UNIT 3 ARABLE LANDS

Structure

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3.0 OBJECTIVES

After going through this unit, you should be able to:

- state the biological measures for erosion control in arable lands;
- describe engineering control measures for erosion control in arable lands;
- explain the vegetative barriers.

3.1 INTRODUCTION

In the earlier block, you were explained the causes, processes and types of soil erosion. Sediment transportation processes in water erosion were also discussed. You also studied the causes and processes and factors affecting wind erosion. The soil loss and its estimation were also dealt with. This unit will deal with various measures for erosion control.

As we know, land can be broadly divided into two categories - arable lands which are suitable for cultivation and the non-arable lands, which are not suitable for agricultural purposes. Both these lands experience one or another form of erosion directly or indirectly. Lands having less than 2% slope do not generally require any structural measure due to less runoff velocity and discharge. However, as slope becomes steeper, the structural or engineering
measures become essential to handle the flow and convey it safely. After understanding the factors responsible for various types of land degradation problems arising mainly due to water and wind erosion, the soil and water conservation measures need to be adopted to protect arable land from further degradation and improve the present condition for viable economic exploitation.

In the next unit, you will be exposed to drainage line treatment and slope stabilization measures for erosion control in non-arable lands. You will also study vegetative measures for wind erosion control.

3.2 BIOLOGICAL AND AGRONOMIC MEASURES

The methods used for controlling soil erosion through crops or vegetation or agronomic practices are called biological measures. Biological methods are equally efficient for controlling both water and wind erosion. Imposition of appropriate mechanical measures retards runoff velocity, minimizes erosion and recharges groundwater. These measures do not necessarily ensure uniform infiltration and moisture distribution in affected areas. Special agronomic practices are, therefore, essential for creating more or less uniform infiltration opportunity in the cultivated lands. The biological methods for controlling water and wind erosion consist of conservation tillage, contour cultivation, strip cropping and vegetative barriers.

3.2.1 Timely Sowing and Crop Canopy Manipulation

Most of the erosion occurs during few initial storms after the onset of monsoon when land surface is bare without any crop cover. Hence, sowing of crops as early as possible with the onset of monsoon helps in early establishment of crops, better root and shoot growth and development of canopy cover and minimizing soil erosion.

Manipulation of crop geometry to achieve closer spacing within the rows across the slope provides greater resistance to overland flow to reduce erosion losses. Although dense plant population is better from soil and water conservation point of view but it may lead to severe moisture, nutrient and light competition resulting in reduced crop yields.

3.2.2 Contour Farming

It is a system of farming on sloping lands in which ploughing, planting, sowing and intercultural operations are carried out along the contour lines as far as possible (Fig. 3.1). It creates numerous ridges and furrows which help in checking soil losses in humid areas and conserve soil moisture in low rainfall areas. Contour farming reduces runoff and prevents soil erosion as compared to up-and-down cultivation. Apart from conserving soil and water, it also builds up soil fertility and increases crop yields and reduces soil erosion even in high rainfall areas.

3.2.3 Intercropping

Growing two or more crops simultaneously in the same field following specific row or line arrangement is known as intercropping which helps in efficient utilization of resources and stability in yields under different rainfall situations. In terms of land use, the practice of intercropping is more
productive than growing crops separately. However, the additional productivity due to intercropping system is mainly dependent on complementarity of component crops. Intercropping of low canopy legumes such as groundnut, green gram, black gram, soybean and cowpea in wider inter-row spaces of crops like maize, sorghum and castor provides sufficient cover on the ground and thereby reduces erosion hazards apart from biological insurance to increase productivity of rainfed arable lands.

![Fig. 3.1: Crop sown along contour lines](image)

### 3.2.4 Mixed Cropping

In India, small size of land holdings mainly restricts farmers from adopting strip cropping. In such a situation, mixed cropping systems of low-canopy legumes with widely-spaced crops is the most suitable option. It provides a better and continuous ground cover, protection against beating action of raindrops and soil erosion and ensures at least one crop under adverse climatic conditions, particularly in semi-arid and hilly regions. The cover crops such as green gram, black gram, groundnut, soybean, sunhemp and dhaincha restore soil fertility, control weeds, conserve rainwater and reduce energy and costs besides reducing soil erosion and improving morphological characters. The roots of various crops in mixed cropping utilize moisture and nutrients from different depths of feeding zone in the soil. In mixed cropping, different crops can be more conveniently sown by mixing the seeds, instead of sowing in alternate rows referred to as intercropping.

