CHAPTER - VII

WATERSHED DEVELOPMENT AND MANAGEMENT

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7.0 CONSEQUENCES OF WATERSHED DEGRADATION

In nature there is perfect balance and harmony between land, vegetation and water. If we disturb this balance, the consequences are serious for human and cattle life. We all know that vegetation depends on land and water. We know this from our experience of how agricultural crops, trees, plants, grasses etc. grow. On the other hand water, both surface and sub-surface, depends on land and the vegetative cover on it. Land with thick soil cover especially with a natural layer of humus absorbs good amount of rainwater, which gradually seeps deeper into lower strata of soils/ rocks to recharge ground water. Thick vegetative cover not only prevents erosion of the topsoil but also traps considerable amount of rainwater thereby enhancing the recharge. It is this water, which we draw from wells and hand pumps and part of it appears as flow in streams and rivers.

Over the last about a hundred years, and more so since Independence, the increasing pace of developmental works and steep rise in population has led to large scale deforestation. This, in turn, has had many adverse effects on land viz. drastic reduction in water holding capacity, increased intensity of drainage of rainwater and excessive erosion of land surface. The drainage areas of rivers and streams, known as "Watersheds" have been particularly worse affected by this process. This has resulted in excessive loss of topsoil, increased intensity of floods during monsoon season, alarming lowering of ground water table and reduction in lean-season flow in rivers and streams. This in turn has reduced availability of both surface and ground water causing the present water scarcity in many parts of the country.

Unfortunately, in nature the degradation process continues unabated. Once the land deteriorates beyond a limit, it cannot support enough and right type of vegetation to prevent further deterioration. Thus the land continues to deteriorate till it becomes totally barren with even worse implications for surface and ground water sources. The economic cost of mindlessly disturbing the delicate balance in nature is enormous and the consequent human suffering is appalling.

This process of environmental degradation is irreversible in nature and corrective measures are very tedious and expensive and are often only partially effective.

7.1 NEED FOR TIMELY ACTION

If corrective measures are not taken in right earnest to improve the condition of our watersheds and maintain them, we may face a serious water crisis in not too distant a future. The objectives of these measures are to reduce soil erosion, augment soil moisture and retard the drainage of rainwater. These measures have two main components viz.

- Restoration of the vegetative cover to bring the watershed close to its original pristine condition.

- Artificial land treatment to strike a balance between the needs of development on one hand and protection of watershed on the other.

These measures, if taken up on a large scale to cover the entire drainage area (or watershed) of a stream, can significantly improve lean season flow in the stream and augment the yield from ground water sources like wells, hand pumps etc.

7.2 WATERSHED PLANNING UNIT

In the context of water harvesting, watershed improvement and management should cover any small drainage area of a local khud or gully or waterway of a drainage channel or a depression where rainwater concentrates after a heavy rain. The size of a drainage area or watershed for planning purposes should be about 40-50 ha so that it could be developed and managed by the village community.

7.3 GENERAL PLANNING APPROACH

Each watershed has unique characteristics and problems. Its treatment and management would therefore require careful consideration of various site specific factors like topography (shape, configuration and slope of the land), nature and depth of soil cover, type of rocks and their pattern of formation and layout, water absorbing capacity of land, rainfall intensity, land use etc. However, as a general rule watershed improvement measures are taken in the following manner as shown in Table 7.1.

