	AGRICULTURAL TVET COLLEGE	

SMALL SCALE IRRIGATION DEVELOPMENT LEVEL-III

MODEL TTLM

Learning Guide- 13

Unit of competency: Implement soil and water conservation Measures

Module Title: Implementing soil and water conservation measures

LG code: AGR SSI1M 13 LO1-LO5

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Nominal Duration: 65Hr

Instruction sheet	Learning guide- 13

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:–

- Implement physical and biological soil and water conservation measures
- Construct micro-catchment's water harvesting structures
- Construct macro-catchment's water harvesting structures
- Construct excess water draining structure
- Construct flood water harvesting structures

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to –

- Assess indigenous soil & water conservation measures
- Prioritize physical & biological soil & water conservation measures
    - Considering cost
    - Considering severity
    - Considering adaptability
- Enhance community awareness & participation
- Identify types & species of trees & crops
- Set design criteria & specifications for physical soil water conservation practices
- Set up physical & biological soil & water conservation structures
- Assess adaptability of different micro-catchment's water harvesting structures
- Enhance community awareness & participation
- Set design criteria & specification for the chosen micro-catchment's water harvesting structure
- Assess adaptability of different macro-catchment's water harvesting structures
- Enhance community awareness & participation
- Set design criteria & specification for the chosen macro-catchment's water harvesting structure
- Estimate area of land irrigated & amount of excess water and identifying design discharge
- Examine general & cross slope of field

- Determine size & cross-section of channel
- Organize all tools &equipment
- Plan excess water reuse and disposal
- Select appropriate types of drainage structures
- Undertake drainage construction
- Assess adaptability of different flood water harvesting structures
- Enhance community awareness & participation
- Set design criteria & specification for the flood water harvesting structure

Learning Activities

1. Read the specific objectives of this Learning Guide.
2. Read the information written in the "Information Sheets.
3. Accomplish the "Self-check" at the end of each learning outcomes.
4. Ifyouearnedasatisfactoryevaluationproceedtothenext"InformationSheet".However, if you acting is unsatisfactory, see your teacher for further instructions or go back to the Learning Activity.
5. Submit your accomplished Self-check. This will form part of your training portfolio
6. Follow the steps and procedure list on the operation sheet
7. Do the "LAP test" and Request your teacher to evaluate your performance

Information Sheet-1	**Implement physical and biological soil and water conservation measures**

Introduction:

Soil erosion is the removal of soil particle from the original place by action of agent: such as Water, Wind and Animal. Soil erosion takes place in three stages

- Detachment
- Transport
- Deposition

Indigenous knowledge refers to the perception that farmers have about their natural and social environment, which they use to adopt, adapt and develop technologies to their local context. The rationale for undertaking certain traditional practices among others is recognition of problems by the local people.

Indigenous soil and water conservation measure- is a dynamic and ever-changing accumulation of the collective experience of generations and is the complex, traditional beliefs and practices generated by indigenous people in relation to natural resource management, agriculture and human; and animal health care.

1.1 Assessing indigenous soil & water conservation measures

Indigenous practices are aimed at arresting the local priority problems. Although they survived the challenges of changing bio- physical and socio-economic environments through a continuous responsive changes and adaptations. It is, however, believed that indigenous practices certainly fit into the local socio-economic situations and might be easily handled by farmers' knowledge and the resources at their disposal.

The following are the most common examples of indigenous conservation technologies.

Fallowing

- Manuring
- Crop residue application
- Terracing/ different types, level, graded fanyajuu….
- Bunding/ soil bund, stone bund, stone faced soil bund
- Crop rotation etc……
- Soil Bund
- FanyaJuu
- Trash lines
- Bench terrace
- Traditional ditches (field cut off drains)
- Tit cultivation

1.2 Prioritizing physical & biological soil & water conservation measures

1.2.1 Considering cost

Negarimmicro catchments have been developed for the production of fruit trees, but even there the returns on investment are not always positive. It is not a cheap technique, bearing in mind that one person-day is required to build (on average) two units, and costs per unit rise considerably as the micro catchment size increases.

It is essential that the costs are balanced against the potential benefits. In the case of multipurpose trees in arid/semi-arid areas, for several years the main benefit will be the soil conservation effect and grass for fodder until the trees become productive. Negarimmicro catchments are appropriate both in village afforestation blocks, or around homesteads where a few open-ended "V" shaped micro catchments provide shade or support amenity trees.

1.2.2 Considering severity

Soil erosion by water is recognized to be a critical economic problem in high land of Ethiopia. However nearly all the available information about its severity and economic costs are extrapolated from plot and micro-watershed level studies which are too few in number to represent the diverse environment of the country. Moreover, plot and watershed level studies do not show actual soil losses.

1.2.3 Considering adaptability

Physical soil and water harvesting structure is suitable/ adaptable on steep slope because biological measures are not recommended on steep slope.

1.3 Enhancing community awareness & participation

Identifying the groups exist within the community one can know the objective of these groups. By identifying these groups with their objectives we can provide good extension service of SWC Program and this helps a great role for the success of your plan.

This identification of range of groups in community is very important for rural development like implementing natural resource conservation, by empowering each group on the conservation and protection of natural resources and development of the community asset and maintenance of good governance with in a community.

Definitions of terms

Culture: - culture as a "… complex whole, which include knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by man as a member of a society". Accordingly, a given people's culture includes their beliefs, rules of behavior, language, ideas, rituals, work of art, customs, taboos, codes, technology, institutions, and styles of dress, ways of producing and cooking food, religion, and economic system

Culture is a general term to represent the symbolic and learned aspects of human society.

Community Values*:* - In general "…values are society's ideas of what is good and desirable; the good and desirable satisfy a collective need or desire" (Stebbins, 1990: 14).

Community values are the foundation for a community's vision and action plan.

1.4 Identifying types & species of trees & crops

Tree seedlings of at least 30 cm height should be planted immediately after the first rain of the season. It is recommended that two seedlings are planted in each micro catchment - one in the bottom of the pit (which would survive even in a dry year) and one on a step at the back of the pit. If both plants survive, the weaker can be removed after the beginning of the second season. For some species, seeds can be planted directly

Zai, planting pit

Planting pits or zai are the simplest form of water harvesting. The planting pit technique consists of digging small holes of about 10 to 15 cm deep, in which a little manure is put together with some seeds. During rainstorm the planting pits catch runoff and concentrate it around the growing plants. AreYields improved in the first season after the land has been treated, and even in very dry years these techniques ensure some yield?

Technical Details

Suitability

Zia are usually constructed on degraded abandoned or unused land that is on crusted, hard, Compacted and poorly structured soil of semi-arid areas. The planting pit meets the criteria for three types of construction practices at the same time.