### 3.2.5 Conservation Tillage

The concept of conservation tillage is based on minimum disturbances on the top soil layer by applying practices like reduced tillage, minimum tillage, zero tillage and mulch tillage (Fig. 3.2). Under the conventional tillage, the soil is easily eroded by water and on drying turns into a fine dust by wind. To overcome these ill-effects, tillage operations are reduced and at least 30% crop residue cover is maintained on the soil surface until establishment of crop canopy cover (Fig. 3.3). All the tillage operations should be done along contour, which reduce soil loss from sloping land up to 50% compared to up-and-down cultivation along the slope. The effectiveness of contour farming varies with the slope steepness. Protection against more extreme storms improves by supplementing contour farming with strip-cropping protection soil against extreme storms.
3.2.6 Strip Cropping

Strip cropping is the method of growing alternate strips of erosion resistant and erosion permitting crops in the same field. For controlling water erosion, the strips are invariably laid out on the contour. In planning the strip cultivation, buffer strips are located on steep or badly eroded areas of the field that do not necessarily fit into the regular rotation. In such cases, strips of grass or other erosion resistant vegetation between or down the cultivated crop strips are called buffer strips which are used to provide more protection to the sensitive area from erosion than that usually afforded by a solid planting of grain or inter-tilled crop (Fig. 3.4). In contrast, in the dry areas, strips are sometimes placed across the prevailing wind direction to prevent wind erosion. Strips of cereals and pulses are likely to be placed alternately to provide resistance against erosion. Sometimes crop strips are made in regular pattern across the prevailing land slope that may not conform to any contour and are called field strips (Fig. 3.5). Such practices are recommended for the areas where topography is very irregular or undulating to follow contour strip cropping.
A strip of erosion resisting close growing crop reduces the velocity of runoff and protects the field from being washed away. Strips should be rotated every year by shifting the erosion resisting crop strips in regular sequence. In strip cropping, fast and dense canopy producing crops such as legumes, pulses or grasses are generally recommended as erosion resisting crops.

### 3.2.7 Mulching

Mulching is the application of plant residues or other materials to cover the topsoil surface and has the following advantages:

- Conserves the soil moisture.
- Reduces runoff and soil erosion.
- Restricts the weed growth.
- Protects the crop from winter season.
- Maintains the soil temperature.
- Minimizes the evaporation.
- Modifies the micro-environment of soil to meet the requirements of seeds for their good germination and better growth of seedlings.

Mulching also improves soil aeration, creates better biological activities and consequently has beneficial effect on the soil fertility. In low rainfall areas,
mulching helps in conserving moisture in the soil profile while in high rainfall areas, it reduces runoff and soil losses which, in turn, are reflected in higher crop yields.

(a) Mulching Materials

The followings mulching materials are generally used:

- cut grasses or foliage and straw materials or foliage;
- wood chips, saw dusts and paper;
- sand stones;
- metal foils; and
- plastics.

(b) Types of Mulches

**Natural:** The natural mulches are bestowed upon by nature itself and no manual effort is required.

**Synthetic:** They include organic and inorganic liquids sprayed on the soil surface to form a thin film for controlling various climatic impacts over the top soil surface. Resins, asphalt emulsions, plastic and paper products, polythene and polyvinyl chloride (PVC) and bitumen emulsions are used as covering materials.

**Conventional:** Hay or straw mulches are more effective than the synthetic mulches. These mulches also conserve moisture and reduce fluctuations of soil temperature. They also protect the soil from raindrop impacts and hold the excess surface water in contact with the soil, increase the infiltration rate thereby reducing runoff and soil erosion. During the day, these mulches also absorb as much insulation as bare soil with little downward energy which keeps soil cool.

**Stone:** A very old practice followed in arid regions involves the spreading of stone pieces on the ground surface to conserve moisture and reduce wind erosion. Soil under the stones tends to be in moist condition with slightly higher temperature of soil. The soils below the stones, hide small animals and involve high nitrification. The stone mulching is also used for trapping the dew particularly in those locations where significant dewfall takes place.

