SMALL SCALE IRRIGATION DEVELOPMENT LEVEL-II

MODEL TTLM

Learning Guide-11

Unit of competency: Assist Erosion and Sediment Control Activities

Module Title: Assisting Erosion and Sediment Control Activities

LG code: AGR SSI1M 07 LO1-LO2

TTLM Code: AGR SSI1 TTLM 1218V1

Nominal Duration: 30 Hours

Instruction sheet	Learning guide #11

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

- ❖ Assess work site practices with erosion and sediment control principles
- ❖ Implement erosion and sediment control principles

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 –

- ➢ Plan and organize erosion and sediment control activities
- ➢ Collect and organizing information
- ➢ Undertake activities
- ➢ Adhere erosion and sedimentation legislation
- ➢ Conduct erosion and sediment control activities
- ➢ Select basic catchments characteristics
- ➢ Apply procedures relating to erosion and sediment control
- ➢ Perform erosion and sediment control work
- ➢ Identify erosion and sediment control structures/measures/practices
- ➢ Solve technical and organizational problems
- ➢ Implement erosion and sediment control
- ➢ Apply practices for erosion and sediment control
- ➢ Carry out routine work with control measures and structures

Learning Activities:-

1. Read the specific objectives of this Learning Guide.

2. Read the information written in the "Information Sheets"

3. Accomplish the “Self-checks”

4. If you earned a satisfactory evaluation proceed to “the next information sheet However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.

5. Submit your accomplished Self-check. This will form part of your training portfolio (if necessary).

6. Read the “Operation Sheet” and try to understand the procedures discussed.

7. Request access to the materials required for that particular practical session. Practice the steps or procedures as illustrated in your learning guide. Go to your teacher if you need clarification or you want answers to your questions or you need assistance in understanding a particular step or procedure.

8. Do the “LAP test” (if you are ready) and show your output to your teacher. Your teacher will evaluate your output either satisfactory or unsatisfactory. If unsatisfactory, your teacher shall advice you on additional work. But if satisfactory you can proceed to the next Learning guide.

Information sheet 1	Assess work site practices with erosion and sediment control principles

1.1 Definition of erosion

Soil erosion is the removal of soil particles (including plant nutrients and organic matter) from the place where it belongs by water or wind. Detachment, transport and deposition are the three processes that are involved in soil erosion, detachment being the first step.

Soil erosion, defined as the detachment of soil particles and their transport by wind or water, is a natural process driven by physical factors. The energy necessary for soil particle detachment and its transport is provided by wind or water (rain or surface runoff).

Soil erosion is influenced from a variety of factors such as rainfall distribution, soil, land use, etc. Such factors have a variety of types according to time and space. This paper is aimed at assessing the soil erosion hazard area in watershed, and for that, the factor in respect to topography and space information of RUSLE was extracted by GIS technique, and the amount of soil erosion occurring in watershed was calculated. And the hazard zone of erosion occurrence was assessed based on such amount of soil erosion. GIS can evaluate the degree of hazard of erosion or the amount of erosion spatially and provide with, and a variety of researchers are proving the effectiveness of DEM in assessment of soil erosion (Burrough, 1986; Moore, et al (1993).

1.2 Causes of soil erosion

There are two causes of Soil erosion

- Natural Factors (geological).
- Human Factors (accelerated)

Human factor in soil erosion

- Deforestation,
- Over-grazing,
- Construction activities,
- Mining activities.

- Defective methods of farming such as ploughing in a wrong way i.e. up and down the slope.

Types of Erosion

It broadly classified in to two:

A. Geologic erosion:
B. Accelerated Erosion:

Accelerated Erosion includes:-

1. Wind Erosion
2. Water Erosion.
    - Raindrop/ splash erosion.
    - Sheet erosion.
    - Rill erosion.
    - Gully erosion.
    - Stream erosion.

C. Other types of Soil erosion:
    - Glacial erosion
    - Snow erosion
    - Organic erosion
    - Anthropogenic erosion

A. Geologic erosion: It refers to the formation of and loss of soil simultaneously which maintain the balance between formation and various losses.

It is normal process which represents the erosion of soil in its normal conduction without influence of human being. It is also known as natural or normal erosion. The various topographical features such as existing of stream channels, valleys, etc. are the results of geologic erosion.

B. Accelerated erosion: It is an excess of geologic erosion. It is activated by naturals and man's activities due is changes in natural cover and soil conditions.

Accelerated erosion takes place by the action of water, wind, gravity and glaciers. Various forces involved in this are:

1. Attacking force of water or wind which remove and transport the soil particle from one place to another.
2. Retarding forces which resist the erosion. In general accelerated erosion is known as soil erosion or erosion.

It is sub classified as:

1. **Water erosion:**
   - Rain drop erosion
   - Sheet erosion
   - Rill erosion
   - Gully erosion
   - Stream erosion

Raindrop Erosion: It is also known as splash erosion. It results from soil splash caused by the impact of falling raindrops. Factor influencing the rate of erosion are:

- Climate, Rainfall, temperature.
- Soil its resistance to dispersion and its infiltration rate.
- Topography – steepness and length of slope.
- Plant cover—living or dead vegetation.

Falling raindrops breaks soil aggregate and detach soil particles from soil mass. Fine soil particles are taken into suspension and the splash thus become muddy. The major effect of surface flow of water is to carry off the soil loosened by splash erosion.

Sheet erosion: Sheet erosion may be defined as: Removal of the fairly uniform layer of soil from the land surface by the action of rainfall and runoff. Uniform removal of soil in the form of thin layer or in sheet form by flowing water from a given width of sloping land.

- Sheet erosion, Two basic erosion processes are involved.
- Soil particles are detached from the soil surface by falling rain drop.
- The detached soil particles are transported away by runoff from their original place.

The eroding and transporting power of sheet flow are dependent upon the depth and velocity of sheet flow for a given size, shape and density of soil particle.

Rill Erosion: It is sometime known as micro channel erosion. It is the removal of soil by running water with the formation of areas of small branching channels. There is no sharp time of demarcation where sheets erosion ends and more readily visible than sheet erosion. It is regarded as a transition stage between sheet erosion and gully. Rill of small depth can be ordinary form tillage.

