Soil Conservation:

Soil conservation is a combination of all management and land use methods that safeguard the soil against depletion or deterioration caused by nature and/or humans. It is a system of husbandry which aims at getting maximum production from the soil on sustained basis. In other words, the conservation of the soil is a matter of using the land as it should be used. i.e., some soils are too steep to be farmed, some are too erodible to be cultivated and some are climatically unsuited to intensive cultivation. Keeping in view the above things, soil conservation may be defined as the use of land within limits of economic practicability according to its capabilities and its needs in order to keep it permanently productive. Or

Soil conservation is set of management strategies for prevention of soil being eroded from the earth's surface or becoming chemically altered by overuse, salinization, acidification, or other chemical soil contamination.

Principal approaches of Soil Conservation:

The principal approaches these strategies take are:

- choice of vegetative cover
- erosion prevention
- salinity management
- acidity control

- encouraging health of beneficial soil organisms
- prevention and remediation of soil contamination
- mineralization

other ways are

- no till farming
- contour plowing
- wind rows
- crop rotation
- the use of natural and man-made fertilizer
- resting the land

Many scientific disciplines are involved in these pursuits, including agronomy, hydrology, soil science, meteorology, microbiology, and environmental chemistry.

Decisions regarding appropriate crop rotation, cover crops, and planted windbreaks are central to the ability of surface soils to retain their integrity, both with respect to erosive forces and chemical change from nutrient depletion. Crop rotation is simply the conventional alternation of crops on a given field, so that nutrient depletion is avoided from repetitive chemical uptake/deposition of single crop growth.

Cover crops serve the function of protecting the soil from erosion, weed establishment or excess evapotranspiration; however, they may also serve vital soil chemistry functions. For example, legumes can be ploughed under to augment soil nitrates, and other plants have the ability to metabolize soil contaminants or alter adverse pH. The cover crop Mucuna pruriens (velvet bean) has been used in Nigeria to increase phosphorus availability after application of rock phosphate. Some of these same precepts are applicable to urban landscaping, especially with respect to ground-cover selection for erosion control and weed suppression.

Principles of Soil Conservation:

Following are some basic principles of soil conservation.

a. **Land use according to its capability:** This is the most important factor for the success of soil conservation efforts. For this purpose, get your soil survey for its capability and use it according to the type of the soil.

b. **Retain rainwater:** Rainwater should be retained as close as possible to where it falls, so as to make the best use of precipitation and minimize potential runoff effects. Rainwater can be retained in the soil in the following ways.

   - Soil surface can be kept covered by cultivated crops or vegetation, particularly during rainy season.
   - Fields should be kept loose to allow maximum infiltration of rainwater when fields are fallow.

- Flow of surface water down a slope can be regulated by constructing field embankments and terraces or by reducing size of the fields.
- A proper system needs to be provided for the safe disposal of runoff water to reduce immediate damage by heavy rains.

c. **Minimize runoff:** Practices adopted on both arable and non arable lands should be such as to minimize runoff and maximize retention of rainwater.

d. **Store surplus water:** Surplus water should be stored in dams or other reservoirs. This water can then be used for supplemental irrigation, livestock, or other purposes.

e. **Maintain soil fertility:** Soil fertility should be maintained at a level which can support crop production.

f. **Use non-arable lands effectively:** Non cultivable lands, or those damaged by erosion should preferably be brought under forest.

Soil Conservation Practices: Specific applications of land and water management knowledge with the goal of protecting soil resources from exploitation, destruction, or neglect are called **soil conservation practices.** Soil conservation measures are highly site specific and depend upon land use pattern, soil characteristics, topographic conditions, rainfall pattern and potential erosion hazards. In order to determine proper land use and appropriate soil practices, a land capability/erosion survey should be carried out.

Soil conservation practices can be classified into soil management, crop management, engineering, range management and forestry operations.

- Land management refers to the proper use of land.
- Crop management pertains to selection of crops, tillage practices and cultural operations.