**Organic:** Tree branches, twigs, leaves, leaf litter, grasses, weeds etc. are used as organic mulches to cover the soil surface. Infiltration through small termite channels reduces runoff and soil loss.

3.2.8 Vegetative Barriers

Conventional conservation farming system approaches on flat as well as sloping lands are undergoing rapid change due to inherent constraints and increasing awareness and participation of the community. Alternative soil and water conservation measures like vegetative strips, grass strips, contour hedgerow on sloping lands are being increasingly adopted. Vegetative barriers or live bunds are closely spaced plantations, usually of a few rows of grasses or shrubs, grown along contours for erosion control in agricultural lands.
The choice of bushy shrubs and grasses in a given habitat is of great importance for the formation of vegetative barriers, used alone or in conjunction with mechanical measures on gentle slopes for erosion control. Vegetative barriers established on contours function as erosion controlling mechanisms with the farming system and also provide other products like fodder, fruits, green manure etc. (Fig. 3.6). Vegetative barriers perform following main soil conservation functions:

- Break slope length, reduce runoff velocity and increase infiltration opportunity time.
- Reduce the erosivity and transport capacity of runoff.
- Cause the deposition of eroded material, trap nutrients and induce formation of terracing.
- Cause cultivation and planning operations to be carried out on contours.
- Stabilize contour cultivation areas on steeper slopes.

**Fig. 3.6: Vegetative barriers to control erosion**

**Check Your Progress 1**

**Note:**

- a) Use the space below for your answers.
- b) Compare your answers with those given at the end of unit.

1) What do you understand by conservation tillage?

2) How do the contour cultivation and strip farming help in soil and water conservation?
3. Describe in brief the vegetative barriers.

3.3 MECHANICAL/ENGINEERING MEASURES

3.3.1 Land Levelling or Grading

Land levelling, land grading, land forming and land shaping are synonymous and refer to preparing or reshaping the land surface to a planned grade to provide a more suitable surface for cultivation. On an uneven land, irrigation is not uniformly applied resulting in uneven crop growth, reduced yields and loss of water and fertilizers. A properly levelled land ensures uniform application and distribution of water throughout the field which helps in maintaining maximum yield per unit volume of water. It is beneficial in irrigated areas to conserve moisture and increase irrigation efficiency. In low rainfall areas, it reduces runoff and induces greater amount of rainfall to infiltrate into the soil and ensures uniform moisture distribution. The initial investment in land levelling is high, thus it is recommended only under special conditions. Land development or on-farm development is recommended to achieve higher water use efficiency and higher yield.

3.3.2 Bundling

Bunds are small embankment type structures made up of locally available earth materials and are constructed for specific purposes. Land slope and soil characteristics are the major criteria for selection of bund type and its design.

Types of Bunds

Contour and graded bunds discussed below are popular from conservation point of view.

(a) Contour Bunding

Contour bunds are constructed along approximate contours (points of equal elevation) on the slopy land for interception of runoff and moisture conservation in areas having slope of 2-6% and scanty (less than 800 mm, annually) or erratic rainfall. Contour bunds can be adopted on most types of relatively permeable soils i.e. alluvial, red, laterite, brown, shallow, medium black except the clayey deep black soils. Contour bunding is recommended for semi-arid areas only where intensive farming is not feasible without irrigation or levelling is not feasible due to high cost involved. Contour bunding is found to increase crop yields by about 15-20% and maintain soil fertility for considerable periods.

Contour bunds perform following functions:

- Intercept runoff flowing down the slope.
- Maintain moisture in the field for longer periods for subsequent use by the crops.
• Ensure uniform distribution of moisture.
• Reduce steepness (degree) of slope.
• Control erosion on agricultural lands in different agro-ecological regions.

Contour bunding has the following limitations.
• Considerable area of arable land lost in bunding (5-10%).
• Skilled labourers required for properly laying the contour lines.
• Problem in disposing off excess runoff due to very high intensity storms.
• Portion of land on the sides of bunds not properly cultivated.
• Unsuitable for area having clay or impervious soil, slopes steeper than 6% and more than 800 mm rainfall.

