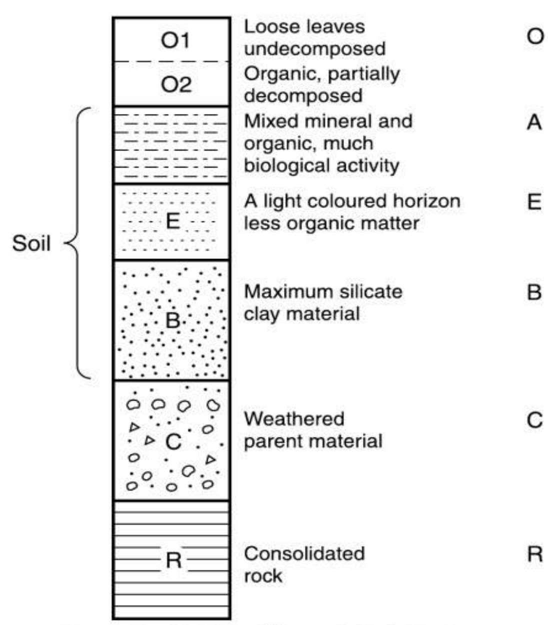


Fig. 6.2 Soil Profile and Soil Horizons

Soil Profile

It is a vertical series of soil horizons from the ground surface to the parent rock. The profile results from the same parent rock having similar horizons and soil profiles, but with varying characteristics according to their location (**Fig. 6.2**).

India is a vast country having great variations in its terrain and climatic conditions. The geo-climatic conditions of India have affected the general distribution of soils, their texture, structure, colour, pH value, and porosity. In general, the soils of India follow the climatic and vegetation belts.

Soil is formed under specific natural conditions and each of the elements of the natural environment contributes to this complex process described by soil scientists as the process of pedogenesis or soil formation. The soil of a place is closely influenced by the nature of parent rock, surface features of relief, climatic conditions, natural vegetation, land use practices, organisms, insects, micro-organisms (bacteria), and time. These factors do not act on soil independently or in isolation, but in close association with each other leading to a whole network of inter-relationships of quite a complex nature. The material for soil formation, termed by soil scientists as the parent material, is derived from the rocks exposed on the surface. The relief and characteristics of slope along with the work of the various agents of weathering, determine conditions for the disintegration of the rock materials. Thus, the original soil characteristics, including the chemical constituents, are borrowed from the rock below. Soils may be transported by running water, wind or other agents of erosion, or may remain in the original position. When soil remains in its original position, it is said to be *in situ*, and in that state it is further modified by the climate, particularly moisture supply, plant growth and bacterial activity dependent on these factors.

As a natural resource, soil is of immense value to humans. Its nature and fertility determines the agricultural productivity on which depends the carrying capacity of the soil and the level of development of the rural communities.

CLASSIFICATION OF SOILS OF INDIA

A number of attempts have been made to classify the soils of India during the last century. The first scientific classification of Indian soils was made by Voeleker (1893) and Leather (1898). According to them the Indian soils may be classified into four categories, namely (i) alluvial, (ii) regur (black-earth), (iii) red soil, and (iv) lateritic soil.

Subsequently, on the basis of texture, structure, colour, pH value and porosity, the All India Soil and Land Use Survey Organisation attempted a classification of soils of India in 1956. In 1957, the National Atlas and Thematic Mapping Organisation published a soil map of India in which Indian soils were classified into six major groups and eleven sub-groups. In 1963, the Indian Council of Agricultural Research, under the supervision of S.P. Ray Chaudhry, published a soil map of India in which the soils have been divided into seven groups. More recently, the Indian Council of Agricultural Research, on the basis of texture, structure, colour, pH value, and porosity has identified the following types of soil groups. [**Table 6.1** (**Fig. 6.3**)].

1. Alluvial soils
2. Red soils
3. Regur (Black-earth) soils

4. Desert soils
5. Laterite soils
6. Mountain soils
7. Red and Black soils
8. Grey and Brown soils
9. Submontane soils
10. Snowfields.