Gully erosion: It is removal of soil by excessive concentration of running water, resulting in the formation of channels ranging in the formation of channels ranging in size from 30cm to 10m or gully is to a large ton be filled by normal tillage practice.

Stream Bank erosion Stream channel [bank] erosion is the sourcing of material from the side and bottom of a stream or water channel and the cutting of bank by running water. It is mainly due to removal of vegetation, over grazing or cultivation on the area near to the streams banks.

2. **Wind erosion:** It is the process of detachment transportation and deposition of soil particles by the action of wind. Basic cause of wind erosion is:

- Soil is loose, finely divided and dry
- Soil surface is smooth and bare.
- Wind is strong to detach the soil particles from soil surface.

Other forms of erosion:

- Glacial erosion [due to mass of ice moving very slowly].
- Snow erosion [due to slow and creeping movement of snow towards slope.]
- Anthropogenic erosion [due to activities of human being]

Factors Affecting Soil & Water Erosion

Factors Affecting Soil Erosion

Factors such as rainfall, runoff, wind soil, slope, plant cover and presence or absence of conservation measures are responsible for soil erosion. But mainly three following factors affect the erosion.

- **Energy:**

It include The potential ability of rainfall, runoff and wind to course erosion and other factor which affects the power of erosive agents such as reduction in length of runoff or wind blow through construction of terrace, bunds etc. in case of water erosion and wind breaks or shelter belts in case of wind erosion.

- **Resistance:**

It is referred to that factors which affect soil erodibility and soil erosion. Mechanical and chemical properties of soil are responsible for infiltration rate of soil which reduces runoff and decreases soil erodibility. Cultivation decreases the erodibility of clay but increases erodibility of sandy soils.

[Erodibility—susceptibility of soil to get erosion]

[Erosivity—Ability of rain to cause erosion]

- **Protection:**

It refers to plant covers which intercept the raindrop falling on ground surface reducing their impact on soil. Plant cover also reduces the runoff and wind velocity, there by soil erosion. Different plant cover offers different protection so suitable cover can be developed to control erosion.

Factors affecting Water Erosion:

Water erosion is due to dispersive and transporting power of water. Factors affecting are:

- **Climatic factors:**

This includes rainfall characteristics, atmospheric temperature and wind velocity

- **Soil characteristic:**

This affect infiltration rate of soil, Infiltration rate depends upon permeability of soil, surface condition and presence of moisture in it.

- **Vegetation:**

It creates the obstacle for raindrops as well as glowing runoff. A good vegetative cover completely reduces the effect of rainfall on soil erosion.

- **Topographic effect:**

The land slope, length of slope and shape of slope are main factors which influences soil erosion. As slope of land increases from mild to steep, erosion increases.

1.1Planning and organize erosion and sediment control activities

1.1.1Preparing erosion and sediment control plan

An erosion and sediment control plan is a document which describes the potential for erosion and sedimentation problems on a construction project and explains and illustrates the measures which are to be taken to control those problems. The plan has a written portion known as a narrative and an illustrative portion known as construction drawings.

The soil erosion and sediment control plan should be an integral part of the overall site plan. However, the soil erosion and sediment control plan needs to be consolidated, so it can be separated from the site pan for review.

The narrative is a written statement which explains the erosion and sediment control decisions made for a particular project and the justification for those decisions. The narrative is especially important to the plan reviewing authority because it contains concise information concerning existing site condition, construction schedules, and other pertinent items which are not contained in a typical site plan.

Since plan reviewers cannot always discuss the project at length with the site planner, it is important that they be provided with adequate information to make their review. The design calculations should be included as an appendix to the narrative.

The narrative also discusses where and when the various erosion and sediment control practices should be installed.

The operation and maintenance of the control measures should be included in the narrative.

The construction drawings visually illustrate the site features including existing conditions and proposed alterations. The construction drawings are important because they show the location, and dimensional details of the control measures. This information is needed by the reviewer to ensure that appropriate control measures are included. Construction super intendents and inspectors need the drawings to ensure that control measures are properly installed.

Purpose of the Plan

The purpose of an erosion and sedimentation control plan is to establish clearly which control measures are intended to prevent erosion and off-site sedimentation. The plan should serve as a blueprint for the location, installation, and maintenance of practices to control all anticipated erosion and prevent sediment from leaving the site.

The approved erosion and sedimentation control plan showing the location, design, and construction schedule for all erosion and sedimentation control practices should be a part of the general construction contract. State specifically the method of payment for implementing this plan in the contract, and consider erosion and sedimentation control an early pay item.

Elements of the Plan

An erosion and sedimentation control plan must contain sufficient information to describe the site development and the system intended to control erosion and prevent off-site damage from sedimentation. As a minimum the plan should include:

- A site location or vicinity map,
- A site development drawing,
- A site erosion and sedimentation control drawing,
- Drawings and specifications of practices designated with supporting calculations and assumptions,
- Vegetation specifications for temporary and permanent stabilization,
- A construction schedule,
- A financial/ownership form, and brief narrative.

1.1.1Collecting and organizing information

Data Collection and Preliminary Analysis

The base map for the erosion control plan is prepared from a detailed topographic map. If available, a soil map should be obtained from the local soil Conservation Service office. Transferring the soil survey information to the topographic map is helpful for site evaluation.

The design engineer responsible for the plan should inspect the site to verify the base map with respect to natural drainage patterns, drainage areas, general soil characteristics, and off-site factors.

The base map should reflect such characteristics as:

- soil type and land slopes,
- natural drainage patterns,
- unstable stream reaches and flood marks,
- watershed areas,
- existing vegetation (noting special vegetative associations),
- critical areas such as steep slopes, eroding areas, rock outcroppings, and seepage zones,
- unique or noteworthy landscape values to protect,
- adjacent land uses—especially areas sensitive to sedimentation or flooding, and
- Critical or highly erodible soils that should be left undisturbed.