**Design Procedure**

(i) **Spacing of the contour bunds**

The bunds should be spaced in such a way so as to intercept erosive velocity. The spacing should not be too close to interfere in the farming operations. It depends on the following:

• Slope length and slope steepness
• Rainfall
• Cropping system
• Conservation practices to be adopted

Ramser’s formula is used for the design of bunds as per suitability based on field observations (semi-arid climate with good infiltration rate).

\[ VI. = 0.3 \left( \frac{S}{3} + 2 \right) \]  

Where,

\[ VI. = \text{vertical interval between two consecutive bunds, m; and} \]

\[ S = \text{degree of slope (as such) \%}. \]

For very high infiltration rate, 25% extra spacing is provided. In case of low infiltration rate, spacing is decreased by 15%.

(ii) **Cross-section**: It depends upon on the following:

• Rainfall factor that decides the depth of water standing against the bund can be obtained from the peak rate of runoff expected for a given area.
• Rate of infiltration of water into the soil (lesser the rate, more is the depth of water impounded).
• Vertical interval \((VI.)\) (more the \(VI.\), more is the depth of water impounded).

For a trapezoidal cross-section (Fig.3.7), the cross-sectional area is given by:

Cross-sectional area = \([ (\text{basewidth} + \text{width})/2 \] × height
(iii) Bund height: It is decided on the basis of following points:

- Depth of water to be impounded i.e. full supply level (F.S.L.) (Fig.3.8).
- Design depth of flow over the weir i.e. highest flood level (H.F.L.).
- Free board (20% to 30%).
- Maintenance needs slightly greater height than the minimum worked out.

The height of the contour bund may be worked out by considering the above points as:

\[ H_w = \sqrt{\frac{R \times V.I.}{50}} \]  

(3.2)

Where,

- \( H_w \) = depth of impoundment in front of bund, m;
- \( R \) = 24 hours excess rainfall to be stored, cm; and
- \( V.I. \) = vertical interval between the consecutive bunds, m.

25% of \( H_w \) is added as free board and 30 cm depth is considered as waste weir flow, hence the total height of the contour bund is computed by applying the formula:

\[ H = H_w + 0.25 \, H_w + \text{flow depth over waste weir (}H_r) \]  

(3.3)
Horizontal interval (H.I.) is related with V.I.

\[ H.I. = \frac{V.I.}{S} \times 100 \]  

(3.4)

(iv) Area lost due to contour bunding

The actual area occupied by the bunds depends upon the base width, the land slope and the V.I. of the bund. The area occupied by the main bund alone is computed as follows:

\[ \text{Per cent area lost due to main bund, m}^2 \text{ per ha} = \frac{(S \times b)}{V.I.} \]  

(3.5)

Where,

- \( S \) = prevailing land slope;
- \( H.I. \) = horizontal interval, m;
- \( V.I. \) = vertical interval, m; and
- \( b \) = base width of contour bund, m.

(v) Earthwork for bunding

Total Earthwork/ha = \([(1.3 \times 100 \times S)/ V.I.] \times \text{Area of cross-section of bund} \]  

(3.6)

Points to Remember:

- 30 cm depth of impounding is being adopted as the designed depth in many states.
- 30 cm depth of flow over the outlet and 15 cm depth as free board should be provided.
- 75 cm height with top width of 60 cm and bottom width of 200 cm are generally adopted.
- Side slope of bund is taken as 1:1 (approx.). With these specifications, the cross-section approximately works out to be 1 m².
- From practical point of view, the contour bunding is recommended in low rainfall areas with permeable soils and cross-section of 1 m².
- Outlet structures are provided at the lowest point of the bund to protect contour bunds from breaching and avoid damage to the crops due to water impounding.
- Contour bunds are generally designed on the basis of 10 years frequency.

(b) Graded Bunding

Graded bunds or graded terraces or channel terraces are laid along a predetermined longitudinal grade instead of a contour up to 10% land slope for safe disposal of excess runoff (Fig. 3.9). They are adopted in areas with low infiltration rate (less than 8 mm/hr) and slope of 2-8%, annual rainfall more than 800 mm and need quick drainage of runoff water to prevent damage. They perform following functions:
Soil and Water Conservation Measures

- Dispose-off runoff water safely at slow velocity instead of rushing off.
- Act as a drainage channel for inducing and regulating the excess runoff water.

**Diversion Channel**

![Diversion Channel Diagram]

Fig. 3.9: Planning graded bunding

- Regulate the runoff with a mild and non-erosive velocity.
- Provide opportunity time for infiltration of water in the field to conserve *in-situ* moisture through longer travel of flowing water.