Table 7.1 : Watershed Improvement Techniques

Nature of Terrain	Improvement Techniques
• Hill tops and upper reaches of watershed	Afforestation
• Steep hill slopes a little lower down	Development of grass lands
• Lower parts of watershed	(i) Contour bunding and terracing of agricultural fields (ii) Contour trenching (iii) Contour cultivation (iv) Strip cropping (v) Gully plugging (vi) Stream bank protection against erosion (vii) Farm ponds (viii) Control & regulation of grazing

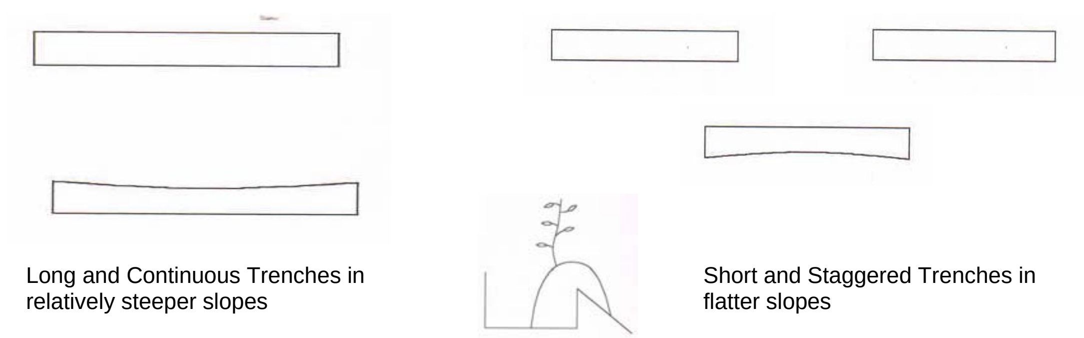
Contour Trenching

This consists of excavating shallow/ intermittent trenches across the land slope and forming a small earthen bund on the downstream side. Plantation is done on the bund to stabilize the bund. The trenches retain the runoff and help in establishment of the plantations made on the bund.

Trenches are useful where the land surface is fairly porous and rainwater collected in trenches can quickly percolate into the ground. The spacing of trenches and their size i.e. length, width and depth should be adequate to intercept about 50% of the peak rainfall in semi-arid regions i.e. with annual rainfall of about 400-550 mm.

The trenches should be cleaned and desilted periodically.

Figure 7.1 : Contour Trenches



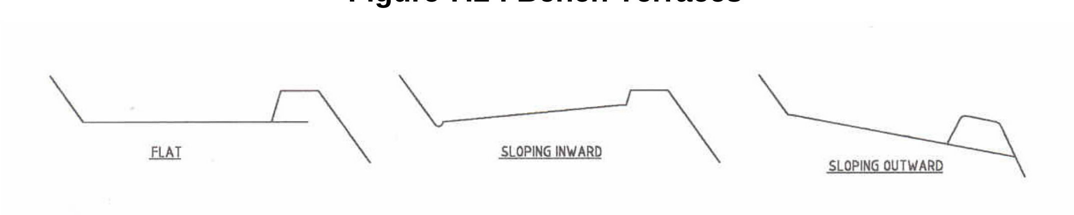
Controlled Grazing

Grazing of hill slopes by cattle denudes the vegetative cover and accelerates soil erosion. As such, grazing of hill slopes should be allowed in controlled manner. For this it is necessary to develop pastures separately and to adopt stall-feeding of cattle.

Bench Terraces

These consist of series of platform excavated on the slope. Depending upon the rainfall conditions and crops to be grown, terraces are constructed flat, sloping inwards and sloping outwards.