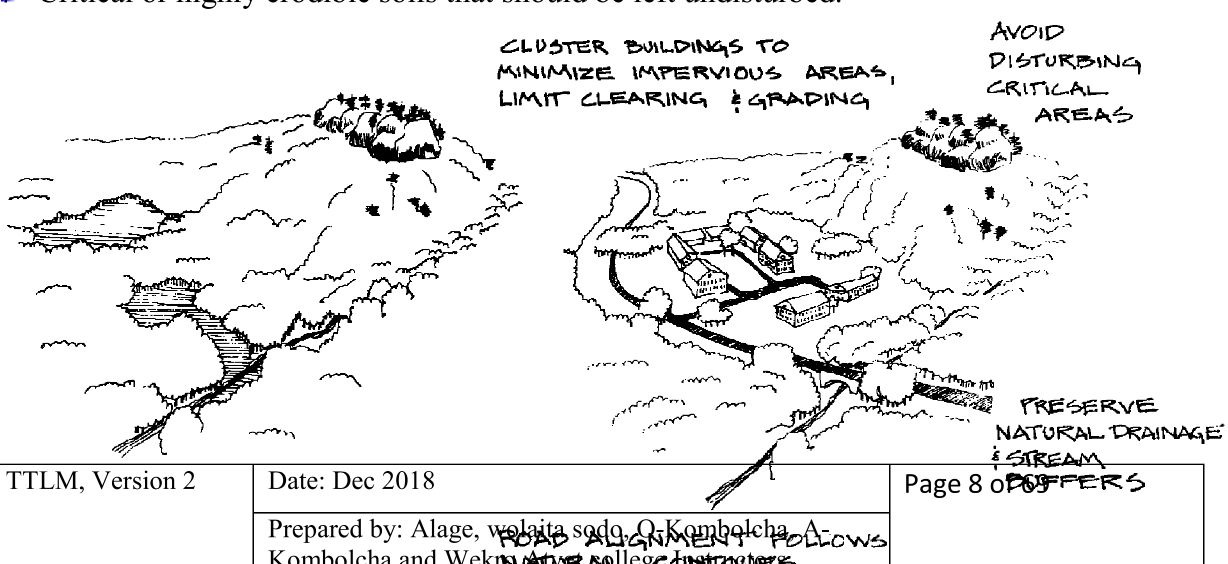


Figure 4.1 Site evaluation.

Fig 1.1 site evaluation

In the analysis of these data, identify:

- Buffer zones,
- Suitable stream crossing areas,
- Access routes for construction and maintenance of sedimentation control devices,
- borrow and waste disposal areas, and
- The most practical sites for control practices.

The analysis of the topography, soils, vegetation, and hydrology should define the limitations of the site and identify locations suitable for development.

1.2 Adhering erosion and sedimentation legislation

Soil erosion and sediment control legislation

Erosion and sedimentation legislation is adhered to the work site as a part of contract works. To provide agricultural support services to farmers in order to ensure sustainable development and management of agricultural resources. The Program provides support in the form of agricultural infrastructure development services that ranges from planning and designing to physical construction of structures to enhance sustainable natural resource management. Apply erosion and sediment control industry practices.

Legislation is intended to promote the protection and proper utilization of land, water and forest resources. In principle, it is better to educate and persuade farmers to mange land well rather than to threaten them with prosecution. Farmers face greater difficulties if the only land available to them is steep but food has to be produced and income generated from it. If alternative land is not available, they need help to manage the land without damaging it. If the law states that they cannot use the land and yet they have nowhere else to go a situation arises which cannot be solved by taking people to court.

The most important Act which concerns the farmers is the Agricultural Act (Legal notice No.26 of 2 February 1965) which deals with two main problems - soil erosion on slopes and erosion caused by cultivation along watercourses.

Any person, who cultivates cuts down or destroys any vegetation, or departures any land of which the slope exceeds 35% shall be guilty of on offence; provided that an authorized officer may authorize an owner to cultivate, departure, cut down or destroy vegetation on the land subject to such condition as he may decide.

An authorized officer may, by written order, prohibit cultivation or cutting down or destruction of vegetation on any land on which the slope exceeds 20%.

Any person who cultivates any land of which the slope exceeds 12% and does not exceed 35%, when the soil is not protected against erosion by conservation works to the satisfaction of an authorized officer, shall be guilty of an offence.

The owner of any land shall take such steps as to prevent water from flowing in to any adjoining land in such manner as to cause the erosion thereof, and to the satisfaction of an authorized officer. The owner of any land on which soil conservation structures have been made should take steps to maintain them.

Any person who fails to comply with any order made or any conditions imposed under these rules shall be guilty of an offence.

Soil erosion control, such as land use planning, aims at using land in ways that prevent and/or reduce the risk of erosion occurring.

These goals can be achieved by applying the following principles

1. Integrate multiple conservation practice
2. Plan and integrate erosion and sediment control with construction activities.
3. Minimize the extent and duration of disturbance.
4. Control storm water flows onto, though, and from the site in stable drainage structures.
5. Use erosion controls to prevent on-site damage.
6. Use sediment controls to prevent off-site damage.
8. Stabilize disturbed areas promptly.
9. Install measures to prevent sediment from being tracked onto public or private roadways.
10. Inspect and maintain control measures.

Principles of Site Development

The site evaluation data and the information shown on the field map serve as the basis for both the site development plan and the erosion and sedimentation control plan (Figure above). Plan development to fit the proposed site, recognizing constraints determined in the site analysis. To determine the best layout of the site, observe the following principles:

- **Fit the development to the site**—Follow natural contours as much as possible. Preserve and use natural drainage systems.
- **Limit clearing and grading**—clearly define work limit lines. Grade to minimize cut-and-fill slopes, preserve natural buffer areas, and limit the time that bare soil is exposed.
- **Minimize impervious areas**—Build in clusters to provide more open space, minimize parking areas, and reduce disturbance for utility line construction. Use porous paving materials when practical. Maintain existing vegetation where possible.
- **Avoid disturbing critical areas**—Identify and avoid areas vulnerable to concentrated runoff.
- **Maintain and enhance existing site values**—Retain significant trees and other plant groups. Avoid disturbing unique land forms, very steep slopes, and rock outcroppings.