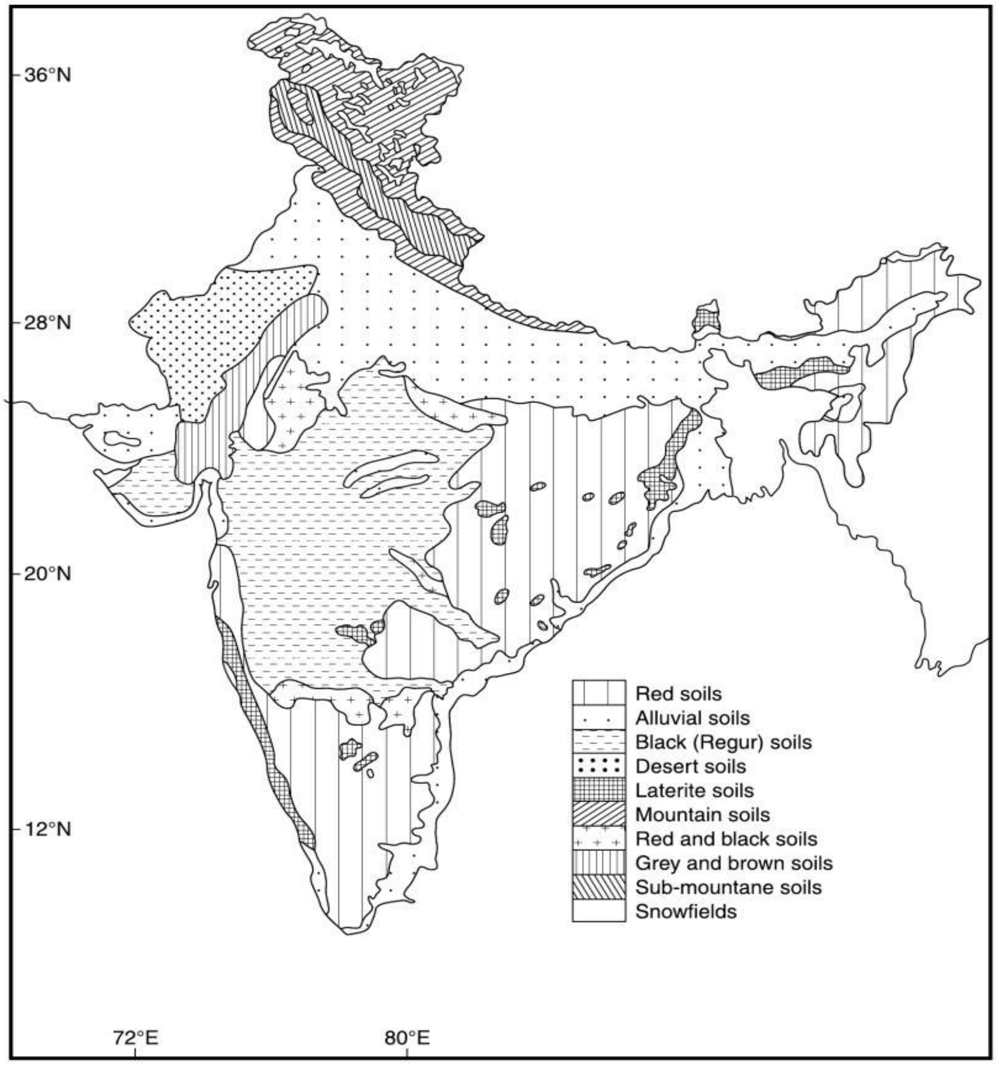


Fig. 6.3 Soils

Table 6.1 *Types of Soils, their Area and Percentage to Total Reporting Area*

Soil types	*Area in million hectares*	*Percentage*
1. Alluvial soil	143.1	43.36
2. Red soil	61.0	18.49
3. Black (Regur) soil	49.8	15.09
4. Mountain soil	18.2	5.51
5. Red and Black soil	17.8	5.40
6. Desert soil	14.6	4.42
7. Laterite soil	12.2	3.70
8. Grey and Brown soil	3.6	1.09
9. Submontane-soil	5.7	1.73
10. Snowfields	4.0	1.21
11. Other soils		
12. Total reported area	330.0	100.00

1. Alluvial Soils

The alluvial soil covers about 143.1 million sq km accounting for about 43.4 per cent of the total reporting area. The alluvial soils occur mainly in the Satluj-Ganga-Brahmaputra Plains. They are also found in the valleys of Narmada, Tapi and in the Eastern and Western coastal plains (**Fig. 6.2**). These soils are mainly derived from the debris brought down from the Himalayas or from the silt left out by the retreating sea. The colour of the alluvial soils varies from light grey to ash grey and the texture is sandy to silty-loam. These soils are both well drained and poorly drained. In general, they have an immature profile in undulating areas, while in the leveled areas they have a well developed and mature profile.

These soils may be divided into the (i) *Khadar* soil: The khadar soils are low-lying, frequently inundated by floods during the rainy season. Thus, the khadar occupies the flood plains of the rivers and is enriched by fresh silt deposits every year. The khadar tracts are generally rich in concretions, and nodules of impure calcium carbonate or *Kankar*. In the drier areas, it also exhibits stretches of saline and alkaline efflorescences locally known as '*reh*', *kallar* or *thur*, (ii) The *Bhangar* soil is above the flood level. It is generally well-drained but contains concretion (kankars) of impure calcium carbonate. The soil texture varies from loamy soil to clayey-loam. It is well drained and suited to wheat, rice, maize, sugarcane, pulses, oilseeds, *barseem* (fodder), fruits and vegetables. Alluvial soils are rich in humus, phosphoric acid, lime and organic matter. They are, however, deficient in potash.

2. Red Soils

Red soils occupy the second largest area of about 61 million hectares or 18.5 per cent of the total reporting area. They are found mainly over the Peninsula from Tamil Nadu in the south to Bundelkhand in the north, and Rajmahal in the east to Kathiawad and Kachchh in the west (**Fig. 6.3**).

These soils are also found in tracts in western Tamil Nadu, Karnataka, southern Maharashtra, Andhra Pradesh, Chhattisgarh, Jharkhand, Odisha, and in scattered patches in Bundelkhand, Mirzapur, Sonbhadra (Uttar Pradesh), Banswara, Bhilwara, Udaipur, (Rajasthan).

Developed on Archaean granite, these soils are also known as the omnibus group. Their colour is mainly red because of the presence of ferric oxides. Generally, the top layer is red, while the horizon below is yellowish in colour. The texture of red soils varies from sand to clay and loam. Their other characteristics include porous and friable structure, absence of lime, *kankar* and carbonates and small quantity of soluble salts. In general, these soils are deficient in lime, phosphate, magnesia, nitrogen, humus, and potash. Intense leaching is a menace to these soils. In the uplands, they are thin, poor, gravelly, sandy, or stony and porous, light-coloured soils, but in the lower plains and valleys, they are rich, deep, dark coloured fertile loams. In places where irrigation water is available, they are devoted to wheat, cotton, pulses, tobacco, millets, oilseeds (linseed), potato, and orchards.

3. Black or *Regur* Soils

Black soils, also known as *Regur* (cotton-soil) and internationally as 'tropical chernozems', are the third largest soil group in India. They sprawl over about 50 million hectares accounting for 15 per cent of the total reporting area of the country. Getting their parent material from the weathered rocks of Cretaceous lava, they stretch over the greater parts of Gujarat, Maharashtra, western Madhya Pradesh, north-western Andhra Pradesh, Karnataka, Tamil Nadu, Rajasthan, Chhattisgarh, and Jharkhand, up to Rajmahal Hills. They are mature soils. Over the greater parts of the black earth soil, the average annual rainfall varies between 50 and 75 cm.

The colour of these soils varies from deep black to light black. In general, these soils have clayey texture and are rich in iron, lime, calcium, potash, aluminium and magnesium. They are, however, deficient in nitrogen, phosphorous and organic matter. Moreover, these soils have a high water retaining capacity. They are extremely compact and tenacious when wet, and develop wide cracks when dry. In other words, they swell greatly and become sticky when wet in rainy season. When the soil is wet, it becomes difficult to plough the field as the plough gets stuck in mud. In the dry season, the moisture evaporates, the soil shrinks and develops wide cracks, often 10-15 cm deep. These soils are highly productive, and thus well suited for the cultivation of cotton, pulses, millets, linseed, castor, tobacco, sugarcane, vegetables, and citrus fruits.