**Merits**

- Lead to increase in crop yields in places where crops are damaged due to impounding of rainwater.
- Help in maintaining the fertility of agricultural lands.
- Straightened natural waterways have the advantage of terrace outlets.

**Limitations**

- Considerable area of arable land is lost in bunding and drainage channels.
- Skilled labourers are required for properly laying the grade of bunding lines and inter-bund terraces.
- Cannot be constructed on uneven topography.
- Crops needing impounding of water cannot be grown.

**Points to remember**

- Decide the location of the waterway (outlet).
- Divert runoff from the upper catchment safely by constructing a diversion channel.
- Provide appropriate grade along the contour.
- Determine outlet elevation of the second terrace.
- Align second and subsequent terraces accordingly.
- As a safety factor, locate a terrace system comprising of short terraces and several outlets in natural water courses.
Construct structures encounter sudden drops, excessive velocities and poor grass cover conditions if vegetation alone is not sufficient to provide protection from concentrated water down the slope.

**Example 3.1**

Calculate the design height of contour bund used to store 24 hours excess rainfall of 10 cm. Annual rainfall is about 100 cm, soil has high intake rate and the land slope is 4%.

**Solution**

a) Vertical Interval \((VI.)\) is computed by applying Ramser's formula

\[
VI. = 0.3 \left(\frac{S}{3} + 2\right)
\]

\[
= 0.3 \left(\frac{4}{3} + 2\right) = 0.3 \times 4 = 1 \text{ m}
\]

b) Depth of impoundment \((H_w)\)

\[
H_w = \sqrt{\frac{R \times VI.}{50}}
\]

Or, \(H_w = \sqrt{\frac{10 \times 1}{50}} = 0.45\) m

Considering 30 cm flow depth \((H_f)\) over waste weir, and 25% as freeboard height of bund is,

\[
H = H_w + 0.25H_w + H_f
\]

\[
= 0.45 + 0.11 + 0.30 = 0.86 \text{ m}
\]

So, the total height of the bund is 0.86 m or say, 90 cm.

**Example 3.2**

Find the horizontal interval of bunds on a land having 3% slope and situated in a medium rainfall zone. Also calculate the length of bunds per hectare.

**Solution**

\[
VI. = 0.3 \left(\frac{S}{3} + 2\right)
\]

\[
= 0.3 \left(\frac{3}{3} + 2\right) = 0.9 \text{ m}
\]

\[
H.I. = \frac{VI.}{S} \times 100
\]

\[
= 0.9 \times \frac{100}{3}
\]

\[
= 30 \text{ m}
\]

Length of bund per ha = \(10,000/30 = 333\) m

**Example 3.3**

Calculate earthwork required to construct a contour bund in an area of 5 ha with land slope of 3%. How much area will be lost in developing the main contour bunds? Proposed base and top widths of trapezoidal section of contour bund are 1.5 m and 0.40 m, respectively and height of bund is 0.80 m.

**Solution**

Given: Area = 5 ha;
Soil and Water Conservation Measures

Slope \( (S) \) = 3%;
Base width \( (b) \) = 1.5 m;
Top width = 0.40 m; and
Height of bund = 0.80 m.
V.I. of contour bund = 0.3 \( \frac{(S/3+2)}{3/3+2} \) = 0.9 m

Cross-sectional area, \( A \) = \[ \frac{(1.5 +0.4)}{2} \times 0.8 \]
= 0.76 m²

Volume of earthwork/ha = \[ \frac{((3 \times 100 \times S)}{V.I.} \] \times A
= \[ \frac{((1.3 \times 100 \times 3)}{0.9} \] \times 0.76
= 329.33 m³

Total volume of earthwork for 5 ha area = 329.33 \times 5 = 1646.67 m³

% area lost in main bunding = \( \frac{(S \times b)}{V.I.} \)
= \( \frac{(3 \times 1.5)}{0.9} \) = 5 %

3.3.3 Bench Terracing

Bench terracing comprising of step like fields constructed along contours usually by half cutting and half filling procedure is used in hilly areas having slope of 6% to 33% (Fig. 3.10). They are also used at lower slopes for raising crops like paddy which require uniform impounding of water. It performs the following functions:

- Converts original steep land slope into nearly level fields to minimize the hazards of erosion.
- Reduces degree and length of slope.
- Helps in soil moisture conservation for enhanced crop production.