Soil: - it generally applied on silt and clay soils

Slope: - zai can be practiced at a slope of up to 8%-12%, if cutoff drain incorporated with in at appropriate space.

Topography: - the topography must be even

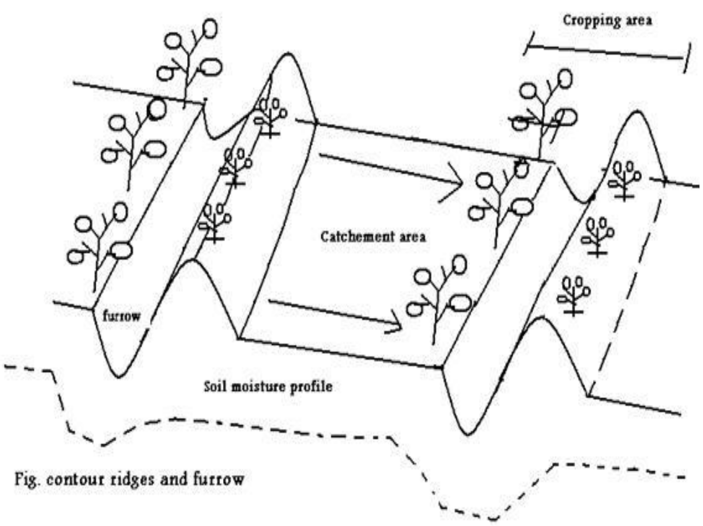
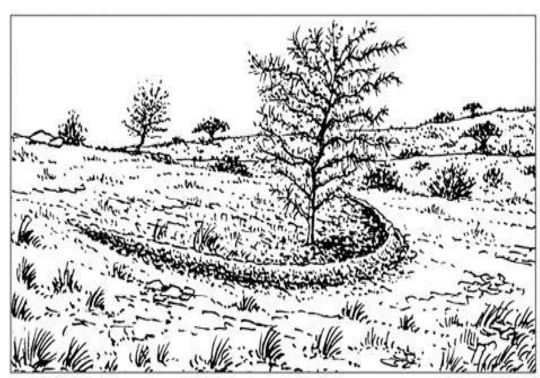


Fig. contour ridges and furrow



Semi-circular bund with *Acacia* tree; Source: Rocheleau 1988

1.5 Setting design criteria & specifications for physical soil water conservation practices

Structural (physical) soil and water conservation Example

Diversion ditch / cut-off drain:a graded channel with a supportive ridge or bank on the lower side. It is constructed across a slope and designed to intercept surface runoff and convey it safely to an outlet or waterway.

Waterways: are needed to conduct runoff safely from hill slopes to valley bottoms where it can join a stream or river.

Retention / infiltration ditch:large ditches designed to catch and retain all incoming runoff and hold it until it infiltrates into the ground.

Pit:planting holes (Sediment / sand trap: device (either an above ground barrier or a dam wall) builtspecifically to trap sand or sediments moving in the wind or in water flow.

Dam / pan:blockage of watercourse or excavation at a low spot of land to collect water for various purposes.

Terrace:involve a more or less permanent change in slope profile.

Level bund / bank terrace: an embankment along the contour made of soil and/ or stones with a basin at its upper or lower side. They often develop into forward sloping terraces.

Graded bund: as level bund, but slightly graded (with 1-4%) towards a waterway or river.

Reshaping surface: smoothening of land surface, e.g. of mining sites, gullies (Cutting edges).

Soil (earth) and combined stone / earth bunds

Definition, specifications and purpose

Stone bunds are constructed where suitable stones are available on or near the field. They are preferred in sub humid environments because the drainage of excess water is better than on soil bunds. A stone layer often makes the foundation, while a combination of stones and soil is used during further development.

Potentials, benefits

- If well maintained, stone terraces are stable and durable
- Excess water can pass through the stone terraces
- Bunds minimize the velocity of runoff
- Loss of land is comparably low

Limitations, weaknesses

- On clay soils terraces can create water logging
- Open animal grazing easily enforces development of cattle pathways, a major source of soil erosion
- No active runoff control
- Removal of stone by the farmers for construction work
- Spillways can create problems for the subsequent fields.
- Overflow with high runoff
- Low durability of newly implemented soil bunds; needs frequent maintenance

FanyaJuu terraces

Fanyajuu terraces are constructed by digging ditches and heaping the soil, forming bunds in the upper sides of the ditches. Between the ditch and the bund a small ledge prevents the soil from sliding back. Spacing depends on slope and soil depth

Its purpose is to protect the high potential land, and to conserve soil and water.

Potentials, benefits

- If maintained highly effective soil and water conservation

Limitations, weaknesses

- Needs high labor input, therefore often applied only on severely eroded fields
- In steeper areas with high runoff there is a risk of overtopping
- Structure occupies a lot of space on steep slopes

Fig1.2.Hillside terracing

Definition, specifications and purpose

Hillside terracing is practiced in mountainous areas with slopes >30% to protect reforestation areas. The effect of hillside terraces is the same as for stone bunds but hillside terracing is combined with cut and carry. The spacing of the terraces in afforestation areas is narrower than on cropland.

Potentials, benefits

- Protection against wind and water erosion
- Moisture and soil conservation

Limitations, weaknesses

- Susceptible under uncontrolled grazing
- Some types of grass sown under the trees, (e.g. elephant grass) are not drought resistant, and need irrigation

1.6 Setting up biological soil & water conservation structures

The main physical and biological soil and water conservation measures are

- Nitrogen fixation
- Mulching
- Terrace
- Bund construction
- check dam
- Retention reservoirs
- Grassed water ways
- Cut off drain

Agronomic and vegetative/biological SWC measures

The principle of agronomic and vegetative measures is to maintain a high vegetative cover, which serves two purposes: production and protection. An improved crop management can involve improved seeds, appropriate varieties, diverse varieties, optimal timing of planting, appropriate spacing of plants, fertilization, integrated pest and disease management, etc.

- Soil Management
- Surface Roughening,
- Surface Mulching

Mulching is the placement of a protective cover over the soil surface to protect it from the erosive effects of raindrop impact and shallow sheet flows. Common mulch materials include wood chip, straw, wood fiber (raw and composted), paper pulp, biogases, brush

Mulching

The placement of a blanket (mulch) of rock over the soil surface protects the soil surface from raindrop impact and overland flow.

Compost / manure application

Life barriers / life fences

Definition, specifications and purpose

Trees, bushes, cactus or sisal are planted along roadsides, at settlement borders, along rivers or field borders.