4. Desert Soils

Sprawling over about 15 million hectares, the desert soils account for over 4.42 per cent of the total reporting area of the country. These soils are developed under the arid and semi-arid conditions and deposited mainly by wind action. They are found mainly in Rajasthan, west of the Aravallis, northen Gujarat, Saurashtra, Kachchh, western parts of Haryana, and the south-western parts of Punjab.

The desert soils are sandy to gravelly with low organic matter, low nitrogen and varying percentage of calcium carbonate. These soils contain high percentage of soluble salts, but have low moisture content and low water retaining capacity. If irrigated, they give high agricultural returns. The availability of water from the Indira-Gandhi Canal has transformed the agricultural landscape of the desert soils of western Rajasthan. These soils are mainly devoted to *bajra*, pulses, *guar,* fodder, and less water requiring crops.

5. Laterite Soils

These soils were studied first by the British geographer F. Buchanan in 1905. Their name has been derived from the Latin word "Later' which means 'brick'. These soils, when wet, are as soft as butter, but become quite hard and cloddy on drying. These are the typical soils of the monsoon climate which is characterised by seasonal rainfall. The alternating wet and dry seasons lead to the leaching away of the siliceous matter of the rocks leading to the formation of such soils. The red colour of the soils is due to the presence of iron-oxide. These soils developed mainly in the highland areas of the plateau. The soils in the higher areas are generally more acidic than those in the low-lying areas.

Laterite soils cover an area of about 12.2 million hectares accounting for about 3.7 per cent of the total reporting area of the country. They are found mainly in the hills of Western Ghats, Eastern Ghats, Rajmahal Hills, Satpura, Vindhya, Odisha, Chhattisgarh, Jharkhand, West Bengal, North Cachar Hills of Assam, and the Garo Hills of Meghalaya.

These soils are rich in iron and aluminium, but poor in nitrogen, potash, potassium, lime and organic matter. Although they have low fertility, they respond well to manuring. They are mainly devoted to rice, ragi, sugarcane, and cashewnuts.

6. Mountain Soils

Covering an area of about 18.2 million hectares or about 5.5 per cent of the total reporting area of the country, these soils are found in the valleys and hill slopes of the Himalayas between 200 and 300 metres. These soils are generally immature and are still to be probed systematically. In structure and texture, they vary from silt-loam to loam. Their colour is dark brown. These soils can be divided into: (i) loamy podzols , and (ii) high altitude soils.

Podzols occupy the mid-latitude zone in the Himalayas corresponding with the deodar, pine and blue-pine areas of Assam, Darjeeling, Uttarakhand, Himachal Pradesh, and Jammu and Kashmir. These soils are acidic in character with low humus content. They are devoted to maize, rice, legumes, fodder and orchards.

The High altitude soils, depending on the forest cover, slope, and rainfall are classified as brown earth type and red-loam. The sub-soil surface of these soils remains frozen under snow. Their soil profile is generally less developed.

7. Red and Black Soils

The red and black soil is found in isolated patches in Bundelkhand, and to the east of Aravallis in Rajasthan and Gujarat (**Fig. 6.3**). They developed over the granite, gneiss, and quartzite of the Archaean and Pre-Cambrian period. These soils are relatively less productive, but perform well under irrigation conditions. They are devoted to maize, bajra, millets, pulses, and oilseeds.

8. Grey and Brown Soils

These soils have been formed by the weathering of granite, gneiss, and quartzite. These are loose friable soils. Due to the presence of iron-oxide (haematite and limonite) these soils vary from red to black and brown in colour. These soils are found in Rajasthan and Gujarat (**Fig. 6.3**).

9. Submontane Soils

These soils are found is the Tarai region of the sub-montane stretching from Jammu and Kashmir to Assam in the form of a narrow belt. These soils have been formed by the deposition of the eroded material from the Shiwaliks and the Lesser Himalayas. The soil is fertile and supports luxuriant growth of forests. The clearing of forests for agricultural purposes has made this area highly susceptible to soil erosion.

10. Saline and Alkaline Soils

The saline soils are characterised by the presence of sodium chloride and sodium sulphate. In these soils, the saline and alkaline efflorescence appears on the surface as a layer of white salt through capillary action. These soils are known by different names in different parts of the country. They are called as *reh, kallar, usar, rakar, thur, karl,* and *chopan.* These soils are found in Rajasthan, Haryana, Punjab, Uttar Pradesh, Bihar, and Maharashtra.

Texturally, these soils vary from sandy to sandy-loam. They are deficient in nitrogen, calcium and have very low water bearing capacity. These soils can be reclaimed by improving drainage, by applying gypsum and/or lime and by cultivating salt resistant crops like barseem, *dhaincha*, and other leguminous crops.

11. Peaty and Marshy Soils

Peaty soils originate in the areas of heavy rainfall where adequate drainage is not available. These are generally submerged during the rainy season and utilised for the cultivation of rice. These soils are rich in organic matter, highly saline, but deficient in phosphate and potash. These soils mainly occur in parts of Kottayam and Alappuzha districts of Kerala and in the Sundarban delta. They are also found in the deltas of Mahanadi, Godavari, Krishna, Kaveri, and the Rann of Kachchh.

12. Karewa Soil

Karewas are the lacustrine deposits in the Valley of Kashmir and in Bhadarwah Valley of the Doda District of the Jammu Division. These are the flat topped mounds that border the Kashmir Valley on all sides. They are composed of fine silt, clay, sand, and bouldery-gravel. They are characterised with fossils of mammals and at places by peat. According to geologists, during the Pleistocene Period, the entire Valley of Kashmir was under water. Subsequently, due to endogenetic forces, the Baramullah Gorge was created and the lake was drained through this gorge. The deposits left in the process are known as karewas (**Fig. 6.4**).

According to Middlemiss, the thickness of karewas is about 1400 m. In fact, the karewas have been elevated, dissected and in great measure removed by subaerial denudation as well as by the Jhelum river giving them the present position. The karewas are mainly devoted to the cultivation of saffron, almond, walnut, apple and orchards. The karewas, devoted to saffron cultivation are fetching good income to the growers. The karewas of Palmpur, Pulwama, and Kulgam are well known for their production of superior quality of saffron.