Strategies in site Development

The erosion and sedimentation control plan should seek to protect the soil surface from erosion, control the amount and velocity of runoff, and capture all sediment on-site during each phase of the construction project. Strategies for controlling erosion and sedimentation should consider the following elements:

- **Schedule activities**—Coordinate the installation of erosion and sedimentation control practices to coincide with the construction activities as the most cost-effective control strategy. Many sedimentation control practices should precede grading activities.
- **Protect the soil surface**—Limit the extent of disturbance, and stabilize the soil surface immediately. Once the surface has been disturbed, it is subject to accelerated erosion, and should be protected with appropriate cover, such as mulch or vegetation, in an expedient manner.
- **Control surface runoff**—Divert water from undisturbed areas to avoid disturbed areas. Break up long slopes with temporary diversions to reduce the velocity of runoff. Divert sediment-laden water to sediment impoundments. Make all outlets and channels stable for the intended flow.
- **Capture sediment on-site**—Divert runoff that transports sediment to an adequate sediment-trapping device to capture sediment on the site.

1.2.1 Conducting erosion and sediment control activities

A. <u>Erosion control activities</u>

1. <u>Buffer Zone</u>

A buffer zone consists of an undisturbed area or strip of natural vegetation or an established suitable planting adjacent to a disturbed area that reduces erosion and runoff.

Advantages

- Filters Sediment.
- Promotes infiltration.
- Provides habitat.
- Reduces velocity and quantity of runoff, dissipates energy.
- Provides visual screening.
- Can be used to stabilize stream banks.

- Low maintenance.

Disadvantages

- Requires keeping all construction equipment, debris and soils out of the natural areas.
- Extensive buffers can cover large areas of land that are not available for project development.

Design Criteria

- Preserve natural vegetation in clumps, blocks or strips.
- Preserve natural vegetation on unstable, steep slopes.
- Clearly establish construction limits with orange construction safety fence and signs spaced 100 feet apart.
- Vegetative buffer zones for streams, lakes or other waterways should meet current regulatory standards for wide.

2. <u>Dust Control</u>

Preventative measures to minimize the wind transport of soil, prevent traffic hazards and reduce sediment transported by wind and deposited in water resources.

Advantages

- Reduces movement of soil to offsite areas.
- Increases visibility.

Disadvantages

- Over watering may cause erosion.
- Most methods require immediate reapplication if disturbed.
- Too little watering fails to control dust.

Design Criteria

- Installing construction entrances and stabilizing construction haul roads with crushed rock
- Designer can provide project-specific dust control specifications for the contractor to apply. Measures include:
  - Seeding

- Mulching
- Matting
- Water
- Tackifier
- Chemical Soil Stabilizers

- Schedule construction operations so that the least amount of project area is disturbed at one time.
- Install temporary or permanent surface stabilization measures immediately after completing land grading.

3. Ground Cover

Ground Cover is a protective layer of straw or other suitable material applied to the soil surface.

Straw mulch and/or hydro mulch are also used in conjunction with seeding of critical areas for the establishment of temporary or permanent vegetation. Ground cover provides immediate temporary protection from erosion. Mulch also enhances plant establishment by conserving moisture, holding fertilizer, seed, and topsoil in place, and moderating soil temperatures.

Advantages

- Provides immediate protection,
- Conserves moisture,
- Acts as a thermal layer for seed,
- If used in conjunction with seed, allows seed growth through the mulch,
- Protects seeding from direct heat, moisture loss and transport due to runoff,
- Used for dust control.

4. Preserve Natural Vegetation

This BMP involves preserving natural vegetation to the greatest extent possible during the construction process and after construction where appropriate. Maintaining natural vegetation is the most effective and inexpensive form of erosion prevention control. This method is particularly important in sensitive areas such as wetlands, stream corridors, lakes, and near steep slopes. The project manager, inspector and contractor should address and discuss preserving natural vegetation during the Pre-construction meeting. Although this is a proven BMP, it is imperative that all exposed soils are covered in a timely manner.

Advantages

- Helps reduce soil erosion and runoff while beautifying an area.
- Saves landscaping costs, provides areas for wildlife, and provides visual screening.
- Helps maintain water temperature. Temperature moderation is especially important when detention ponds drain to salmonid-bearing streams.
- Retains existing shade and cover habitat.

Disadvantages

- Retaining older trees could create a safety hazard.
- May constrict area available for construction activities.

Design Criteria

- Coordinate with the Landscape Architect and Environmental Professionals assigned to the project when determining what to save and how to save it.
- Vegetation can be preserved in natural clumps or as individual trees, shrubs and vines.
- Clearly establish ground disturbance limits outside the drip line of preserved trees, using orange construction safety fence or flagging if approved

Protect vegetation from:

- Construction equipment injury above or below the ground level. Injury occurs from scarring, cutting roots, or compaction.
- Grade changes, which affect the plants' ability to obtain air, water or minerals. Placing a layer of gravel and a tile system over the roots before a major fill allows air to circulate and protects the plant from the fill.

- Terracing the area around the plant, or leaving the plants on an undisturbed mound can increase the plants' survival chances.
    - Root exposure.

5. <u>Sod</u>

Establishes permanent turf for immediate erosion protection and stabilizes drainage ways.

Advantages

- Provides immediate, effective protection, and is aesthetically pleasing.
- Provides high-density vegetation, which is superior to a recently seeded area.
- Placement can occur any time that soil moisture is adequate and the ground is not frozen.

Disadvantages

- Expensive.
- Availability is seasonal.
- Irrigation may be required if installed in summer.
- Difficult to mow if installed on slopes steeper than 3:1.
- Installations in grassed waterways may roll up if not anchored or drained properly.
- Time necessary for root establishment may be lengthy.

Design Criteria

- Use sod as a short or long-term cover.
- Around inlets located off roadways
- Use sod that is generally weed free, has uniform thickness (approximately 1 inch thick) and dense root mat for mechanical strength.
- Generally inappropriate for bios wales. Sod can be used for lining ditches or waterways carrying intermittent flows.

The following steps are general recommendations for sod installation:

- Shape and smooth the surface to final grade in accordance with the approved grading plan.
- Fertilize as per supplier's recommendations. Non-phosphorous fertilizer is required near water bodies and wetlands.
- Work lime and fertilizer into soil 1-2 inches deep and smooth the surface.
- Lay sod strips perpendicular to the direction of water flow, beginning at the lowest area to be sodded. Wedge strips securely into place and square the ends of each strip to provide for a close, tight fit. Stagger joints at least 12 inches. Staple sod onto 3:1 and steeper slopes.

- Roll the sodded area and irrigate.
- Not for use in high velocity channels/ditches.