Fig. 3.10: Terrace agriculture

Merits

- Provides opportunity to raise a number of crops where cultivation is otherwise difficult due to topographic constraints.
- Helps in maintaining the fertility of agricultural lands.
- Helps in irrigating table top terraces for better production.
- Checks land degradation.

Limitations

- Skilled labourers required for laying the contours.
- High initial investment for construction.
- Unsuitable for shallow soil depth.
- Loss of considerable area in case of steep slopes.

Types of Bench Terraces

(a) Level bench terraces (table top)
There is no slope on the terrace in any direction and it looks like top of a table, hence, called table top terrace (Fig. 3.11). They are used for paddy cultivation to provide uniform impounding and can be adopted for highly permeable deep soils and even on mild slopes with medium rainfall.

(b) Inwardly sloping bench terraces
The slope of such a terrace is towards hillside, therefore, it is called as inward sloping bench terrace (Fig. 3.11). They can be adopted under following conditions:
- High rainfall regions for safe disposal of runoff water.
- Deep and good permeable terrain.
- Quick and safe disposal of runoff through the drain provided on the inner side.
- Used for raising crops susceptible to the water stagnation.

(c) Outwardly sloping bench terraces
It is called outward sloping bench terrace as the slope of the terrace is towards the valley side (Fig. 3.11). They can be adopted in areas with shallow soil depth and low rainfall.

(d) California type bench terraces
These terraces are developed by gradually excavating soil during each ploughing and pushing the soil down hill against a vegetative or structural barrier laid along the contour. The terraces are developed gradually through deposition behind the structural or vegetative barrier in a period of 3-5 years.

Fig. 3.11: Types of bench terraces
(e) Conservation Bench Terracing (CBT)

CBT system is a mechanical measure which has been applied successfully to mild sloping lands in arid, semi-arid and sub-humid regions for erosion control, water conservation and improvement of crop productivity. It consists of a terrace ridge to impound runoff on a level bench (recipient area) and a donor watershed, which is left in its natural slope and produces runoff that spreads on the level bench (Fig. 3.12). Crops such as maize, sorghum or bajra requiring drainage are cultivated on sloping area while water intensive crops like paddy is taken on the level bench and runoff is harvested from upper area for the benefit of crops grown in the lower levelled portion of the field. Thus, even in low rainfall conditions, assured crops can be taken on conserved moisture. The system is suitable on mild sloping areas having silty loam to silty clay loam soils of medium depth in semi-arid to sub-humid regions.

The ratio of donor to recipient area may vary from 1:1 to 3:1. At the end of receiving area, a shoulder bund is provided to impound runoff up to 20 cm depth. The CBT system registers 7.4% of rainfall as runoff and 1.19 tones/ha of soil loss as compared to 36.3% of rainfall as runoff and 10.1 tones/ha in the conventional system of sloping borders.

![Fig. 3.12: Conservation bench terrace (CBT) system](image)

**Main Features of CBT System**

- Gentle land slopes up to 10% are most suitable. A steeper slope requires more earth movement and hence more cost is involved.
- Deep soil is essential for providing enough soil moisture storage as well as reducing the effect of cutting while constructing the terrace.
- Velocity of runoff flow is minimized by reducing the slope length.
- Good permeability of soil is desired so that impounded water is absorbed quickly.
- Smooth slopes are advantageous under mechanised farming if terraces of uniform width are laid parallel to each other.
- Suitable for raising crops in the level bench portion on conserved moisture due to harvested runoff from the upper contributing area.
- Precise levelling of the bench terrace is important to facilitate uniform infiltration.
• Adequate storage of runoff is provided during the periods of low intensity storms due to water storage in the levelled portion.

• In the event of greater quantity of runoff from the contributing area that can be absorbed and stored in the terrace, provision must be made for proper outlets at the end of the terrace for safe disposal into a pond/water way.

• Typical ratios of contributing to receiving areas may be selected as 1:1 or 2:1 or 3:1 as per need of the location and rainfall of the area.