Potentials, benefits

- Stabilizing riverbeds
- Improving soil structure, roots stabilizing soils
- Trapping sediments, controlling wind erosion
- N-fixation
- Control of soil erosion, slow down runoff velocity
- Protection against wind erosion

Limitations, weaknesses

- Competition with crops for water and nutrients
- Lack of knowledge about species and effects
- Potential habitat for birds, insects, pests

Changing land management practices

The prevailing farming system can be optimized in many ways, such as:

- Changing management / intensity, e.g. from grazing to cutting (for stall feeding)
- Changing the degree of mechanization and commercialization, farming inputs, from mono-cropping to a crop rotation system, from mono-cropping to mixed cropping system.

Self-Check 1	Written Test

Name: ______________________ Date: _______________

Directions: Answer all the questions listed below

1. List and explain the indigenous soil and water conservation measures? Under the following heading. (10pts)

A. Agronomic/biological Measure B. Structural/physical measure

2. Discuss the objectives and limitations of each indigenous soil and water conservation measures? (5pts)
3. How we can maintain indigenous SWCP? (5pts)

Note: Satisfactory rating - 10 points and above Unsatisfactory - below 10 points

You can ask your teacher for the copy of the correct answers

Information Sheet-2	Construct micro-catchment water harvesting structures

Introduction:

Water harvesting is considered as a water management technique for collecting,storing, directing and distributing rain water and run off for any productive purpose. It is used when rain water is normally inadequate to meet water requirement of crops and trees.Water harvesting involves the transfer of runoff water from a catchment area that is not cropped to supplement the rainfall received directly on the area that is cultivated. It is considered as a direct, productive form of soil and water conservation and also it is a rudimentary form of irrigation. Where mean annual rainfall is below about 400 to 500mm, moisture conservation technique alone is usually not enough to ensure a crop. Irrigation is one approach to providing additional water for crop production, but there is increasing disillusion with sophisticated irrigation schemes, which frequently present alarming social, economic, technical and environmental problems. Water harvesting is an alternative approach to increasing the soil moisture available to a crop. It may be more widely applicable than irrigation, and may also have useful environmental benefits (especially as regards erosion control). It involves concentrating water that runs off the soil surface during a storm onto the growing crop. Water harvesting offers considerable hope for increasing production in arid and semi-arid areas for which irrigation is not a viable option.

What Are The Goals and Benefits Of Water Harvesting?

The Main Goals of Water Harvesting

To secure water supply in dry areas where other water resources (surface or groundwater) are not available or uneconomical to develop, in order to:

- Increase the productivity of arable and grazing land which suffers from inadequate rainfall
    - Increase yields of rain-fed farming
    - Minimize the risk of crop failure in drought prone areas
- combat desertification by afforestation, fruit tree planting or agroforestry
- supply drinking water for animals
- supply domestic water for people

Benefits of Water Harvesting

- Higher productivity (higher yield and lesser risk)
- Crop production in areas where it is normally not feasible
- Soil conservation (for macro catchments or cropping area only) i.e., less erosion
- Pasture improvement = more livestock
- Improved re-afforestation = less desertification
- Suppression of salinity in soil = more productive land
- Water conservation (tapping unused water)
- Ground water recharge = more water available

2.1 Assessing adaptability of different micro-catchment's water harvesting structures

Micro catchments (Rain water Harvesting)/ (Sometimes referred to as "Within-Field catchment System')

Micro-catchment rain water harvesting structures may include:

- Small planting pits,
- Micro-basins (negarims, semicircular bunds, eyebrow basins)

Main characteristics:-

- Overland flow harvested from short catchment length
- Catchment length usually between 1 and 30 meters
- Runoff stored in soil profile
- Normally no provision for overflow
- Plant growth is even

Typical examples

- Negarim micro catchment (for tree)
- Contour bunds (for trees)
- Semicircular bunds (for range and fodder)

A. Negarium Micro catchment

Negarim micro catchments are diamond shaped basin surrounded by small earth bunds with an infiltration pit in the lowest corner of each. Runoff is collected from within the basin and stored in the infiltration pit. Micro catchment is mainly used for growing trees or bushes. This technique is appropriate for small scale tree planting in any area, which has a moisture deficit. Besides harvesting water for the trees, it simultaneously conserves soil.

Technical details

Suitability:

Negarim micro catchment's is mainly used for tree growing in arid and semi-arid areas.

Rain fall: - ranges from 150mm-700mm per annum.

Soil: -should be at list 1m-2m deep in order to ensure adequate root development and storage of the water harvested.

Slope: -from flat to 8%

Topography: - need not to be even, if unevens a block of micro catchment should be sub divided.

Micro catchment size

The area of each unit is either determined on the bases of a calculation of the plant/tree water requirement or more usually, an estimation of this. Size of micro catchment(per unit) normally range between 10m2 and 100m2 depending on the species of tree to be planted but large sizes are also feasible, particularly when more than one trees will be grown within one unit.

Overall configuration

Each micro catchment consists of a catchment area and an infiltration pit (cultivatedarea). The shape of each unit is normally square, but the appearance from above is of a network of diamond shapes with infiltration pits in the lowest corners.

B. Contour bund for trees

Description

The contour bunds for trees are very similar to the contour ridges for crops system. Thedifference is that the system for trees, the harvested water is collected in an infiltration pit insteadof in a furrow. As with the contour ridges for crop the efficiency of contour bund for tree is highdue to the comparatively short slope length of the catchment area.

Technical Details

Suitability

Contour bund for tree planting can be used under the following conditions:

Rain fall: - 200mm-750mm; for semi-arid to arid areas

Soil: must be 1m-2m deep to insure adequate root development and water storage

Slope: - 5%-20%

Overall configuration

The overall layout consists of a series of parallel or almost parallel earth bunds approximatelyon the contour at a spacing of between 5 and 10 meters. The bunds are formed with soil excavated from an adjacent parallel furrow on their up slope side.

C. Semi-circular bunds

Description

Semi-circular bunds are earth bunds in the shape of a semi-circle with the tips of the bund o thecontour. Dimensions vary, from small structure with a radius of 2m t very large structure with aradius of 30m. Large semi-circular bunds are used for rangeland rehabilitation and fodderproduction; smaller semi-circular bunds for trees, shrubs and crops.

The advantages of this structure are that they are

- Easy to construct,
- Labor efficient because a maximum enclosed area is obtained with a minimum of bund volume (thanks to the semicircular shape), and
- Suitable for uneven terrain because the structure are free standing.

Technical details

Suitability

Semi- circular bunds for rangeland improvement fodder production and tree planting can be usedunder the following conditions.