1. Maintaining crop cover. Soil is the biggest storehouse of water. Soils vary widely in the degree to which they allow infiltration of water and the degree to which they retain it. Although these characteristics depend upon inherent soil properties, they can be improved by appropriate soil and crop management practices. Efforts should be made to maintain crop cover on the soil surface during the monsoon. If soils are to be left fallow, they should be ploughed across the slope before the onset of the rainy season and occasionally thereafter. This practice is especially important where the slope is more than 2 percent. Shafique et al. (1988) observed that runoff was highest under bare soil conditions, and that crop cover reduced the runoff significantly. Based on data for three years, it was found that the runoff under crop cover was reduced by 20, 22, and 25% with minimum precipitation and 19, 16, and 9 percent with maximum precipitation from that of bare soil conditions under 1, 5, and 10 percent surface gradients, respectively (Table 17.1).

Table 17.1 Mean annual rainfall, rainfall intensity, and runoff under different surface gradients and crop cover conditions, 1984–86.

			RUNOFF (%)					
			Slope 1%		*Slope 5%*		*Slope 10%*	
	Rainfall (mm)	**Rainfall intensity (mm/h)**	**Fallow**	**Crop**	**Fallow**	**Crop**	**Fallow**	**Crop**
Minimum	8.0	3.0	5.0	4.0	9.0	7.0	12.0	9.0
Maximum	141.0	85.0	62.0	50.0	64.0	54.0	71.0	65.0

Source: Shafique et al. (1988). Data collected at PARC Experiment Station near Fateh Jang.

2. Field embankments. The practice of constructing field embankments (Fig. 17.4) is called *wat bandi* in Panjabi. The boundaries of the fields are raised to a height of 15–50 cm depending upon the rainfall and the slope of the land. In low rainfall areas like Khushab, Mianwali, and Dera Ghazi Khan districts, the field boundaries may be raised as much as 50 cm in order to allow maximum absorption of rainwater into the soil.

3. Tillage to an appropriate depth. It is a common practice, unfortunately, to plough too shallowly and down the slope. Such incorrect ploughing practices reduce moisture retention and accelerate erosion. In the barani tracts of our country there are several different types of soils, which vary widely in their response to tillage operations. It is therefore essential that