13. Snowfields

The area under snow and glaciers is about 4 million hectares. The high peaks of the Greater Himalayas, Karakoram, Ladakh, and Zaskar (Zanskar) are covered by ice and glaciers. The soils in these areas is immature, generally without soil erosion. It remains frozen and is unsuitable for the cultivation of crops.

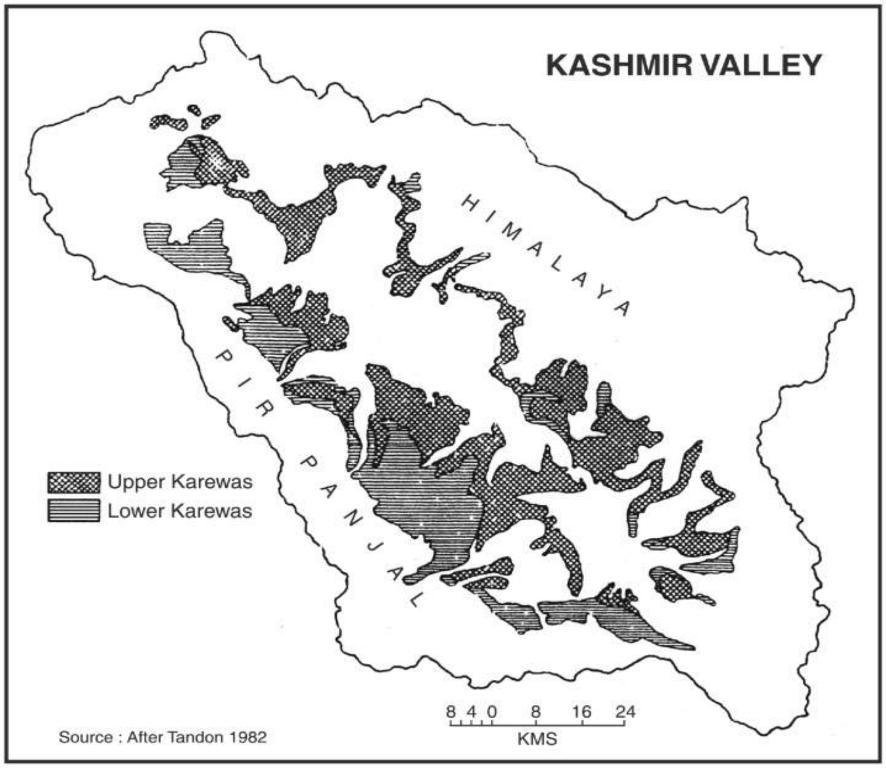


Fig. 6.4 Karewas

PROBLEMS OF INDIAN SOILS

The forces of nature often destroy the soil cover of an area. The process of soil destruction is the result of natural forces. Soils are however, also being damaged and destroyed by human activities, such as deforestation, over-grazing of animals and unscientific use of agricultural land. The main problems of the Indian soils are (i) soil erosion, (ii) declining fertility of soil, (iii) salinity and alkalinity, (iv) water-logging, and (v) desertification.

(i) Soil Erosion

Soil erosion refers to the removal of top soil. Soil erosion is a growing menace in many parts of India. When the top soil is removed, it is known as sheet erosion, and when the runoff makes gullies, it is known as gully erosion. In India, soil erosion is a universal problem. In the areas where rainfall is heavy water is the main agent of soil erosion, while in the arid and semi-arid areas wind is responsible for soil erosion. According to one estimate about 180 million hectare (about 60 per cent of the total area of the country) is adversely affected by soil erosion.

The main agents of soil erosion are water, wind, sea-waves, glaciers, and shifting cultivation. The areas adversely affected by the different agents of erosion have been shown in **(Fig. 6.5).** Out