A. Runoff Control Practices

The greater the volume and velocity of surface water runoff on construction sites, the more sediment and other pollutants are transported to streams, wetlands, and lakes. Diverting runoff away from exposed soils can greatly reduce the amount of soil eroded from a site. Decreasing runoff velocities reduces erosion and the amount of pollutants carried off-site.

Runoff controls divert runoff from exposed areas and reduce runoff velocities. Runoff control BMP's that divert runoff from exposed areas include pipe slope drains and diversion swales.

Runoff controls BMP's that reduce runoff velocities include check dams and sediment traps.

1. Check Dam

Small dams constructed across a swale or ditch to reduce velocities of concentrated flows, thereby reducing erosion in the swale or ditch. Check dams not only prevent gully erosion from occurring before vegetation is established, but also allow a significant amount of suspended sediment to settle out. Check Dams can be constructed from a variety of materials.

- Rock: Rock material only.
- Bio-filter Bags: Bio-filter bags staked to the ground.
- Sand Bags
- Pre-fabricated Check Dam System: A manufactured system specifically designed to slow water so that suspended particles settle out. Field fabricated systems are not allowed.

Advantages

- Prevent erosion and promote settling of sediment in runoff.
- When carefully located and constructed, check dams may function as permanent installations.
- Reduces flow velocity
- Inexpensive and easy to install.
- Rock can be spread into ditch and used as a channel lining when the check dam is no longer necessary.

- Some pre-fabricated check dams are reusable.

Disadvantages

- Removal may be costly for some types of check dams.
- Suitable only for a limited drainage area.
- May reduce hydraulic capacity of the channel.
- May create turbulence downstream, causing erosion of the channel banks.
- Ponded water may kill grass in grass-lined channels.
- May be an obstruction to construction equipment.

2. <u>Diversion Dike/ Swale</u>

A ridge of compacted soil or a lined swale with vegetative lining located at the top, base or somewhere along a sloping disturbed area. The dike or swale intercepts and conveys smaller flows along low-gradient drainage ways to larger conveyances such as ditches or pipe slope drains or to a stabilized outlet. Dikes and swales may be used singly or in combination with each other.

Advantages

- Provides a practical, inexpensive method to divert runoff.
- Can handle flows from large drainage areas.
- Use on-site material and equipment to construct.

Disadvantages

- If improperly constructed, can contribute to erosion caused by concentrating the flow.
- High flow velocity can damage vegetation.
- Not effective for preventing illegal discharge.

3. <u>Grass-lined Swale</u>

A channel with vegetative lining constructed to convey and dispose of concentrated surface runoff without damage from erosion, deposition, or flooding.

Advantages

- Does not generate high velocity runoff and offers temporary slope protection, which is superior to plastic sheeting.

- Capture a great deal of sediment due to the filtering effect of vegetation.
- Usually easy to install.

Disadvantages

- Requires temporary irrigation to establish vegetation.
- Cannot be used until vegetation is established.

4. **Outlet Protection**

Outlet protection reduces the speed of concentrated flow, thereby preventing scour at conveyance outlets. By dissipating energy, outlet protection lowers the potential for downstream erosion. Outlet protection includes riprap-lined basins, concrete aprons, and settling basins.

Outlet protection prevents scour at storm water outlets, and minimizes the potential for downstream erosion.

Advantages

- Many techniques are effective and relatively inexpensive and easy to install.
- Removes sediment and reduces velocity.

Disadvantages

- Can be unsightly.
- May be difficult to remove sediment without removing and replacing the structure itself.
- Rock outlets with high velocity flows may require frequent maintenance.

5. **Surface Roughening**

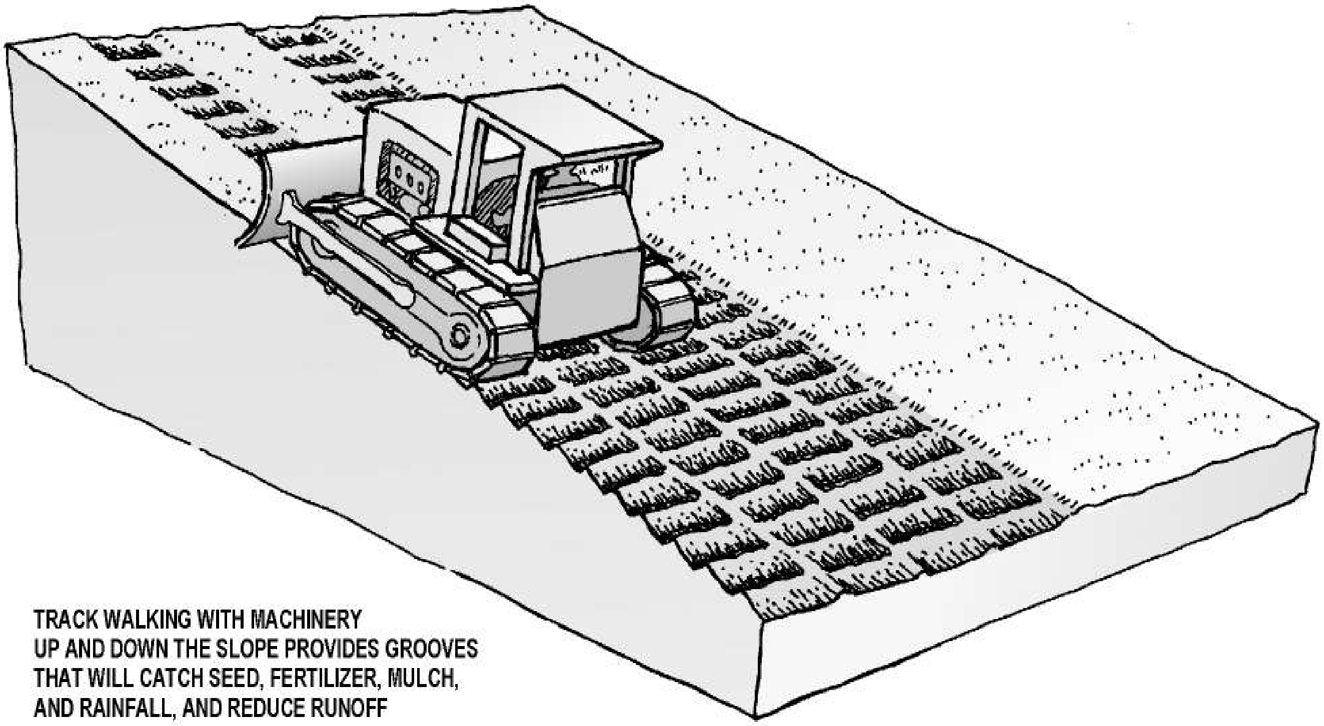


Fig 1.2 Surface roughness

Leaving the slopes in a roughened condition after clearing or creating a rough soil surface with horizontal depressions or grooves will trap seed and reduce runoff velocity. Roughening can be accomplished by 'track walking' slopes with tracked equipment, by using a serrated wing blade attached to the side of a bulldozer, or by other agricultural equipment.