Figure 7.2 : Bench Terraces

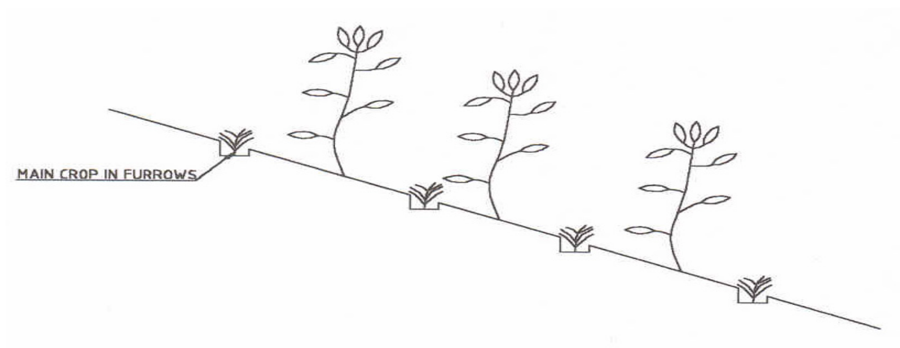


Continuous bench terraces differ from the tree-crop or orchard terraces. There are no idle spaces between terraces in the former case while they are prominent in the later. On a hill slope, bench terraces for vegetable and short-term crop usually are continuous. The lower terrace starts exactly from the line where the upper terrace ends. In other words, the cut section of the lower terrace begins where the fill section of the upper terrace ends. So we see benches between the riser slopes in a continuous manner. Unless the soil is extremely porous, such terraces have down-the-slope outlets, like a grassed channel with wooden drops or a prefabricated concrete channel with short drops or any other erosion control structures on the steep channel. The terraces have about 5 percent hillward grade. The riser slopes vary with the land slope (upto 30% land slope 1:1, above 30% and upto 60% land slope 0.75:1 and above 60% land slope 0.5:1). A longitudinal grade of about 1% is provided to lead the terrace water to the outlet. Riser slopes are grassed.

Contour Cultivation

This consists in carrying out different agricultural operations like ploughing, planting and inter-culture in horizontal lines across the sloping land. Such practices help in retaining rainwater and retarding erosion. These measures are effective when land slope is about 2% and less.

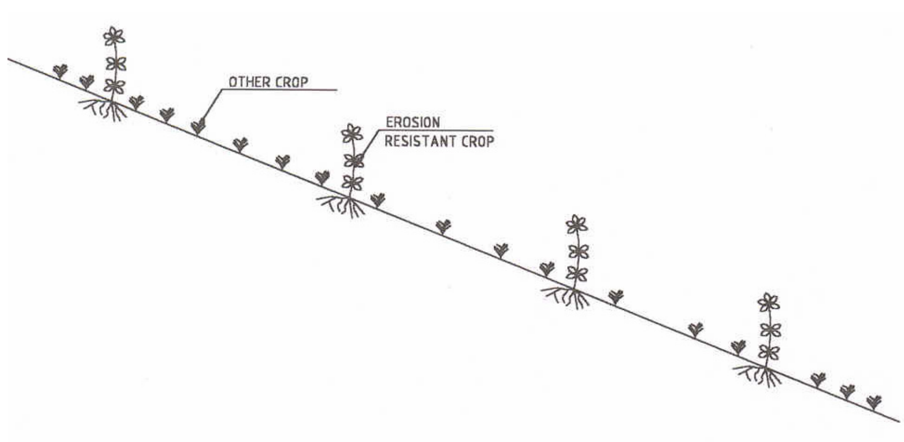
Figure 7.3 : Contour Cultivation



Strip Cropping

This involves growing parallel rows of erosion resisting crops to control loss of surface soil, with other crops grown in between.

Figure 7.4 : Strip Cropping



Gully Plugging

Gullies are a symptom of functional disorder of the land, improper land use and are the most visible result of severe soil erosion. They are small drainage channels, which cannot be easily crossed by agricultural equipment.

The gully plugging measures include vegetative plantings and brushwood check dams, boulder bunds, brick masonry and earthen bunds or a combination of both, sand bag plugs etc. The specifications for gully plugs are given in Table 7.2.