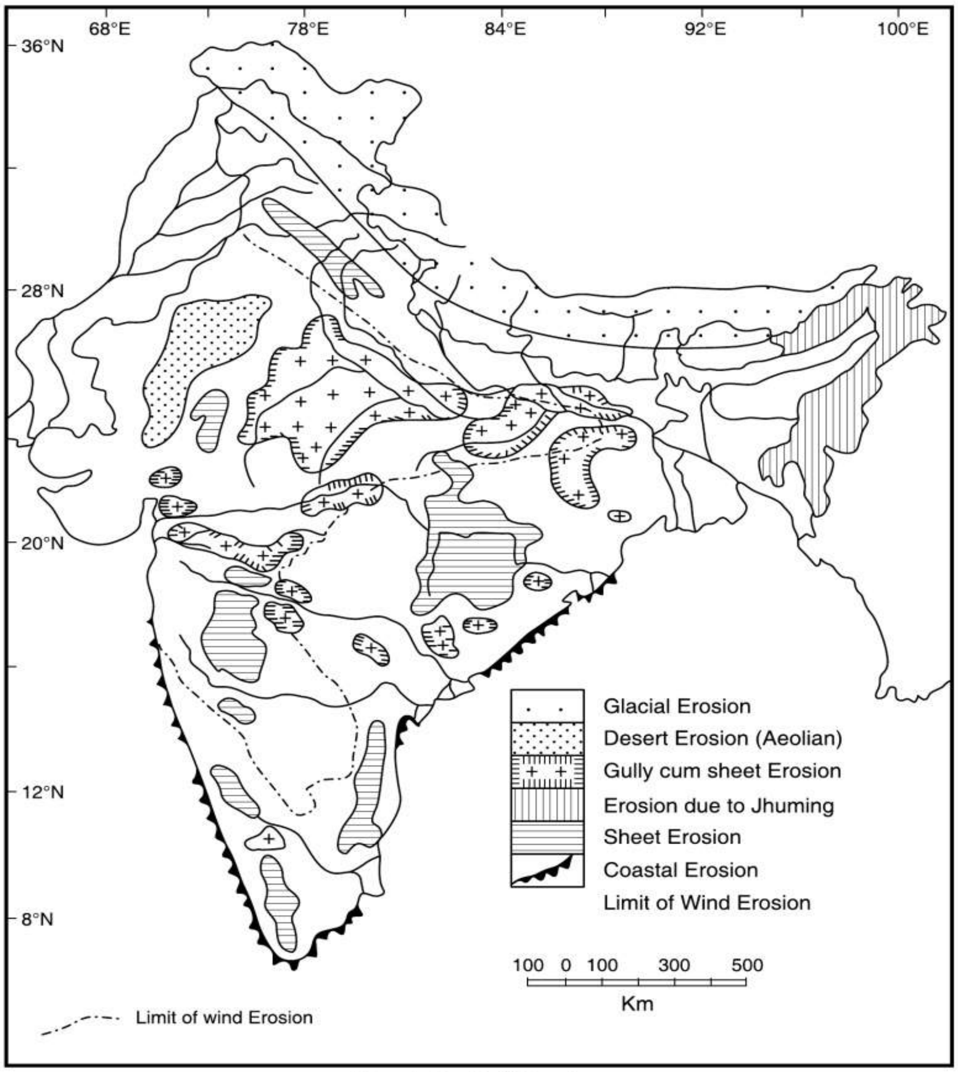
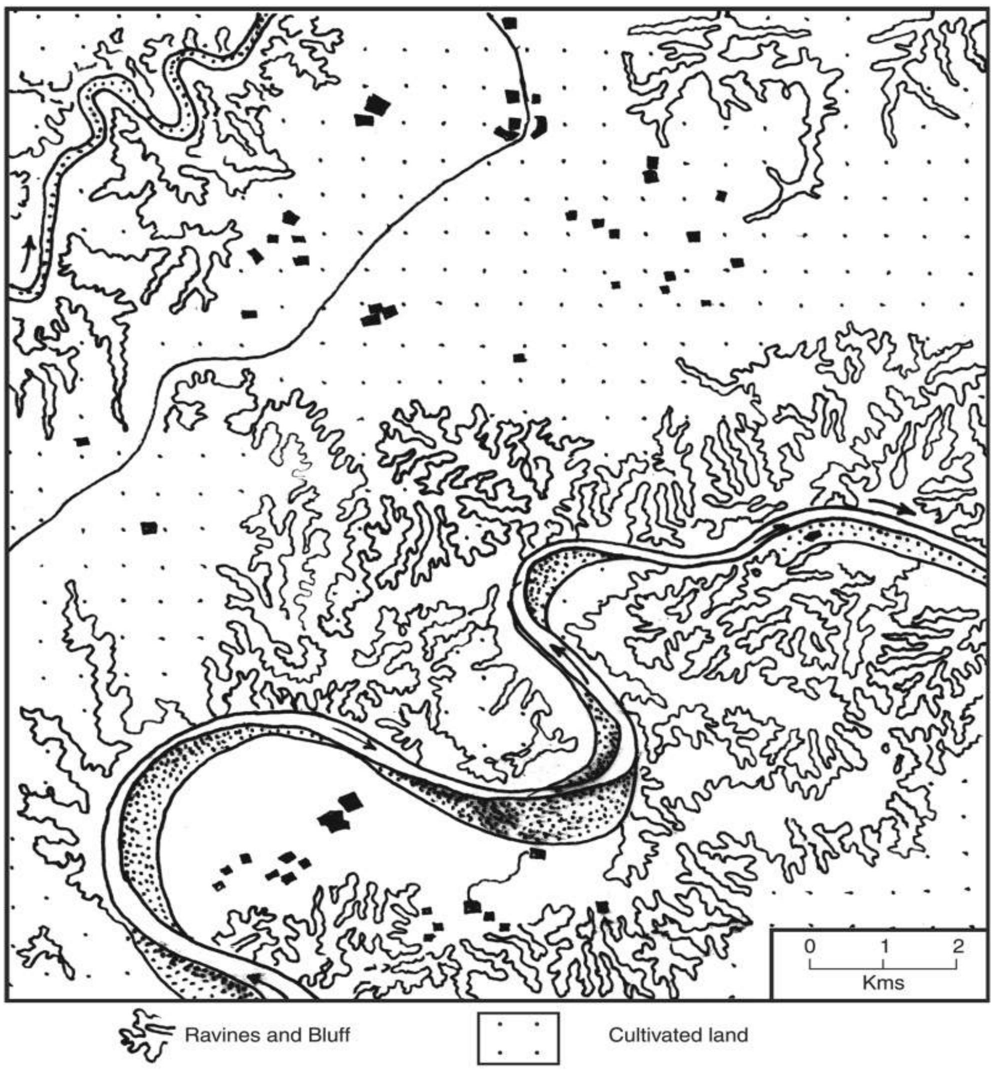


Fig. 6.5 Soil Erosion

of these, water is the most important agent of erosion. Water erosion may be classified under three categories: (a) surface erosion or the uniform removal of soil from the surface, (b) Rill erosion in which the running water makes finger-shaped grooves in the land, and (c) gully formations, in which the rills are enlarged, making the land bad and unsuitable for cultivation. A typical example of gully erosion is provided in the Chambal valley in Madhya Pradesh. Rajasthan, and Uttar Pradesh also provide typical examples of gully erosion. (**Fig. 6.6**). Gully erosion is also significant in the Shiwalik tracts of Punjab, Haryana, Himachal Pradesh, Jammu and Kashmir, Uttarakhand, Uttar Pradesh and along the southern slopes of Himalayas, and the Western and Eastern Ghats.

Wind erosion is significant in the arid and semi-arid areas of Rajasthan, Haryana, Punjab, western Madhya Pradesh and Gujarat. Wind erodes soil along the coastal plains of Peninsular India. Thousands of hectares of fertile lands of Uttar Pradesh, Gujarat, Haryana, Punjab, and western Madhya Pradesh have been adversely affected by this process.

The tidal waters of the Arabian Sea and the Bay of Bengal cause considerable damage to the soils along the coastal areas. Severe erosion of beaches along the Kerala, Tamil Nadu, Andhra Pradesh, Odisha, and Gujarat coasts is the example of sea-wave erosion.



Chambal Ravines

Fig. 6.6 Gully Erosion in Chambal Valley

The largest area affected by soil erosion is in the state of Rajasthan, followed by Madhya Pradesh, Maharashtra, Uttar Pradesh, Gujarat, Andhra Pradesh and Karnataka. The worst affected areas of soil erosion include: (i) Chambal and Yamuna rivers **(Fig. 6.6),** (ii) the southern slopes of Shiwaliks, Lesser and Greater Himalayas, (iii) the Western and Eastern Ghats, (iv) the Chotanagpur Plateau, and (v) the arid and semi-arid areas of Rajasthan, Gujarat, Haryana, and Punjab.