Rainfall: - 300mm-700mm for arid to semi- arid areas

Slope: - all soils which are not too shallow or saline

Slopes: - for range improvement it can be up to 5%, for tree planting slope can be considered up to 30

2.2 Enhancing community awareness & participation

A settled way of thinking or feeling typically reflected in a person's behavior.Cultural authorities are laws and regulations which are developed locally by the community members or any enforcing or respecting role of the community. These cultural authorities can identify by consulting any people which have knowledge and experience regarding the community. These peoples may be outside of the community member or members of the community we want to apply our development program.These cultural authorities are very important for development activities. For example any cultural respect on forest or land is very important for the protection and conservation of the resources.

Example: Community watershed team (CWT) and Participatory forest management (PFM) committees are organized from different community member such as Youth association, Female association, Elders, Religious leader, etc

2.3 Setting design criteria & specification for the chosen micro-catchment's water harvesting structure

A. Design of negarim micro -catchment's water harvesting structure

The first step is to find a contour line using a line level or other equipment. The first line at thetop of the block is marked, if the topography is very uneven, separate small block of micro catchment should be considered. By means of tape measure the tips of the bund are now marked along the straight contour. The first line should be open ended. The distance between a-b depends on the selected catchment size,

The formula to find the distance a-b is,

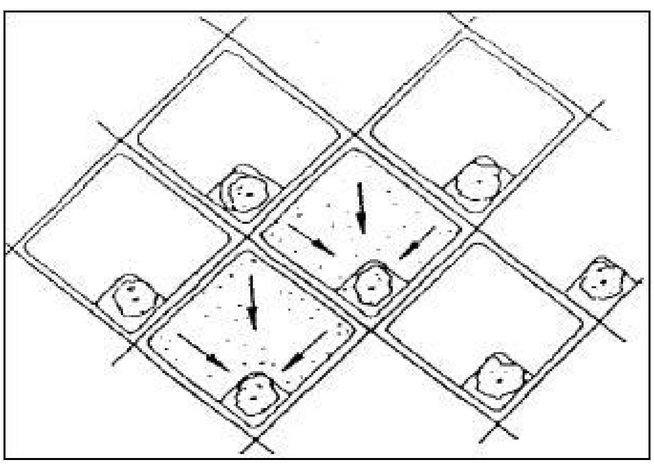
$$ab_2=ac2+bc2$$

For 25 meter selected catchment, length of catchment the will be 5mx5m micro catchment, is held at one tip(a) andthe second string of the same length at other tip(b) they will exactly meet at apex (c). The apex is now marked witha peg and the catchment sides (a-c) and (b-c) marked on the ground alongside the string with a hoe.

This procedure will be repeated until bund alignment in the first row has been determined.

The next row of micro catchments is staked out. The apex of the bunds of the upper row will be the tip for the second row and the corresponding apex will be found according the first step. Repeat the procedure for the third row

Typical examples of micro catchment negarium



Negarim

Negarim with bushes; Photo: Ovis

Figure 2.1Negarium

B. Layout and construction of semi-circular bund

The layout for both designs is similar, only diminution differs.

Step one: -The first contour, at the top of the scheme, is staked out using a simple surveying Instrument like line leveling.

Step two: -A tape measure is now used to mark the tip of the semicircular bund on the contour. For design semicircular bund for tree planting having a radius of 3m, the tips of one structure are 6meters apart (2times the radius) and the distance to the next unit is 1.5m, which is half of the radius of the semi-circle.

Step three: - The center point between the tips of each semicircular unit is marked. A piece of string as long as the selected radius is now fixed at the center point by a means of pegs. Holding the string tight at the other end, the alignment of the semi-circle is defined by swinging the end of the string from one end to the other. The alignment can be marked by pegs or scratching the earth with the peg.

Step four: - It is important that the structures in each row are staggered in relation to structure in the row above. It must be ensured that the space between bund from one row to another is according to the chosen distance that is half of the radius of the bund, which is 1.5m.

Step five: - After setting out, bund construction is started with excavation of small trench inside the bund. Further excavation should always be from inside the bund as evenly as possible. This will increase the storage capacity of the semi- circular bund; the bund height must be greater than 40cm when the slope exceed 20%. The bund bottom width is 75cm with the side slope 1:1. It is advisable to provide one or more diversion ditches within the block as a safety factor.

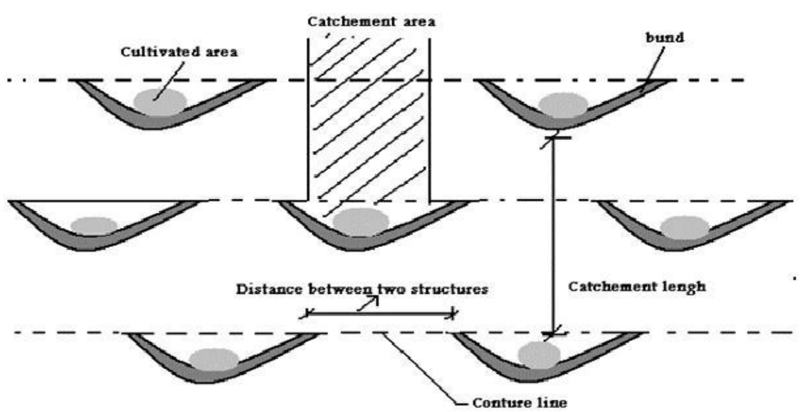


Fig. Layout of smaller semi-circular bunds

Self-Check 2	Written Test

Name: ________________________ Date: _______________

Directions: Answer all the questions listed below.

1. What is water harvesting? Explain it. (5 pts)
2. List and explain micro and macro water harvesting techniques; at least three? (5pts)
3. What is the purpose of constructing contour trench on grazing lands? (5pts)
4. Write the steps used for the construction stone bunds for tree? (5pts)

Note: Satisfactory rating - 10 points and above Unsatisfactory - below 10 points

You can ask your teacher for the copy of the correct answers

Information Sheet-3	Construct macro-catchment water harvesting structures

3.1 Assessing adaptability of different macro-catchment's water harvesting structures

External catchment systems (Rain water harvesting)/ (Long slope catchment Techniques)

Main characteristics:

- Overland flow or rill flow harvesting
- Runoff stored in soil profile
- Catchment usually 30-200 meters in length
- Provision for overland flow of excess water
- Uneven plant growth unless land leveled

Typical examples

- Trapezoidal bunds (for crops)
- Contour Stone Bunds (for crops)

Trapezoidal bunds

Trapezoidal bunds are used to enclose larger areas (up to 1ha) and to impound larger quantitiesof runoff which is harvested from an external or "long slope" catchment. The name is derived from the layout of the structure which has the form of a trapezoid a base bund connected to twoside bunds or wing walls which extend up slope at an angle of usually 135 degree. Crops are plants within the enclosed area. Over flow discharges around the tips of the wing wall. The concept is similar to semi-circular bunds; in this case, three sides of a plot are enclosed by bunds while the fourth (up slope) side is left open to allow runoff to enter the field. The simplicityof design and construction and the minimum maintenance required are the main advantages of this technique.