Table 7.2 : Specifications for Gully Plugs

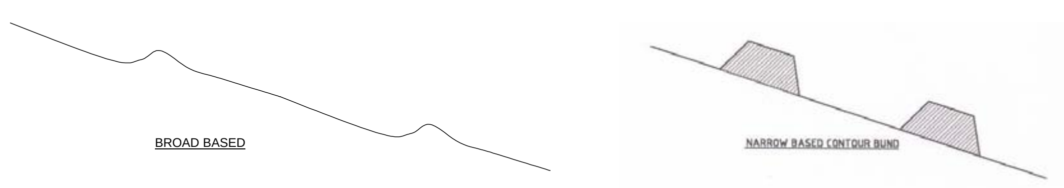
Slope of Gully Bed %	Width of Gully Bed (m)	Location	Type of Gully Plug	Vertical Interval
0-5	4.5 4.5-10.5 7.5-15.0 7.5-15.0	Gully bed Gully bed At the confluence of two gullies At the confluence of all branches of a compound gully	Brush wood Earthen Sand bag Brick masonry	3.0 2.25-3.0
5-10	4.5 4.5-6.0	Gully bed Gully bed and side branch	Brush wood Earthen	3.0 1.5-3.0

For gullies in which no significant runoff is expected from upstream, earthen gully plugs of 1.1 m cross-section with a grassed ramp of 22.5 cm below the top level are provided at 45-60 m intervals. For gullies in which excessive runoff from the top is expected, an earthen gully plug of 2.2 m cross-section is provided with a pipe outlet. The diameter of the R.C.C. spun pipe is 15 cm for a discharge of 0.03 to 0.09 cumecs coming from a catchment area of upto 1.6 ha. A composite check dam of earth and brick masonry is necessary for catchment areas larger than 1.6 ha. The first structure is located at the confluence of two or more gullies. For long gullies, more such structures are built either at 1.2 m vertical interval or 120 m horizontal interval.

Contour Bunding

This measure involves construction of horizontal lines of small earthen or boulder bunds across the sloping land surface.

Figure 7.5 : Contour Bunding



Top Width of Bund = 0.5 m
Side Slopes = 1:1
Height of Bund = 0.8 m

The term contour bunding used in India is same as “level terraces” and “ridge type terraces”. The bunds act as barriers to the flow of water and at the same time impound water to build up soil moisture storage. The spacing of bunds is so arranged that the flowing water is intercepted before it attains the erosive velocity. The vertical interval between the two bunds is determined by the following formula:

$$V = 0.3 \left(\frac{S}{3} + 2\right)$$

Where,

S = Degree of slope in percent
V = Vertical interval between two bunds

The spacing is increased by 25% in highly permeable soils and decreased by 15 percent in poorly permeable soils. It is always desirable to remove local ridges and depressions before building contour bunds. If levelling is not economical, a deviation of 10 cm for crossing the ridges and 20 cm for crossing the depressions.

For narrow bunds the top width is 50 cm, height is 80 cm and side slopes of 1:1. Cross sectional area in sq.m of broad based contour bunding with different height and side slope, is recommended as given in Table 7.3.

Table 7.3 : Recommended Side Slope for different Heights of Bund

Height of bund (m)	Side Slope				
	4:1	**5:1**	**6:1**	**7:1**	**8:1**
0.30	0.36	0.45	0.54	0.61	0.72
0.40	0.64	0.84	0.96	1.12	1.28
0.50	1.00	1.25	1.50	1.75	2.00

The design of cross-section of contour bund, which can store runoff excess from 24 hrs rainstorm, can be done with the help of the following equation.

$$h = \frac{Re \times VI}{50}$$

Where,

h = Depth of impounding in m near the bund
Re = 24 hours rainfall excess in cm
VI = Vertical interval in m

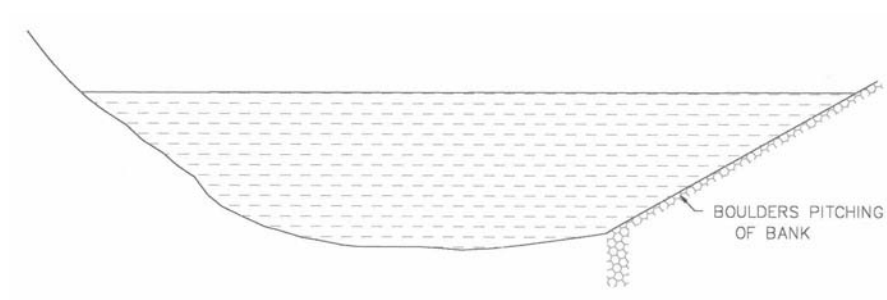
Using the above equation, height of impounding required for 10 years frequency (or any other frequency) can be obtained which will not cause any spill over. To the depth of impounding ‘h’, the free board of 25 to 30% may be added.