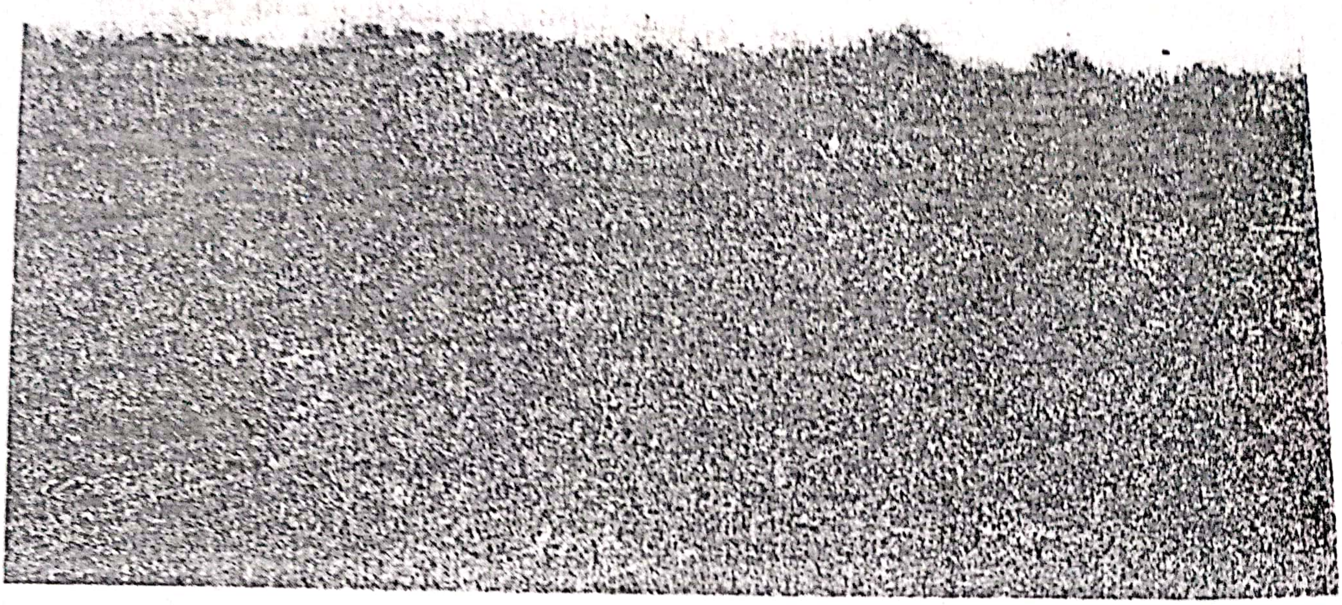

Figure 17.4 Field embankments on terraced fields help increase water retention.

tillage practices be suited to the particular type of soil and its depth. For example, experimental results on wheat at the Soil Conservation Research Station at Tarnol in 1972 showed that the yield of wheat was significantly higher at 12 in than at 6 in ploughing depth. However a comparison of two tillage operations—conventional tillage with bullocks, and deep tillage with a tractor—carried out in the research area of the Barani Agricultural College, Rawalpindi on a loam soil revealed no significant difference in the yield and yield parameters of wheat (Chaudhry and Ali 1987). It has been reported by various workers that heavy-textured soils show good response to deep tillage. Some recent studies with the mouldboard plough have shown encouraging results. Because the use of heavy machinery in our country is not yet widespread, there is no serious surface compaction problem; those soils which are underlain by a compact substratum, hardpan, or ploughpan respond well to deep tillage. Also, it has been observed that deep tillage operations need not be carried out every year and can be carried out beneficially every three or four years.

4. Effective mulching. The practice of spreading plant residue or any other material like straw or stone on the soil surface to reduce evaporation water losses is called **mulching**. Mulching has been found effective in conserving soil moisture, regulating soil temperature, preventing crust formation, and protecting soil against erosion. The mulching material absorbs the kinetic energy of raindrops, improves infiltration, and reduces the velocity of runoff water. Mulches can be used particularly effectively for soil and water conservation on moderately sloping arable lands. Chaudhry et al. (1988) observed the response of gram to the application of wheat straw, maize stover, and rice straw mulches. Their study showed that mulch treatment moderated soil temperature, improved moisture retention in the soil, increased biomass, and enhanced crop yield. In a study on mung (*Vigna radiata*) in which chopped wheat straw was top-dressed at 0, 2, 4, and 6 t/ha, Chaudhry and Faizullah (1989) found that mulch treatment produced a significant increase in moisture content, biomass, number of pods per plant, and crop yield. It was observed that mulch application @ 2, 4, and 6 t ha^{-1} caused 12.5, 26, and 42 percent increase in moisture content and 20.69, 44.83, and 44.83 percent increase, in grain yield, respectively, over unmulched treatments. However, mulch application at the rates of 4 and 6 t/ha delayed crop maturity.

5. Cropping systems and crop rotation. Selection of proper cropping systems and crop rotation are the key to success of conservation-oriented farming. The allocation of farm area to different crops depending upon the potential of the land is very important. In the Pothwar area the *dofasli dosala* ('two crops in two years') system of cropping is quite common. Wheat is the dominant rabi crop and is sown in about 60% of the area.

Millet, mung beans, and *mash* are important kharif crops. Gram is a dominant rabi crop in the low-rainfall areas. The Gujar Khan, Chakwal, Mianwali, and Attock areas are still the home of groundnut, but the area under this crop is declining. The issue of introducing change in the cropping pattern of the rainfed area is controversial. One school of thought believes that the existing cropping pattern is not suitable since a major portion of the area remains fallow during the summer. Most erosion takes place during the summer because about 60–75% of the precipitation falls in that season in the form of heavy downpours. These people believe that there should be more crop cover during the kharif season. The other school of thought is of the opinion that the present system is based on centuries of experience of the farming community, who have found that there are more chances of crop failure during summer than winter. Studies of relay cropping and intercropping are under way, which could be helpful in the readjustment of cropping systems, if the results are encouraging.