B .Contour stone bunds

Description

Contour stone bunds are used to slow down and filter runoff thereby increasing infiltration andcapturing sediments. The water and sediment harvested lead directly to improve crops performance. This technique is well suited to small scale application on farmer's field and give an adequate supply of stone can be implemented quickly and cheaply.Improved construction and alignment along contour makes the technique considerably more effective. The great advantage of systems based on stone is that there is no need of spill ways, where potentially damaging flows are constructed.

Technical Details

Suitability

Stone bunds for crop production can be used under the following conditions:

Rain fall: - 200-750mm from arid to semi- arid areas

Soils: - agricultural soils

Slopes: - preferably below 2%

Topography: - need not be completely even

Stone availability: - must be good local supply of stone

Overall configuration

Stone bunds follow the contour, or the approximate contour, across fields or grazing land. The spacing between bunds ranges normally between 15 and 30 meter depending largely on the amount of stone and labor availability. There is no need for diversion ditches or provision of spillways.

3.2 Setting design criteria & specification for the chosen macro-catchment's water harvesting structure

The main type of macro-catchment rain water harvesting structures includes:

- ➢ Hill side run off/conduit
- ➢ Foothill reclamation structures
- ➢ Large semicircular/trapezoidal bunds
- ➢ Road run off collecting structures
- ➢ Gully plugging
- ➢ Cut off drain

- ➢ Natural depressions
- ➢ Surface dams
- ➢ Small earth and stone dams
- ➢ Ponds for ground water

Design and layout of trapezoidal bund

When the site for the bund has been decided, the first thing to do is to establish the land slope using an Abney level or line level.

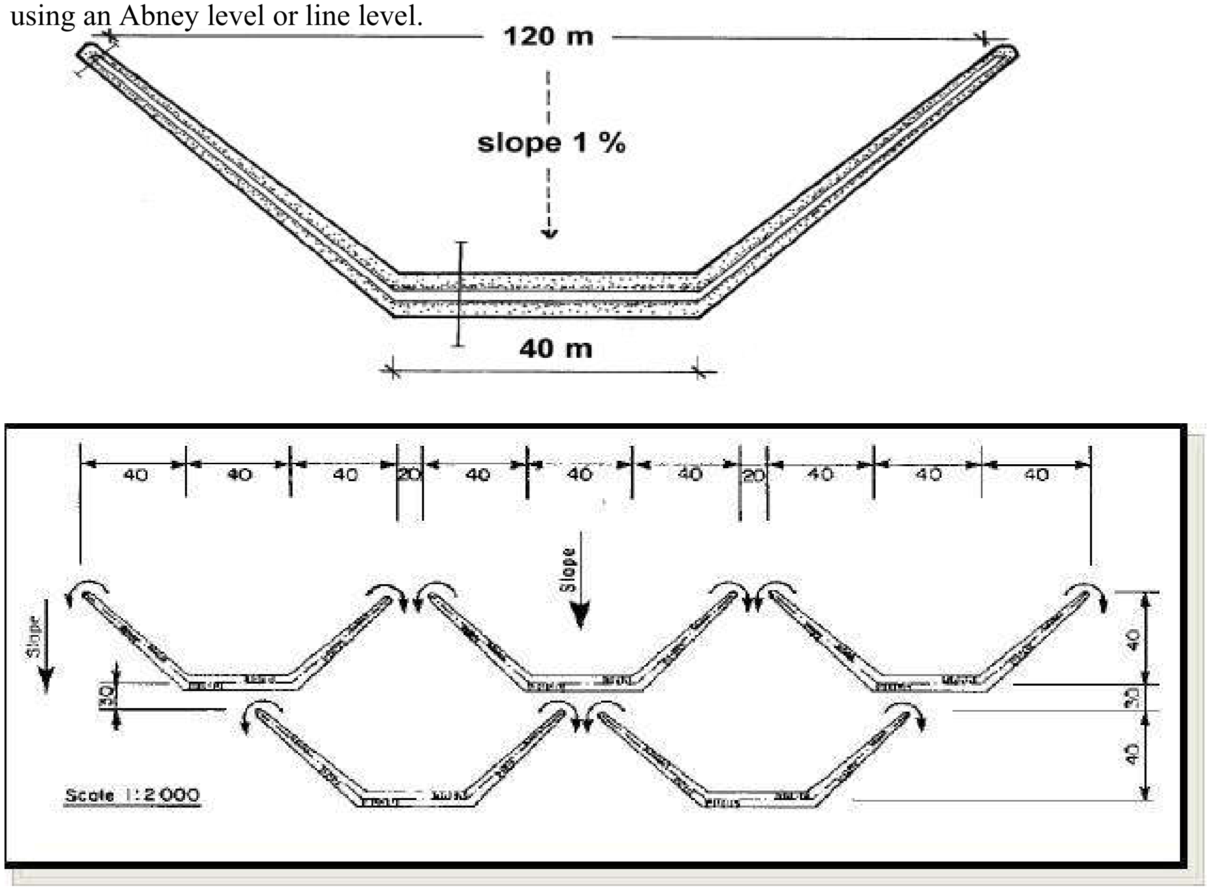


Figure 3.1 Trapezoidal bund

B. Layout and construction contour stone

Step one: - When the site for the bund has been decided, the first thing to do is to establish theland slope using line level. The dimensions of bund vary with the slope of the area.

Starting at the top of the field a peg is placed which will be the tip of one of the wing walls. The second wing wall tip is at the same ground level at the distance obtained from table above.

Step two: - Stake out the four dimensions of the bund and measure the right angle using a wooden right angle triangular template

Step three: - The accuracy of the setting can be checked by measuring the distances between points 4ocm.

Step four: - Having the main points of the bund it is necessary to set out pegs or stones to mark the earth work limits.

Step five: - Construction of a set of trapezoidal bunds must start with the row furthest up-slope.The bund is constructed in two layers each having a maximum thickness of 0.3m, the thickness of the first layer will gradually taper off to zero as filling proceeds up slope along the wingbunds.

Step six: - The tips of the bunds are only 20 cm high and exceed runoff drains around them. To prevent erosion of the tips they should be shaped with a small extension or "lip" to lead water away.

Step seven: - Where the catchment is large in relation to the bunded area it is advisable to construct a diversion ditch to prevent excess water or inflow to the bunds. This ditch usually 50cm deep and of 1-1.5 meters width, and is usually graded at 0.25%.