(f) Strip terraces on contour

This practice is adopted in fairly deep soils in steep hilly areas for making ‘fruit belts’ in unexploited sites in Kashmir, H.P., North-Eastern Hilly region and Uttarakhand hills. The width of these terraces is quite narrow (1 to 1.5 m) for the purpose of plantation of orchards and some cash generating inter crops such as potato and ginger etc. The design includes estimation of terrace spacing, terrace grade along the width and length and terrace cross-section.

(i) Terrace spacing

Terrace spacing usually expressed in terms of vertical interval (V.I.) affects the depth of cut and the height of the bund and thereby the total vertical drop. The width of the terrace should be such that it enables convenient and economic agricultural operations. The following steps are used in terrace design:

Step I: Find out the maximum depth of productive soil (D). Lesser the depth of cutting, the greater will be the depth of productive soil available for cultivation.

Step II: Find out the maximum admissible cutting (d) for the desired land slope (S) and the crops to be grown. This depth of cutting should enable construction of terraces with convenient widths.

Step III: The width of terrace (W) can be computed for a given slope (S) by the formula

\[ W = \frac{200d}{S} \]  

Where, 

W and d are in meter and S in %

Step IV: If the riser batter is 1:1, then

\[ V.I. = \frac{WS}{100 - S} \]  

For riser batter of 0.5:1,

\[ V.I. = \frac{2WS}{200 - S} \]  

Note: For a given slope: Greater the V.I.; greater would be the width.

For a given V.I. steeper the slope, smaller would be the width.
(ii) Terrace gradient

Suitable terrace gradient has to be provided in new terraces in high rainfall areas for safe and quick disposal of the excess water.

(iii) Terrace cross-section

In bench terrace construction, the earth excavated from the upper half is deposited over the lower slope and this forms an embankment which should be properly and safely secured on the slope by clearing the vegetation and providing the key trenches. Suitable batter in the cutting and embankment is provided for ensuring stability.

Earth work in bench terracing:

\[ E = \frac{WS}{8} \times 100 \]  

Where,

- \( E \) = volume of earthwork, m³;
- \( W \) = width of terrace, m; and
- \( S \) = land slope, %.

Area available for cultivation = 100 (100 - \( nS \))

Where,

- \( n \) = batter slope, %; and
- \( S \) = land slope, %.

3.3.4 Scooping

It is a small ditch constructed in a semi-circular or helical shape. The dugout soil is kept on downstream tip of scoop as a soil bank. The tip of the scoop is made along the contour or slightly adjusted along the contour lines. The runoff flowing from contributing micro-catchment is collected in the scoop to a maximum depth equal to the height of bund made on downstream. Provisions are made to drain the excess water safely from the tip point of upper scoop to the next lower scoop. Thus, the rows of scoops are constructed in a staggered manner so that the overflowing water from the upper row may be easily harvested into lower row of scoops. The height of scoop is kept 0.1 to 0.5 m and radius varies from 0.5 to 2.5 m. Scoops are efficient moisture conservation practices which help in survival of plantation crops, grasses, fodders, shrubs and trees.

Check Your Progress 2

Note: a) Use the space below for your answers.

b) Compare your answers with those given at the end of unit.

1) Explain the suitability of graded bunding and enumerate the main points to be considered in designing.
2) List types of bench terraces and their functions.

3) Which type of terrace will you design for paddy crop?

4) What is a conservation bench terrace?

3.4 LET US SUM UP

- The suitability of a given type of conservation measure in an area depends upon slope, rainfall (amount and distribution), soil type and depth, water holding capacity, location of impervious layer, agricultural practices, power/equipments used and economics.

- Lands having less than 2% slopes do not require any structural measures. Narrow or broad based terraces are recommended for lands up to 10% slope. The broad based terraces are useful when land holdings are large and machinery is used for farming operations.

- In high rainfall areas, land slopes more than 6% need uneconomically closer spacings resulting in more loss of area. It is difficult to achieve uniformity in bunding practice on lands steeper than 4% and in any case steeper than 6%.

- For lands with slopes between 10% and 33%, bench terracing is an effective measure as it breaks the length and also reduces the degree of slope. It, however, is expensive, restricts farming operations and significant area is lost out of cultivation.

3.5 KEYWORDS

Arable Farming: The farming system which involves tillage practices for crop cultivation is called as arable farming.
Bench Terrace: It is a mechanical measure to control soil erosion on sloping lands by converting the steeply sloping land into steps or bench like fields. The benches constructed are used to grow the agricultural crops depending upon soil depth and water available in the area.