Advantages

- Grooves trap seed.
- Increased vegetation establishment.
- Reduces runoff velocity, increases infiltration.
- Provides some instant protection from sheet erosion.
- Traps soil eroded from the slopes above.

Disadvantages

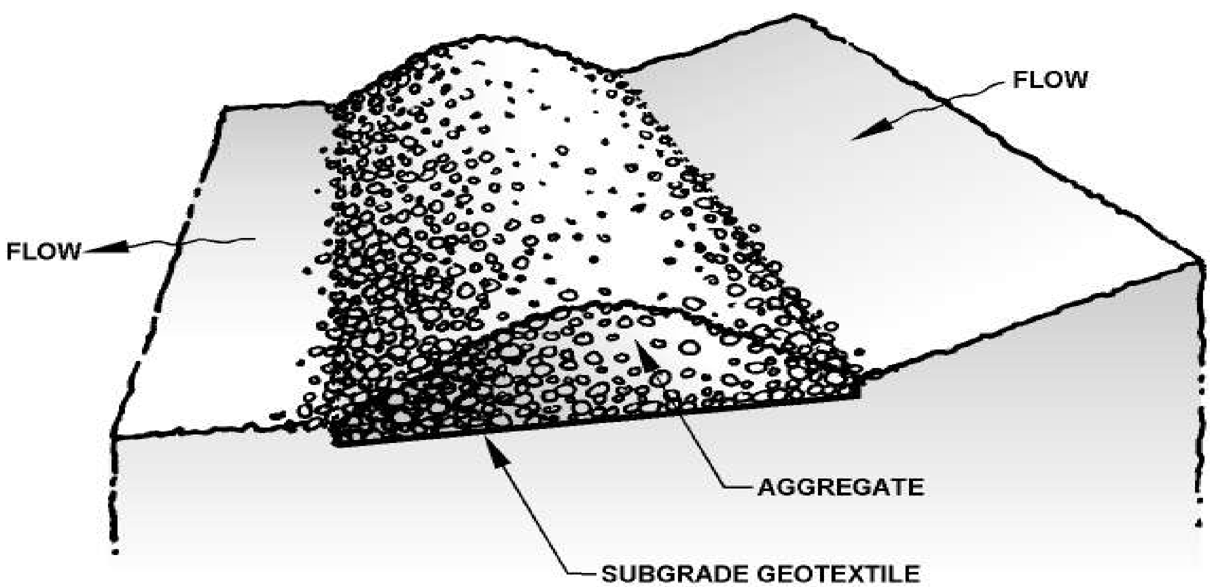
- Tracking with a bulldozer or other heavy equipment may compact the soil.

- May increase time to finish slopes.
- Should not be relied upon as sole means of erosion control.

B. Sediment Control Practices

Once soil erosion occurs, sediment trapping or removal techniques can reduce the amount of sediment and associated pollutants that leave the site, thus protecting nearby streams, wetlands, and lakes. Sediment controls are usually placed around the perimeter of a disturbed area and where concentrated water leaves the site. Sediment control BMP's should be in place before land clearing and grading begins. It is important to note that sediment controls, if poorly maintained, can become sources of sediment and other pollutants during larger storms.

1. Filter Berm



1.3 Fig filter berm

AGGREGATE BERM - Retains sediment in gravel or crushed rock berm.

Advantages

- Very efficient method for sediment removal.
- Reduces runoff velocity.

Disadvantages

- More expensive than some other measures because requires clean gravel or crushed rock rather than materials found onsite.
- Clogging from mud and soil may make maintenance difficult.
- Has a limited life span.

COMPOST BERM - Can be used in place of sediment fence, straw wattles, etc. (For sheet flow only.)

Advantages

- Very efficient method for sediment removal.
- Reduces runoff velocity.
- Compost retains a large volume of water
- The mix of particle sizes in the compost filter material retains as much or more sediment than traditional perimeter controls, such as sediment fences, while allowing a larger volume of clear water to pass through the berm.
- Low removal cost as compost berm can be spread/tilled into surface as a soil amendment when no longer needed or can be seeded and left in place.

Disadvantages

- Initial cost may be higher than some other more commonly used measures.
- Clogging from mud and soil may make maintenance difficult.
- Has a limited life span.

2. **Pre-Fabricated Barrier System**

Pre-fabricated barrier systems typically consist of a triangular shaped dike, usually made of foam or other flexible, lightweight material. The dike is wrapped in geotextile, which extends from the bottom of the dike to provide aprons on the upslope and downslope sides of the dike. The dike is anchored by trenching and stapling the aprons. Barrier materials, section lengths and weights vary among manufacturers. Other pre-fabricated barriers consist of water filled hinged panels that act as a sediment basin or toe of slope base measure. Their purpose is to hold run-off for designed periods of time in order to allow for settling of soil.

Advantages

- Can be lightweight.
- Installation is relatively simple.
- Can be used to divert and slow velocity of small drainage areas.
- Reusable.
- Can retain larger suspended soils particles.

Disadvantages

- Can be easily damaged by construction equipment.
- Not effective in steep swales, channels or ditches.
- If improperly installed can allow undercutting or end-flow.
- Not effective where water velocities or volumes are high.
- Installation must be done exactly as specified by manufacturer.
- Not intended for use on steep slope applications.

Fig 1.4 Pre-Fabricated Barrier Systems

3. **Sediment Fence**

Temporary sediment trap consisting of an entrenched geotextile stretched across and attached to supporting posts. Sediment fences are adequate to treat flow depths consistent with overland or sheet flow.