Self-Check 3	**Written Test**

Name: ________________________ Date: _______________

Directions: Answer all the questions listed below.

1.What does the external/rain water harvesting structure mean? Explain it. (10 pts)

2. List and explain the main types of macro-catchment rain water harvesting structures? (10pts)

Note: Satisfactory rating - 10 points and above Unsatisfactory - below 10 points

You can ask your teacher for the copy of the correct answers

Information Sheet-4	Construct excess water draining structures

Introduction

Drainage structure is a structure used to remove excesssurfaceandsubsurfacewater from agricultural field to enhance agricultural crop production,including theremoval of dissolved salts from the soil.

4.1 Estimating area of land irrigated & amount of excess water and identifying design discharge.

To assess the information on land and water resources at the river basin level, knowledge of physical irrigation potential is necessary. The area which can potentially be irrigated depends on the physical resources 'soil' and 'water', combined with the irrigation water requirements as determined by the cropping patterns and climate. Therefore, physical irrigation potential represents a combination of information on gross irrigation water requirements, area of soils suitable for irrigation and available water resources by basin.

Design parameters of runoff disposal system

The size of any runoff disposal system is calculated based on the basis of maximum expected runoff from the catchment area, which to be handled. Generally, 10 years recurrence interval is considered to calculate the maximum expected runoff of the catchment area.

Determine the peak runoff rate, generated from the area which is needed to drain through the structure. The peak runoff rate (Q) is estimated the Rational formula (which is applicable for watersheds 5 km^2 or less) given as under:

$Q = CIA/360$

Where,

Q = Design peak flow rate, m^3/s

C = Runoff coefficient, (Table 2)

I = Rainfall intensity (mm/hr)

A = Area of catchment (ha)

The runoff coefficient, C is the portion of the total rainfall that is expected to become runoff during the design storm.

4.2 Examining general & cross slope of field

Compute the grade (S) of the channel using Manning's formula, given as:

$$V = \frac{S^{1/2} R^{2/3}}{n} \rightarrow \text{S} = \sqrt{V * S * R^{-2/3}}$$

Where,

Q = flow rate, m^3/s

V = mean velocity, m/s

A = area of flow, m^2;

R = hydraulic radius, m,

S = bed slope, m/

n = Manning's roughness coefficient. This value is often assumed to in the range of 0.03 to 0.04

4.3 Determining size & cross-section of channel

Compute the cross-sectional area of the channel.

The cross-sectional area should suit the value of peak runoff rate (Q) and permissible flow velocity (V). It is computed by the following equation:

Q= A*V→ A = Q/V

Where,

Q = Peak discharge (m^3/s)

V = Maximum permissible velocity (m^3/s)

A = Cross-sectional area of the channel (m^2)

4.4Organizing all tools &equipment

Tools and equipment used for layout and construction of excess water draining structures are:

- Leveling equipment,
- Wheelbarrow,
- String lines,
- Tape measures,
- Marking gauges,
- Spades,
- Shovels,
- Crow bars,
- Rakes,
- Brooms,
- Sandingblock

4.5 Planning excess water reuse and disposal

Sources of irrigation water can be groundwater extracted from springs or by using wells, surface water with drawn from rivers, lakes or reservoirs or non-conventional sources like treated wastewater, desalinated water or drainage water. Rainwater harvesting is the collection of runoff water from roofs or unused land and the concentration of this. In order to use our water resources appropriately or to develop excess water re using and disposal we are expected to develop habits of using our water resource by plan. Excess water reuseand disposal mayinclude:

- Water way,
- cut off drain,
- dikes and tail water reuse,
- ground water
- recharge techniques

Occupational Health and safety

During the implementation of soil and water conservation measure there are many types of hazards may occur. These hazards may include;

- Chemicals
- Slippery or uneven surfaces
- Moving machinery and vehicles
- Snake
- Spider and Insect bites,
- Solar radiation and
- Dust

In order to overcome those problems we are expected to use the following PPE; s like

- Glove
- Safety wear
- Helmet and
- Eye glass

4.6 Selecting appropriate types of drainage structures

There are different types of drainage structures among them the main ones are:

- Catch-water Drains (Cut-off Drains):
- Culverts:
- Drifts:
- Scour Checks

- Side Drains

Catch-water Drains (Cut-off Drains): Catch water drains are ditches more or less parallel to the road. Their function is to catch and lead away the surface water coming from higher lying areas before it reaches the road or to direct water to where it can safely cross the road at constructed water crossings such as culverts, bridges and drifts. These drains, when properly built, are very effective in reducing the amount of water around the road, thus limiting the damage to the road and consequently reducing maintenance costs.

Culverts: Culverts are the most common crossdrainage structure used on roads. They are built using a variety of materials, in different shapes and sizes, depending on the preferred design and construction practices.

Culverts are required in order to

- Allow natural streams to cross the road, and
- Discharge surface water from drains and the areas adjacent to the road.

Drifts: Drifts provide an efficient and economic method of allowing water to cross from one side of a road to the other. In the case of drifts, the water is actually allowed to pass on top of the road surface. As a result, the road surface needs special protection to stand up to the forces from the flow of water. This is usually done by constructing a stone packed or concrete surface where the water will pass. The level of the drift is lower than the road on each side, to make sure that water does not spill over onto the unprotected road surface. Drifts are normally constructed to pass river streams which are dry during long periods of the year. If the waterway has a continuous flow of water throughout the year, the use of other cross-drainage solutions such as culverts, vented fords or bridges should be considered.

4.7 Undertake drainage construction

The construction of fords should take place during the dry season when water levels are at its lowest. Equipment and construction materials need to be assembled in advance, so work is ready to start when the stream is at its lowest. Before any construction can take place, the existing stream needs to be temporarily diverted away from the work site. As with culverts, the

First step is to excavate the trenches for the cut-off walls. A suitable culvert bed is then leveled and compacted between the cut-off walls. It is recommended that concrete bedding is provided on which the pipes are placed. The bedding should be indented to accommodate the shape of the culverts and its joints.

Second step: The bedding must be set out at the correct level, thus ensuring that the culvert pipes are flush with the riverbed. After laying the culvert pipes, the headwalls are constructed up to the road level. Headwalls are normally built from cement bound masonry. The space between the pipes is backfilled with a well-graded stony material.

Third step: Lean concrete with rock may also be used as a backfilling material, although this choice will increase the costs of the structure. For the road surface, it is recommended to install a 10 cm reinforced concrete layer with a 3 percent cross-fall. The surface slab needs to be strong enough to protect the culvert pipes from the 7d r a i n a g e building rural roads 2 4 7 expected traffic loads. The connection between the approaches and the horizontal stretch should be rounded to provide a smooth riding surface. The concrete slab must be kept moist for at least 10 days during curing.