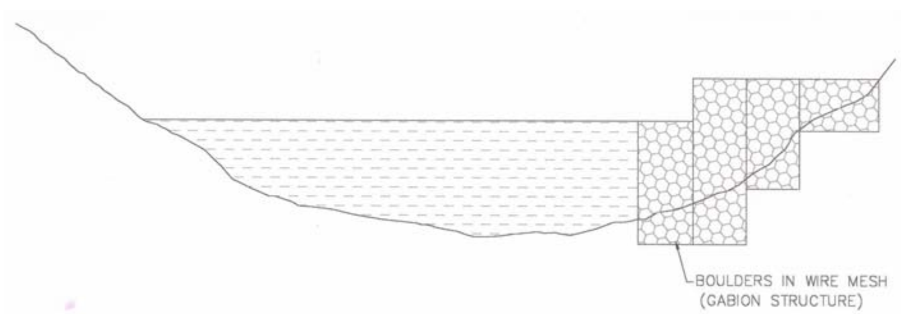
Stream Bank Protection

Eroding stream banks not only damage adjoining agricultural lands but also contribute large quantities of sediment load to the river systems. Under the watershed management programme, bank protection of only small/ minor streams are included. However, works of this nature should only be taken up if the benefits justify the cost of construction.

The works usually involved are in the nature of boulder pitching on banks of about 20-30 cm thickness after dressing the bank to a stable slope. Where the flow velocity of the stream is high (1.5 m/sec or more) gabion structures should be built at the toe of the bank with foundation firmly embedded in the streambed and bank.

Figure 7.6 : Stream Bank Protection





Farm Ponds

There is very little qualitative difference between a pond/ tank, which usually serves the population of a village, and farm pond, which serves an individual agricultural field. Farms ponds greatly vary in size depending upon the rainfall. In high rainfall areas of Orissa, for example, these have only a few metres of length and width and are built across the flow path of natural drainage channels. Surplus water from one pond spills over to a lower pond. In some cases a series of farm ponds are built on one single stream. Each pond caters to the irrigation needs of one farm and also augments ground water recharge.

In any watershed management programme farm ponds are an important component. Farm ponds are useful in storing water for irrigation. They also retard sediment and flood flows to the downstream river system. In relatively flatter terrain with good soil cover, a farm pond has an earth section with usually 3:1 side slopes on waterside and 2:1 side slopes on the downstream face (A uniform side slope of 2½:1 on both sides can be adopted at some sites). The sides are sodded. A natural depression nearby may be used as an earthen spillway with minimum channel section construction. A pipe drop inlet spillway and an irrigation outlet are also provided. A key trench is dug to give a good bondage between the original ground and the filled earth. Storm riprap against wave action may be required in some cases. The pond crest usually serves as a farm road (provide 4.25 m roadway for motorable roads).

A good pond site should possess the following traits:

(i) The site for the earthen bund should be narrow gorge with a fan shaped valley above so that a small amount of earthwork gives a large capacity.
(ii) The drainage area above the pond should be large enough to fill the pond in 2 or 3 spells of good rainfall.
(iii) The pond should be located where it could serve a major purpose: e.g. for irrigation, it should be above the irrigated fields and for sediment control it should intercept the flow from the most erodible parts of the catchment.
(iv) Junction of two drainage channels or large natural depressions should be preferred.
(v) The land surface should not have excessive seepage losses unless it is meant to serve as a percolation tank for ground water recharge.

Planning and design aspects of farm ponds are dealt with more or less in accordance with those for ponds/ tanks as discussed in Chapter-VI.