Advantages

- Reduces runoff velocity.
- Requires minimal ground disturbance to install.
- Relatively inexpensive.

Disadvantages

- Applicable to small drainage areas and overland flow; not applicable to concentrated flows.

- Incorrect geotextile or installation decreases sediment fence performance.
- Requires frequent maintenance and inspection.

Fig 1.5 Sediment Fence

1. Sediment Trap

A sediment trap consists of a small, temporary ponding area, with a rock weir or perforated riser pipe at the outlet, formed by excavation or by constructing a weir. The sediment trap serves drainage areas 5 acres and smaller. They are a retention structure designed to remove sediment from runoff by holding a volume of water for a length of time, allowing particles 0.02 mm and large to settle out. Sediment retention should be used as a last line of defense when included in an ESCP and never used by itself.

Combining with Permanent Drainage Facilities

If a project includes a permanent storm water retention/detention pond, the rough graded or final-graded facility could function as a trap during construction.

Design features of the permanent structure, such as surface area, retention time and outlet control, should meet the design requirements of the temporary facility.

Completion of the permanent facility should occur only when all upstream control structures are in place and stabilization of contributing drainage areas is complete.

If a project includes an infiltration facility, the roughly excavated facility could be used as a trap or basin providing the facility provides the surface area and retention time required by the trap or basin. Excavate the sides and bottom of the facility to a minimum of 3 foot above final grade with a backhoe working at "arms length" to minimize disturbance and compaction of the infiltration surface.

Additionally, any required pretreatment facilities should be fully constructed prior to any release of sediment-laden water to the facility. Pretreatment and shallow excavations are intended to prevent the clogging of soil with fines.

Advantages

- Protect downstream riparian properties from sediment deposits.
- Prevent reduced downstream capacity due to sediment deposition in a stream channel.
- Prevents clogging of downstream facilities.
- Remove particles up to medium silt size (0.02 mm).
- Surface water conveyances can be connected to the facility as site development proceeds. The designer may want to route surface water collected from disturbed areas of the site through a sediment trap prior to release from the site.

Disadvantages

- May become an attractive nuisance. Care must be taken to adhere to all safety practices.
- Maintenance and sediment removal is essential for adequate performance.
- Serves limited areas.

- Does not reduce turbidity resulting from fine silts and clays in runoff. Traps are more effective when used in conjunction with other measures such as seeding and mulching.

Fig 1.6 permanent drainage facilities

4. **Sediment Basin**

A temporary sediment basin has one or more inflow points and baffles to spread the flow, wet storage and dry storage, a securely anchored riser pipe, a dewatering device and an emergency overflow spillway. The sediment basin serves drainage areas less than 10 acres and has a design life of approximately 1-year.

Basins are large facilities that treat runoff from large drainage areas. Because of this, basins have limited application on linear construction projects. The applications, advantages and disadvantages of basins are included here for the designer's edification.

Combining with Permanent Drainage Facilities

If a project includes a permanent storm water retention/detention pond, the rough graded or final-graded facility could function as a basin during construction.

Design features of the permanent structure, such as surface area, retention time and outlet control, should meet the design requirements of the temporary facility.

Completion of the permanent facility should occur only when all upstream control structures are in place and stabilization of contributing drainage areas is complete.

If a project includes an infiltration facility, the roughly excavated facility could be used as a basin, providing the facility provides the surface area and retention time required by the basin. Excavate the sides and bottom of the facility to a minimum of 2 foot above final grade with a backhoe working at "arms length" to minimize disturbance and compaction of the infiltration surface.

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Disadvantages

- May become an attractive nuisance. Care must be taken to adhere to all safety practices.
- Failure of a basin which is not properly located could result in loss of life, damage to homes or buildings or interruption of services such as transportation or power.
- Maintenance and sediment removal is essential for adequate performance.
- Does not reduce turbidity resulting from fine silts and clays in runoff. Basins are more effective when used in conjunction with other measures such as seeding and mulching.

Fig 1.7 permanent drainage facilities

1.2.2. Selecting basic catchments characteristics

Important factors to be considered in the planning of erosion and sediment control activities like catchments characteristics are:-

A. **Climate: -** Rain fall, temperature, sunshine hours, wind, and humidity, influence the water availability to the plant/crop to be grown under erosion and sediment control activities the catchments characteristics. Rain fall mount, intensity and timing direct bearing on runoff production and consequently its availability. Temperature, and sunshine hours, wind and humidity directly affect the evaporation and thus water availability to plants/crops.

B. Rain fall: - Low intensity and longer duration rain fall is considered more suitable than high intensity and of shorter duration. Annual rain fall concentrates in short time span (one or, two months) is less suitable than it spans over longer period (4-5 months or more).

C. Topography: - A land slope is considered more suitable for erosion and sediment control activities, however, it is practiced on a steeper slope. Steeper the ground slope, higher be the risks of uneven distribution of runoff, soil erosion and higher be the cost of structures. Highly flat slopes are also prohibitive to runoff generation and collection at the target area and thus less suitable for erosion and sediment control activities of catchments characteristics.

D. Soils: - Soil depth, texture, structure, and nutrients have direct impacts on the success of erosion and sediment control activities of the catchments characteristics. Soil texture affects the water infiltration rate. For example infiltration rates of sand= 30mm/hr, loam= 10-20mm/hr, clay=1-5mm/hr. loosely packed and cracked soils have high infiltration rates as compared with tightly packed soil structure.

Water holding capacity of soil directly affects the water availability of the plant/crop higher the water holding capacity of soil higher be the water availability to the plant and vice versa. Water holding capacity of sand=55mm/m depth, sandy loam=120mm/ and clay loam=150mm/m.

E. Crops: - Crop water requirements effective rooting depth, timing of rain fall in respect to crop developments stage and drought sensitivity are the major responsible crop factors for success of erosion and sediment control activities of catchments characteristics. Lower the effective rooting depth lesser is the water extraction from the soil and vice versa.