Forth step: Traffic should be kept off the slab for two weeks.

Fifth step: Aprons can be constructed from stone masonry, concrete or gabions. On the downstream side they should be at least two times the height of the causeway.

A cross drainage work

A cross drainage work is a structure carrying the discharge from a natural stream across a canal intercepting the stream.Canal comes across obstructions like rivers, natural drains and other canals.

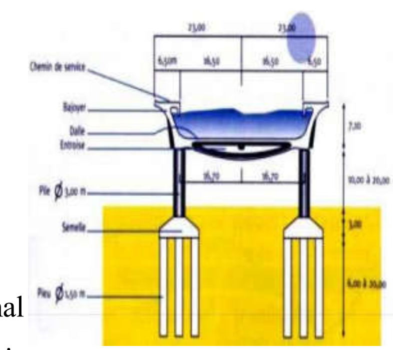
Types of cross drainage works

Depending upon levels and discharge, it may be of the following types:

Cross drainage works carrying canal across the drainage:

The structures that fall under this type are:

- An aqueduct
- Siphon aqueduct



Aqueduct:

When the HFL of the drain is sufficiently below the bottom of the canal such that the drainage water flows freely under gravity, the structure is known as Aqueduct. In this, canal water is carried across the drainage in a trough supported on piers.

Bridge carrying water

Provided when sufficient level difference is available between the canals and natural and canal bed is sufficiently higher than HFL

Siphon Aqueduct:

In case of the siphon Aqueduct, the HFL of the drain is much higher above the canal bed, and water runs under siphon action through the Aqueduct barrels.

The drain bed is generally depressed and provided with floors, on the upstream side, the drainage bed may be joined to the floor either by a vertical drop or by glacis of 3:1. The downstream rising slope should not be steeper than 5:1. When the canal is passed over the drain, the canal remains open for inspection throughout and the damage caused by flood is rare. However during heavy floods, the foundations are susceptible to scour or the waterway of drain may get choked due to debris, tress etc.

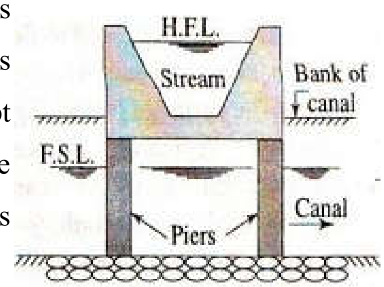
Cross drainage works carrying drainage over canal.

The structures that fall under this type are:

- Super passage
- Canal siphon or called siphon only

Super passage:

The hydraulic structure in which the drainage is passing over the irrigation canal is known as super passage. This structure is suitable when the bed level of drainage is above the flood surface level of the canal. The water of the canal passes clearly below the drainageA super passage is similar to an aqueduct, except in this case the drain is over the canal. The FSL of the canal is lower than the underside of the trough carrying drainage water. Thus, the canal water runs under the gravity.



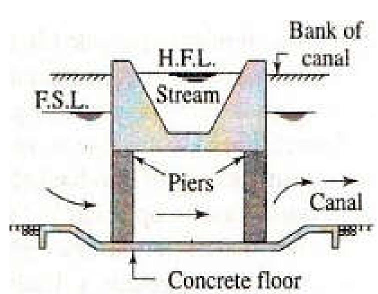
Super passage

Reverse of an aqueduct

Canal Siphon:

If two canals cross each other and one of the canals is siphoned under the other, then the hydraulic structure at crossing is called “canal siphon”. In case of siphon the FSL of the canal is much above the bed level of the drainage trough, so that the canal runs under the siphoned action. The canal bed is lowered and a ramp is provided at the exit so that the trouble of silting is minimized.

Reverse of an aqueduct siphon



Siphon super passage

Self-Check 4	Written Test

Name: _________________________ Date: ________________

Directions: Answer all the questions listed below.

1. What is drainage? Explain its functions briefly (4pts)

2.List and explain the major types of drainage structures and explain their function. (10 pts)

2. List and explain the handling and organization procedures of the tools and materials that we use the construction drainage structures? (8 pts)

3. What are cross drainage structures? Explain (4pts)

Note: Satisfactory rating - 13 points and above Unsatisfactory - below 13 points

You can ask your teacher for the copy of the correct answers

Information Sheet-5	Construct flood water harvesting structures

Introduction

Flood water harvesting can be defined as the collection and storage of creek flow for irrigation use. Flood water harvesting also known as" large catchment water harvesting "or '' spate irrigation'', may be classified in to the following two forms:-

a) In case of 'flood water harvesting with in stream bed' the water flow is dammed and as a result, inundates the valley bottom of the flood plain. The water is forced to infiltrate and the wetted area can be used for agriculture or pasture improvement.

b) In case of 'flood water diversion' the wad water is forced to leave its natural course and conveyed to nearby cropping fields.

5.1 Assessing adaptability of different flood water harvesting structures

Flood water Farming (Flood water Harvesting)/ (Often referred to as "Water Spreading "and sometimes "Spate Irrigation"

Main characteristics:

- Turbulent channel flow harvested either (a) by diversion or (b) by spreading within channel bed/valley floor
- Runoff stored in soil profile
- Catchment long (may be several kilometers)
- Provision for overland flow of excess water

Typical examples

- Permeable rock dams (for crops)
- Water spreading Bunds (for crops)

A. Permeable rock dams

Description

Permeable rock dams are a flood farming techniques where runoff waters are spread in valley bottoms for improved crop production. Developing gullies are healed at the same time. The structures are typically long, low dam walls across valleys. Permeable rock dams can be considered a form of "terraced wad", though the latter term is normally used for structures within watercourses in more arid areas.

Technical Details

Suitability

Permeable rock dams for crop production can be used under the following conditions:

Rainfall: - 200-750mm; from arid to semi-arid areas

Soils: - all agricultural soils-poorer soils will be improved by treatment

Slope: - best below 2% for most effective water spread

Topography: - wide, shallow valley beds

The main limitation of permeable dams is that they are particularly site specific and require considerable quantities of loose stone as well as the provision of transport.

Overall configuration

A permeable rock dam is a long, low structure, made from loose stone (occasionally some gabion baskets may be used) across a valley floor. The central part of the dam is perpendicular to the watercourse, while the extension of the wall to either side curves back down the valleys approximately following the contour.The idea is that the runoff which concentrates in the centerof the valley, creating a gully, will be spread across the whole valley floor, thus making conditions more favorable for plant growth. Excess water filters through the dam or overtops during peak flow. Gradually the dam silts up with fertile deposits. Usually a series of dams is built along the same valley floor, giving stability to the valley system as a whole.