(ii) Declining Soil Fertility

Being utilised for centuries, and multiple cropping without fallowing the agricultural land, the natural fertility of soil is depleting fast. The farmers of Punjab, Haryana, and western Uttar Pradesh often complain about the decreasing fertility of their soils. It has been reported that the farmers are using more inputs each subsequent year to get the return to the level of the previous year. This testifies to the diminishing fertility of land. In fact, the unscientific rotation of crops (wheat and rice) over several decades has depleted the soil fertility in the Great Plains of India substantially. The cultivation of leguminous crops after a soil exhaustive crop can improve the soil fertility affected regions.

(iii) Water-Logging

An area is said to be waterlogged when the water table rises to the extent that soil pores in the root zone of a crop become saturated, resulting in the restriction of normal circulation of the air, decline in the level of oxygen, and an increase in the level of carbon dioxide.

Apart from soil erosion, there are many ill-drained, low lying areas in India where the soil has been damaged by water-logging (**Fig. 6.7**). The main causes of waterlogging are: (i) seepage of water from canals, (ii) faulty on farm water management, (iii) lack of drainage, (iv) interception of natural drainge, (v) indiscriminate cultivation in bed of drainage channel, and (vi) inundation of marine delta cycles, and (vii) inundation in coastal areas during cyclonic storms. Water logging has affected substantial tracts of land along the Indira Gandhi Canal (Rajasthan) and the canals of Punjab, Haryana, and Uttar Pradesh. Adequate development of drainage and lining of the canals to reduce water seepage can go a long way in the reclamation of water-logged areas.

(iv) Saline and Alkaline Soils

Soil salinity and alkalinity are found in the relatively less rainfall recording areas where the rate of evaporation is generally higher than the rate of precipitation. They also develop in the *Khadar* lands and the canal irrigated areas. Under such conditions, the ground water level rises and saline and alkaline efflorescence consisting of salts of sodium, calcium, and manganese appear on the surface as a layer of white salt through capillary action. According to one estimate, about 80 lakh hectares (2.4% of the country's reporting area) has been adversely affected by saline and alkaline formations.

(v) Salt Flats

The soils seriously damaged by the excess of calcium chlorides are found in the Rann of Kachchh (**Fig. 6.7**). These soils are saline, marshy and infested with tall grasses, bushes and scrubs. They are almost useless from agricultural point of view. A sound strategy needs to be developed to bring the salt flats under agriculture or pastures.

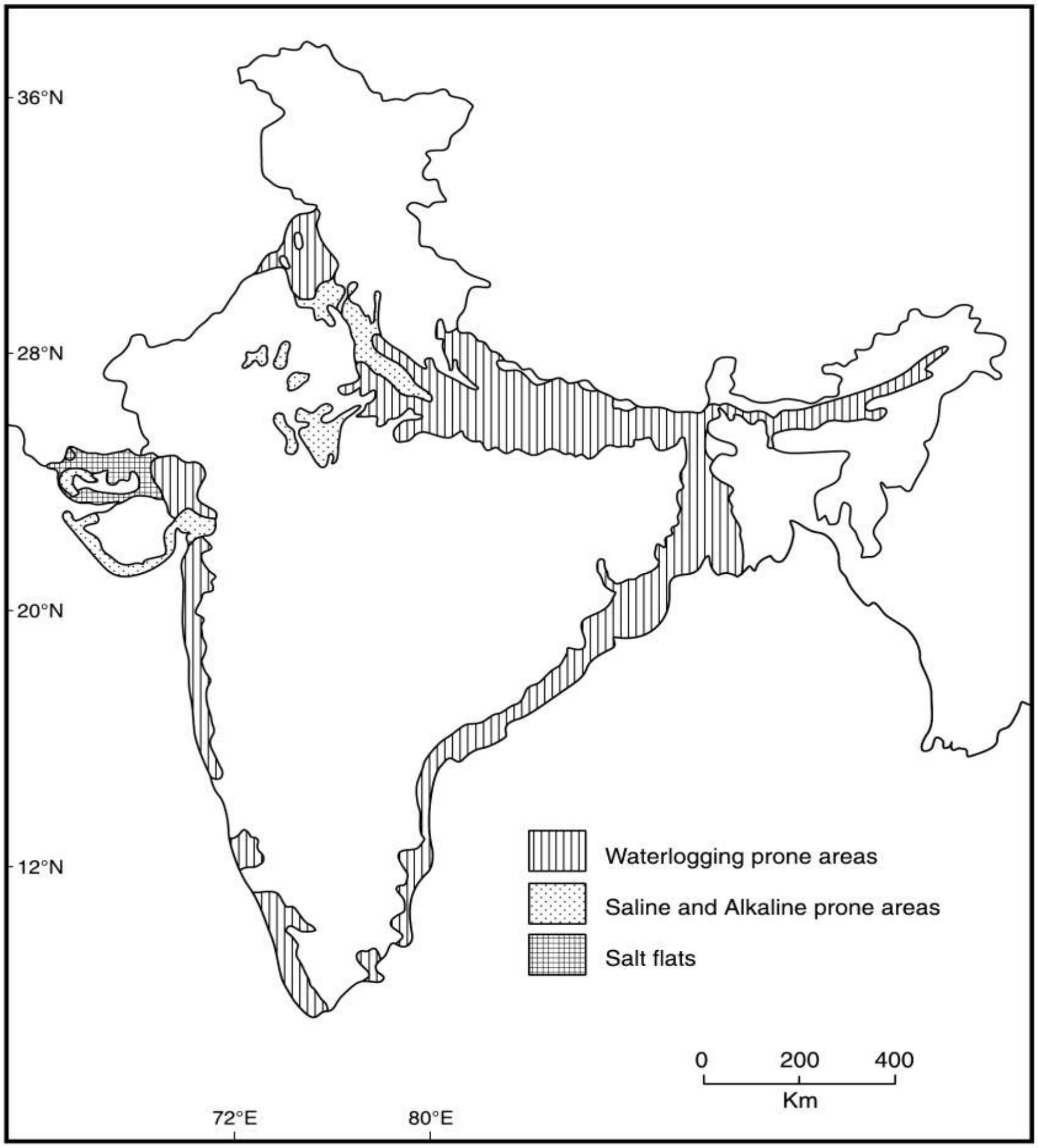


Fig. 6.7 Soil Affected Areas

The Planning Commission, on the basis of data provided by the Ministry of Agriculture in 1985, mentions the types of degraded soils/land and their causes. These categories of land and their causes have been given in **Tables 6.2 and 6.3.**