CBT: Conservation Bench Terracing.

Check Dams: These dams are smaller in size than the conventional dams. The check dam is constructed in the gully section to control the runoff and impound water on the upstream side for various uses.

Drainage: Removal of excess surface water either from the soil surface or from saturated profile to create favourable conditions for plant growth.

Scooping: It is a small ditch constructed in a semi-circular or helical shape.

Semi-permanent Gabion Check Dams: These structures are commonly used for drainage line treatment in relatively bigger streams. Cross barriers have been found more suitable in main drainage channels of the mine spoil areas for debris collection and grade stabilization.

Spillway: It is an outlet provided in the water bodies for safe disposal of excess runoff from unforeseen events.

Strip Cropping: It is the method of growing alternate strips of erosion resistant and erosion permitting crops in the same field.

3.6 SUGGESTED READING


3.7 MODEL ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1) The concept of conservation tillage is based on minimum disturbances in the top layer of field soil by using practices like reduced tillage, minimum tillage, zero tillage and mulch tillage.

2) Contour farming/cultivation is a system of farming on sloping lands in which ploughing, planting, sowing and intercultural operations are carried out along the contour lines as far as possible. It creates numerous ridges and furrows which help in checking soil losses in humid areas and conserve moisture in low rainfall areas.

In strip farming, the alternate strips of erosion resistant and erosion permitting crops are taken in the same field. For controlling water erosion, the strips are invariably laid out on the contour. In planning the strip cultivation, buffer strips are located on steep or badly eroded areas of the field that do not necessarily fit into the regular rotation.

3) Vegetative barriers are closely spaced plantations, usually of a few rows of grasses or shrubs, grown along contours for erosion control in agricultural lands. The main soil conservation functions of a vegetative barrier are:

- Breaks the slope length, reduce runoff velocity and increase infiltration opportunity time.
- Reduces the erosivity and transport capacity of runoff.
- Causes the deposition of eroded material, trap nutrients and induce formation of terracing.
Soil and Water Conservation Measures

- Enables cultivation and planning operations on contours.
- Stabilizes contour cultivation areas on steeper slopes.

Check Your Progress 2

1) Graded bunding is recommended under the following conditions.
- Land slope between 2 and 8%.
- Annual rainfall more than 800 mm.
- Infiltration rate less than 8 mm/hr and rainwater not readily absorbed into the soil due to low infiltration rate such as clayey soils.
- Crops need quick drainage of runoff water to prevent damage.

Main points to be considered in designing
- Decide the location of the waterway (outlet).
- Runoff from the upper catchment has to be diverted safely by constructing a diversion channel.
- Provide appropriate grade along the contour.
- Determine outlet elevation of the second terrace.
- Alignment of second and subsequent terraces need to be done accordingly.
- As a safety factor, a terrace system comprising of short terraces and several outlets is located in natural water courses.
- If vegetation alone is not sufficient to provide protection from concentrated water flowing down the slope, structures need to be constructed to encounter sudden drops, excessive velocities and poor grass cover conditions.

2) Bench Terracing comprises of construction of step like fields along contours usually by half cutting and half filling procedure. Following types of terraces are used.

(a) Level bench terraces (table top)
(b) Inwardly sloping bench terraces
(c) Outwardly sloping bench terraces
(d) California type bench terraces
(e) Conservation bench terracing

Functions
- Converts original steep land slope into nearly level fields and thus the hazards of erosion are minimised.
- Reduces degree and length of slope.
- Helps in soil moisture conservation for enhanced crop production.
3) Level bench terrace is a suitable terrace for paddy crop. There is no slope on the terrace in any direction and it looks like top of a table. They are made for paddy or other such crops to provide uniform depth of irrigation. Uniformity of depth of irrigation on the levelled terraces is maintained to a great extent.

4) The Conservation Bench Terrace (CBT) system consists of a terrace ridge to impound runoff on a level bench and a donor watershed which is left in its natural slope and produces runoff that spreads on the level bench. It is suitable for arid, semi-arid and sub-humid areas up to a slope of less than 10%. The ratio of contributing and receiving areas depends upon the rainfall, slope and type of soil besides the crops to be grown.