Cropping systems, cropping patterns, and crop rotation are site specific. Good information about the selection of crops in various ecological regions is contained in *Agro-ecological Zonation of Pothwar* (Beg et al. 1985). Much more research needs to be carried out in order to develop a comprehensive plan for cropping systems in Pakistan.

Cover crops are very important in cropping patterns and crop rotation in erosion affected areas because they provide good cover for the soil and have deep root systems. They protect the soil from the erosive effects of the beating action of rain, and they hold the soil against erosion. Groundnut, mung, and *mash* are good cover crops for medium-rainfall areas.

Figure 17.5 Water disposal outlets are helpful in disposing of excess rainwater.

6. Water disposal systems. Water disposal systems (Fig. 17.5) aim at the safe disposal of surplus rainwater that remains unabsorbed into the soil. These systems include **water disposal outlets** and **storm water channels**. There are different types of water disposal outlets — grassy, loose stone, and brick masonry. The selection of a particular outlet type for an area depends upon the soil characteristics, rainfall, slope of the land, availability of labour and construction materials, and the economic condition of the farmers.

Grassy outlets are very inexpensive. They are constructed in low-rainfall areas or where the volume of water to be disposed of is not great. The grasses should not be edible by animals, otherwise they will be destroyed by the cattle. Grassy outlets can be constructed satisfactorily in the Jauharabad, Khushab, and Mianwali areas.

Loose stone outlets are constructed in low-to-medium rainfall areas where the field-to-field fall is less than 2 feet. Because they are made with local material, loose stone outlets are also inexpensive. They are found in the Soan valley, Attock, and Jhelum areas where stones are available.

Brick masonry water disposal outlets can be laid out where the field-to-field fall is more than 2 feet, where rainfall is more than 750 mm per annum, or in the lower reaches of a catchment.

In addition to the above types, prefabricated and specially designed structures like concrete pipes can also be used under certain conditions. These have been tried in the Gully Rehabilitation Project of PARC near Fateh Jang, but the farmers are still reluctant to adopt this technology.

The outlets are usually located at the lowest point of the field. The crest of an outlet is slightly higher (about 15 cm) than the ground level. Once surplus water has been safely conducted away from the cultivated land it should be carried through a storm water channel or watercourse which eventually leads to a natural drainage channel. The storm water channel should be designed keeping in view the peak flow during high intensity downpours.

7. Fertilizer use. Soil fertility is a very important factor in the conservation of soil and water. Fertile soils produce high crop yields and also have better physical properties than infertile soils. Organic matter improves the structure of the soil; a fertile soil with adequate amounts of organic matter (at least 1%) is resistant to erosion. Well-managed soils develop a granular structure which makes them porous and able to absorb more rainwater. It has been observed that 9.5% of rainfall water was lost as runoff from an unfertilized maize crop, while only 6.4% percent was lost where the maize crop was fertilized at the rate of 200 pounds/acre of 5–10–5 fertilizer (FAO 1965). However the best kind and amount of fertilizer to be used in each individual case depends on the soil type, crop, and rainfall.

8. Terrace farming. "The field terrace is an earthen embankment adjusted to soil and slope to control runoff. It is designed primarily for the control of runoff in high-rainfall areas and for the conservation of water in low-rainfall areas (Bennett 1955:193)." Terraces are constructed to decrease the length of a slope, reduce erosion, prevent formation of gullies, and retain runoff in areas of inadequate precipitation. There are two main types of field terraces: (1) broad-based terraces which remove or retain water on sloping lands, and (2) bench terraces which reduce land slope.