Table 6.2 *Types of Degraded Land*

Categories	*Area in million hectares*
Gullied lands	2.05
Land with/without scrub	19.40
Water logged and marshy lands	1.66
Land affected by salinity and alkalinity	2.05
Shifting cultivation area	3.51
Under utilised/degraded forests	14.06
Degraded pastures and grazing lands	2.60
Degraded land under plantation crops	0.58
Sand (inland/coastal)	5.00
Mining/industrial wasteland	0.12
Barren rock/strong waste sheet rock area	6.42
Steep sloping area	0.77
Snow covered/glacial area	5.58
Total	63.80

Source: ***Planning Commission and Five Year Plan,*** New Delhi, p. 582

Table 6.3 *Causes and Extent of Degradation*

Causes of degradation	*Area in million hectares*	*Total Area percentage*
Water erosion	107.12	61.71
Wind erosion	17.79	10.25
Ravines	3.97	2.28
Salt affected	7.61	4.38
Water logging	8.52	4.91
Degraded forest land	19.49	11.23
Special problems	2.73	1.57
Coastal sandy areas	1.46	0.84
Degraded land due to shifting cultivation	4.91	2.83
Total	173.60	100.00

Source: ***Planning Commission and Five Year Plan,*** New Delhi. p. 582.

The causes of soil degradation differ from region to region and from place to place. In some places, it is due to water erosion, while at others it is due to wind erosion, or salt and toxic chemicals.

It may be seen from **Table 6.2** that over 2 million hectares of land is gullied and about 1.66 million hectares are waterlogged and marshy lands. Moreover, 3.51 million hectares are adversely affected by shifting cultivation. The degraded notified forests cover over 14 million hectares and over 19 million hectares of land is without scrub. These lands need immediate attention for reclamation.

Water and wind erosion are the most potent causes of land degradation. Water erosion produces gully erosion, while water and wind erosion lead to sheet erosion. Wind erosion becomes active when the vegetation is removed from the land and land is exposed to wind action. Soil degradation by wind and water erosion have been shown in **Fig. 6.8**. It may be observed from this figure that wind erosion is mainly in the Thar desert while soil erosion by water is well spread in the Himalayas, Gangetic plains and the Peninsular India (**Fig. 6.8**). Intensive agricultural practices that rely heavily on water, chemical fertilisers, and insecticides and pesticides have caused water-logging and salinity in many parts of India. The expansion of irrigation without proper drainage has accentuated this. The extent of degraded land is not precisely known. According to land use statistics 2002, published by the Department of Agriculture of India, the estimates of cultivable wastelands are 13.9 million hectares (**Table 6.2**).

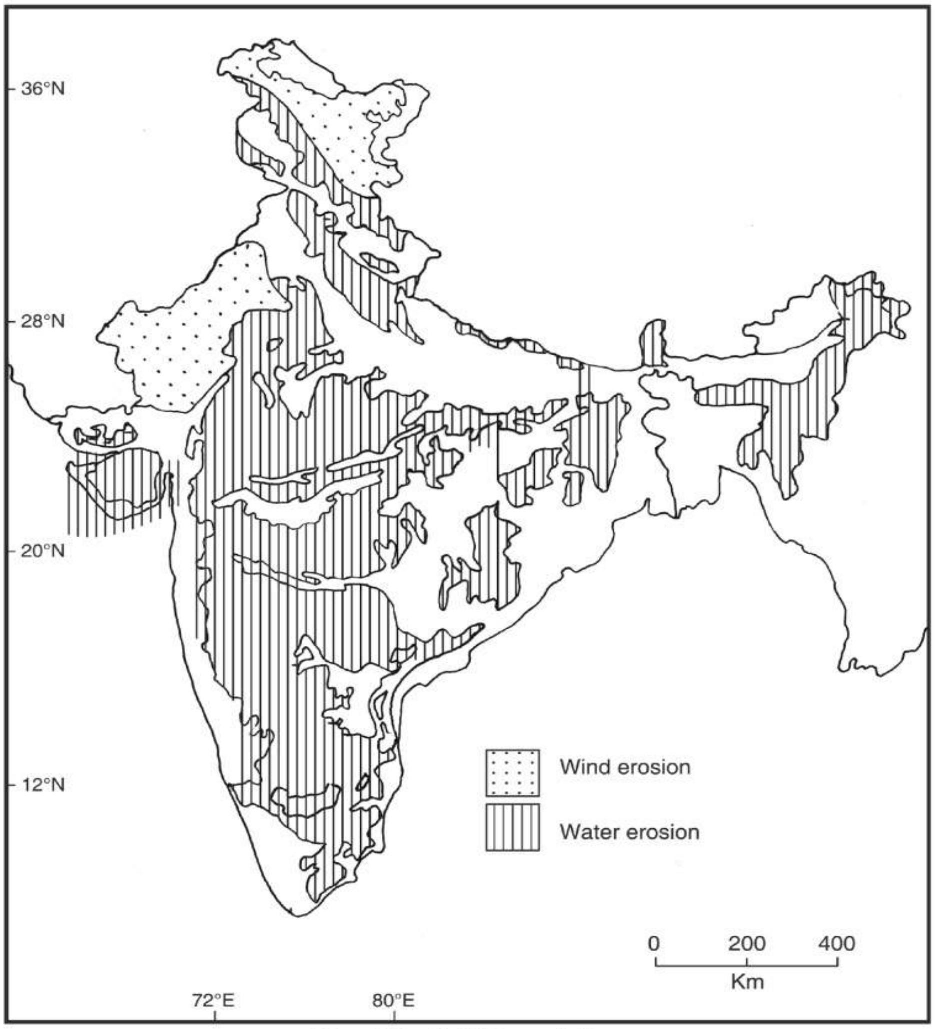


Fig. 6.8 Soil Degradation

CONSEQUENCES OF SOIL EROSION

Soil erosion is responsible for the removal of productive nutrients from the soils and causes ecological imbalances. Some of the adverse consequences from soil erosion are:

(i) Loss of fertile top soil from the top layer leading to gradual loss of soil-fertility and agricultural productivity.
(ii) Loss of important nutrients from soil through leaching and water-logging.
(iii) Lowering of the underground water-table and decrease in soil moisture.
(iv) Drying of vegetation and extension of arid lands.
(v) Increase in the frequency of droughts and floods.
(vi) Silting of rivers and canal beds.
(vii) Recurrence of land slides.
(viii) Adverse effect on economy which retards cultural development.
(ix) Increase in crimes and anti-social activities through the formation of natural hideouts for criminals and dacoits.
(x) Burden on the exchequer to reclaim the bad lands.

There is no uniform strategy to reclaim all the wasteland and degraded soils of different types. Some strategies that might help in the reclamation of wasteland are given below:

(i) All the degraded forest lands should be planted with trees. Marginal lands which are not suitable for agriculture should be brought under social forestry and agro-forestry.
(ii) Degraded soils and degraded lands can be reclaimed with the help of watershed programmes.
(iii) Rainwater harvesting and conservation should be the focus of development planning. A series of small projects of water harvesting in the watershed area should be undertaken to maximise benefits from watershed projects.
(iv) Soil conservation practices should be adopted which have been briefly described in the following pages.

SOIL CONSERVATION

Looking at the importance of soil resources for a country of over a billion people, a judicious utilisation and conservation of soil is of parmount importance.

The farmers in the drier parts of Gujarat, Haryana, Rajasthan, and western Madhya Pradesh have successfully protected their fields from soil erosion by planting rows of trees to reduce the velocity of winds which continually erode soil cover. Soil conservation includes reduction in soil erosion, afforestation, rational utilisation of soils and ways to enhance their sustainability. Some of the important steps which can go a long way in the conservation of soils are as under:

1. Afforestation

Tree plantation helps in the reduction of soil erosion. Trees reduce the intensity of runoff and increase the seepage of water to the underground water-table. Social forestry can be developed along the banks of rivers, canals, lakes, roads, and railway tracks.

2. Restriction on the Felling of Trees

Apart from afforestation, it is equally important to check the indiscriminate felling of trees. People's awareness that resulted in the launch of the *Chipko Movement* can help in achieving this objective.

3. Contour Ploughing and Strip Cultivation

In the hilly and mountainous areas, ploughing should be done according to the contours and not in an up-down direction of slope. The contour ploughing is an effective way of checking soil erosion.

Similarly, small strips can be developed on gentle slopes for sowing crops which help in overcoming the menace of soil erosion.

4. Control of Floods

In India, the problem of soil erosion is closely associated with floods. The floods generally occur during the rainy season. Efforts, therefore, need to be made for the storage of flood water or the diversion of additional rain-water. The inter-connecting of rivers as in the Garland Canal Project or the Ganga-Kaveri Link Canal Project can be of immense help in this direction.

5. Reclamation of Ravine and Badlands

Reclamation of gullies and ravines is also necessary to overcome the problem of soil erosion. Several such schemes involving plugging of gully mouths, construction of bunds across the gullies, levelling of gullies, afforestation, restriction on grazing are under implementation in the Chambal ravines of Madhya Pradesh, Uttar Pradesh, and Rajasthan.

6. Restriction on Shifting Cultivation

In the states of north-east India and Western and Eastern Ghats, shifting cultivation (slash and burn) is one of the main causes of soil erosion. The shifting cultivators need to be persuaded to stop the practice of shifting cultivation and should be trained and motivated to adopt terraced farming. A scheme to control shifting cultivation has been launched in the seven states of north-east India. This is a beneficiary oriented programme which aims at the rehabilitation families of the Jhumias (shifting cultivators). There is a need to extend this programme to other states of the country and gradually replace this agricultural system by sedentary farming.

7. Restoration of Long Fallow

There are 96 lakh hectares of fallow land. The old fallow land is mainly found in Andhra Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu, Bihar, Uttarakhand, and Uttar Pradesh. This old fallow land can be brought under cultivation, grazing and orchards which shall be helpful in the reduction of soil erosion.

8. Reclamation of Saline and Alkaline (usar) Soil

The saline and alkaline affected area in the country is more than 80 lakh hectares. The state-wise distribution in the major states of India has been given in **Table 6.4.**

This land needs reclamation. Application of cow-dung and gypsum are quite helpful in the reclamation of salt-affected soils.

9. Other Measures of Soil Conservation

The government of India has been attempting to check the soil erosion through out the planning period. The following steps can go a long way in reducing the rate of soil erosion.

(i) Construction of small dams across the tributaries of rivers in their upper reaches to control floods and soil erosion.

Table 6.4 *Salinity Affected Areas in the Major States of India*

States	*Area (in lakh hectares)*
Uttar Pradesh	12.95
Punjab	12.25
Gujarat	12.14
West Bengal	8.50
Rajasthan	7.28
Maharashtra	5.34
Haryana	5.26
Karnataka	4.04
Odisha	4.04
Madhya Pradesh	2.24
Andhra Pradesh	0.42
Total	74.46

(ii) Lining of canals to stop seepage of water which leads to waterlogging.
(iii) Solving the problem of waterlogging by improving the surface and vertical drainage.
(iv) Formation of windbreak and shelter belts in arid and semi-arid regions.
(v) Increasing use of organic and compost manure.
(vi) Popularising the application of cowdung and green manure.
(vii) Conversion of human waste and city garbage into manures.
(viii) Scientific rotation of crops.
(ix) Filling up gullies and forming terraces along the slopes.
(x) Levelling of ravines and planting of trees and grasses in the slopes.
(xi) Check on shifting cultivation and conversion of Jhum lands into sedentary agriculture.
(xii) Promotion of afforestation in the degraded soils.
(xiii) Adopting the techniques of sustainable agriculture.
(xiv) To educate public about the adverse effects of soil erosion through seminars, conferences, and workshops in the regions of degraded soils.

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