Dam design

The main part of the dam wall is usually about 70cm high although some are as low as 50 cm.however; the central portion of the dam including the spillway (if required) may reach a maximum height of 2m above the gully floor. The dam or 'spreader' can extend up to

1000meters across the widest valley bed but the lengths normally range from 50 to 300 meters.The amount of the stone used in the largest structures can be up to 2000 tones.For all soils it is recommended to set the dam's wall in the excavated trench of about 10cm depth to prevent undermining by runoff water. In erodible soils it is advisable to place a layer of gravel or at least smaller stones in the trench.

B. Water spreading bund

Water spreading bunds are often applied in situations where trapezoidal bunds are not suitable, usually where runoff discharges are high and would damage trapezoidal bunds or where the crops to be grown are susceptible to the temporary water logging, which is a characteristic of trapezoidal bunds. The major characteristic of water spreading bund is that, as their name implies, they are intended to spread water, and not to impound it. The bunds are usually made of earth, slow down the flow of flood water and spread it over the land to be cultivated, thus allowing it to infiltrate.

Technical details

Suitability

Water spreading bunds can be used under the following conditions:

Rainfall: - 100mm-350mm normally hyper-arid /arid areas only.

Soils: - alluvial fans or flood plains with deep fertile soils

Slopes: - most suitable for slopes of 1% or below

Topography: - even

5.2 Setting design criteria & specification for the flood water harvesting structure

The major flood water harvesting structures are

- Spate irrigation and
- Flood water spreading structures

A Layout and construction of permeable rock dams

Step one: - Site selection depends both on the beneficiaries and the technicians. Theoretically it is best to start at the top of the valley, though this may not always be the people's priority. As a rule thumb no spillway is required if the gully is less than one meter deep. For greater depths a spillway is recommended.

Step two: - Where a spillway is required this should be built first. Gabions are best for spillways.As a loose stone is easily destabilized by heavy floods.

The following should be noted:

- A foundation of small stones set in a trench is required
- An apron of large rocks is needed to break the erosive force of the over flow
- The downstream banks of the watercourse should be protected by stone pitching to prevent enlargement of the gully.

Step three: - The alignment of the main dam walls can be marked out starting at the center of the valley. This alignment is ideally along the contour or as close to the contour as possible. The extension arms sweep backwards in an arc like the contours of a valley on a map.

Step four: - A typical cross section is recommended with 280cm base width, 70cm height, and side slope of 1:1 upstream and 3:1 downstream. Dig a 280cm width and 10cm deep trench (according to the base width of the bud). The earthshould be deposited upslope and the trench filled with gravel or small stones.

Step five: - The skill of construction is in the use of large stones for the casing of the wall. This should be built up gradually following the required side slopes, and the center packed with small stones.Earth should not be mixed with the stone because it may be washed out and thus destabilize the structure. The structure is finished off with a cap of large stones.

Step six: - If a series of permeable rock dams is to be built, an approximate vertical interval (VI) should be selected. Technically speaking it is correct to:-

Start at the top of the valley and work down

b) Use a vertical interval equal to the height of the structure, so that the top of one structureis at the same level as the base of the one above it.Therefore for dams 70cm height the VI should be 70cm; however this may not beapplicable due to the amount of stone and labor involved. As a compromise, a VI of100cm might be more realistic. Even wider spacing could be adopted and the "missing" structures "filled in" afterwards. The horizontal spacing between adjacent dams can be determined from the selected VI and the prevailing land slope according to the formula.

HI= (VI*100)/%slope

Where,

HI= horizontal interval (m)

VI= vertical interval (m)

%slope= land gradient expressed as a percentage

For example, for a VI of 0.7 m and a 1% land slope,

HI = (0.7 x 100)/1 = 70 meters

For a VI of 0.7 m and a 2% land slope,

HI - (0.7 x 100)/2 = 35 meters

Figure 5.1 Flood water harvesting structure

B .Layout and construction of Water spreading Bunds (for crops)

Step one: - The first step is to measure the slope of the land, in order to select the appropriate bunding system. This can be done most simply with an Abney level or with a line level.

Step two: - Straight bunds are used for slopes less than 0.5% and are spaced at 50m intervals. The bund should be staggered. Using a line or water level mark point A and point B with spacing of 100 meter apart. Line AB is then the center line of the first bund and should be marked with pegs or stones.

Step three: - For ground slope above 0.5% bunds aligned a 0.25% gradient are used and termed as "graded bunds".

Step four: - Having marked out the centerlines of the bunds the limit of fill can be marked bystakes or stones placed at a distance of 0.25m on either side of the centerlines.

Step five: - Construction begins at the top of the field as in all water harvesting systems. Earthshould be excavated from both sides to form the bunds and in the shallow trenches formed earthties should be foreseen at frequent intervals to prevent scouring.

The bunds are constructed in two layers of 30 cm each and compaction by trampling is recommended on the first course and again when the bund is complete.

Step six: - At the beds of the contour bunds and at the tip of the wing walls of the graded bunds,stones pitching should be placed (If loose stone is available) to reduce potential damage fromflow around the bunds.

Self-Check 5	**Written Test**

Name: ________________________ Date: _______________

Directions: Answer all the questions listed below.

1.What is flood water harvesting? Explain (4 pts)

2. List and explain the major characteristics of flood water harvesting structures? (8 pts)

3. What the main types of flood water harvesting system, explain? (4pts)

Note: Satisfactory rating - 8 points and above Unsatisfactory - below 8 points

You can ask your teacher for the copy of the correct answers

Operation sheet #1	**Conduct physical soil and water conservation activities ondevelopment sites**

Objective:Construct soil and water conservation activities

Procedure: -

- Use PPE
- Select the site to constructsoil and water conservation activities
- Remove UN wanted material from the construction site
- Measure and Fix the appropriate dimension for the construction of the structures
- Mark and Layout the dimension of the structure.
- Dig andexcavate the soil according to the dimension
- Compact the excavated soil to construct embankment of the structures
- Store the tools and materials after construction

LAP Test1	Practical Demonstration

Name: _____________________________ Date: ________________

Time started: ________________________ Time finished: ________________

Instructions:

1. You are required to perform any of the following:

   1.1 Request your teacher to arrange for you to visit the nearby soil and water conservation activities. You should identify physical structures.

   1.2 Request a set of physical structures, then perform the following tasks in front of your teacher

      1. Identify the type of physical structures
      2. Using the dimension of those physical structure construct

1.3 Request your teacher for evaluation and feedback

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