1. **A broad-based terrace** is a wide surface channel or embankment constructed across the slope of rolling land. From a functional point of view, there are two types of broad-based terraces: (a) channel terraces and (b) ridge terraces. The primary function of a **channel terrace** is to remove excess water in such a way as to minimize erosion (Fig. 17.6a). These are constructed by cutting a shallow channel on the uphill side and using the excavated soil for the construction of an embankment. The side slopes of both the channel and ridge are kept as flat as possible so as to facilitate farming operations. These are mainly constructed in medium to high rainfall areas and should not be built on soils that are too stony, steep, or shallow; or on deep sands.

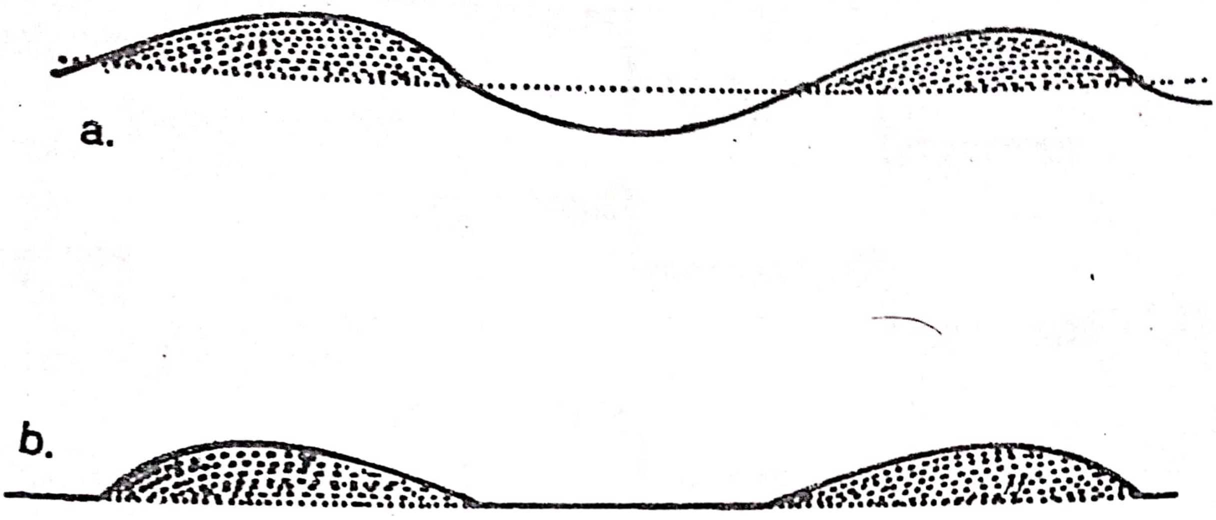

Figure 17.6 Types of terraces: (a) interception and diversion; (b) interception and retention. (Redrawn after Bennett 1955:194).

Ridge terraces are primarily constructed for moisture conservation, and erosion control is a secondary objective (Fig. 17.6b). They are helpful in trapping and retaining rainwater for infiltration into the soil in low-to-medium rainfall areas. They may also be used on permeable soils in high rainfall areas. The channel in this type is generally level to allow maximum retention.

2. **Bench terraces** with broad channels are commonly used around the world to reduce the length and steepness of land slope. Bench terrace farming is a centuries-old practice in the subcontinent. In Pakistan it is practised particularly in the Pothwar plateau and the northern hilly areas. There are four types of bench terraces: (a) Level bench terraces, (b) Sloping bench terraces, (c) Reverse slope bench terraces, (d) Irrigation bench terraces (Fig. 17.7).

Level bench terraces have an almost level field surface. They are suitable for medium-to-high rainfall areas. They are quite common in the Pothwar, Murree, Kahuta, and northern hilly areas. **Sloping bench terraces** can be adopted in high rainfall areas or where the purpose is to dispose of extra water. This type is not common in Pakistan. **Reverse slope bench terraces** are recommended for low-rainfall sloping areas so that the maximum possible rainwater can be retained in the soil. **Irrigation bench terraces** are suitable for sloping areas where fields are to be irrigated. In this case the field boundaries are raised above the level of the field, and the surface of the field is almost level (Fig. 17.7d).