1.3. Applying procedures relating to erosion and sediment control

Principles of Soil Erosion and Sediment Control

- Plan the site to fit its natural characteristics lick Topography, Soil, Drainage patterns, Existing vegetation etc.
- Preserve and protect areas of existing vegetation.
- Take special precautions to prevent damages to adjacent watercourses, lakes, and wetlands.
- Minimize the extent and duration of the area exposed at one time.
- Apply temporary erosion control practices as soon as possible to stabilize exposed soils and prevent onsite damage.
- Install perimeter control and sediment control practices prior to site clearing and grading.
- Minimize runoff velocities and retain runoff on the site.
- Install measures to prevent sediment from being tracked onto public or private roadways.
- Complete final grading and install permanent vegetation on disturbed areas.
- Conduct thorough inspection, maintenance, and follow-up programs.

Control vs. repair: it is less costly to plan ahead and identify techniques to control erosion than conduct repairs.

Communication: discus plans with regulatory agencies and the field crews early in the process.

Phasing: plan the various phases of construction to occur closely to reduce the erosion potential of exposed soil.

Erosion and sediment control plan: from basic to complex depending on size of activity and known hazards. "Preventation is better cure than controlling soil erosion" such as:

1. Install all runoff and sediment control practices around the perimeter of the site.

2. Install and stabilize construction entrance(s).

3. Install and stabilize storm water management facilities.

Inspection: -

- At a minimum, inspect BMPs every weeks or after a 0.5 inch rain event or event or equivalent snowfall.
- Inspect BMPs daily during prolonged rain events.
- Conduct annual inspections for permanent storm water management

Sequencing of SE/SC

- Install all runoff and sediment control practices around the perimeter of the site.
- Install and stabilize construction entrance(s).
- Install and stabilize storm water management facilities.
- Seed within 7 days (temporary or permanent).
- Phase the plan in workable units in a construction sequence so that only the area actively being developed is exposed.
- Seed both temporary and permanent vegetation to all appropriate areas, including soil stockpiles and disturbed areas.
- Stabilize all channels adequately (with channel lining and outlet protection).

- Take measures to address dust control as needed (stabilize with seed and water spraying trucks).

Self-Check 1	Written Test

Name: ___________________________ Date: ________________

Directions: Answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers.

1. What is erosion and sedimentation? (5pts)
2. Write types of erosion and explain each?(5pts)
3. Write the catchment characteristics in erosion and sediment control activity?(5pts)
4. What are the purpose of Planning and organize erosion and sediment control activities?(5pts)
5. Write and explain Principles of Soil Erosion and Sediment Control activities?(5pts)

Note: Satisfactory rating – 20 points and above Unsatisfactory - below 20 points you can ask you teacher for the copy of the correct answers

Information sheet 2	Implementing erosion and sediment control principles

2.1 Implementing erosion and sediment control

Erosion and sediment control structures may include Grade stabilizing structures, outlet protection structures, storm water detention measures, dust control, and rural roads and tracks.

Grade Stabilization Structures: A grade stabilization structure is an embankment built across a draw or drainage way to take runoff from a higher elevation to a lower elevation while preventing gullies from extending upslope. Grade stabilization structures not only provide many benefits to water quality, they also provide a water source for wildlife. They provide a stable outlet for grassed waterways, reduce peak storm water flows, reduce sediment load which protects fish and aquatic habitat in streams and rivers and reduces sediment deposition in road ditches and other downstream areas. Grade stabilization structures are just one of many practices available to address your soil and water resource concern on your property. There are state and federal cost share programs available through the local SWCD and NRCS office to help offset the installation cost of new or rehabilitate existing practices. Contact the SWCD office for more information.

How it Works

A dam or embankment built across a gully or grass waterway drops water to a lower elevation while protecting the soil from gully erosion or scouring. Structures are typically either a drop spillway or a small dam and basin with a pipe outlet

Minimum technical standards for physical techniques

A. Level soil bunds

- **height: -** min 60cm after compaction
- **base width: -** 1-1.2m in stable soils (1 horizon :2 vertical) and 1.2-1.5m in unstable soils
- (1horiz :1 vertical)
- **top width: -** 30cm (stable soil) -50cm (unstable soil)
- **channel: -** shape, depth and width vary with soil, climate and farming system
- **ties: -** tie width dimension as required, placed every 3-6m interval along the channel
- **Length of bund: -** 30-60m in most cases, higher (max 80m) on slopes 3-5% - need to be spaced staggered for animals to cross.

B. Level stone bunds

- **height: -** 60-70cm up to 100cm (lower side)
- **total base width: -** (height) + (0.3-0.5m)
- **top width: -** 30-40cm
- **foundation: -** 0.3 width x 0.3m depth
- **grade of stone face down side: -** 1 horiz: 3ver.
- **grade of soil bank (seal) on upper side: -** 1horiz: 1.5-2vert.
- **bunds need to be spaced staggered for animals to cross**

- **max bund length: -** 60-80m.

C. Stone faced soil bunds

- **grade of lower stone face: -** 1 horizon to 3 vertical
- **grade of upper stone face (if any):-** based on soil embankment grade
- **grade of soil: -** 1 horizon to 1.5 vertical on stable soils and 1 horizon to 2 vertical on unstable soil
- **lower stone face riser foundation: -** 0.3 depth x 0.2-0.3 width
- **upper stone face riser foundation: -** 0.2 x0.2m
- **stone size: -** 20cm x 20cm stones (small and round shape stones not suitable)
- **top width: -** 0.4-0.5 m
- **height**: - min 0.7 and max 1m (lower stone face)
- **channel or trench along bund**
- **ties required every 3-6m along + trench /channel**

D. Level Fanya Juu bunds

- **height: -** min 60cm after compaction
- **base width: -** 1-1.2m instable soil (1horiz : 2 vertical) and 1.2 – 1.5m in unstable soils (1horiz :1 vertical).
- **top width: -** 30cm (stable soil)-50cm (unstable soil)
- **collection ditch: -** 60cm w x 50cm d
- **ties: -** placed every 3-6m interval along channel
- **length of bund: -** up to 60m in most cases, max 80m. fanya juu needs to be staggered to allow animal, to cross fields as required.

E. <u>Cutoff drain</u>

The first step is to estimate a probable maximum rate of surface run-off to design a channel or ditch which will carry this amount

Step 1 . For a given area, compute the peak discharge rate $\mathbf{Q_{pt}}$ by multiplying the corresponding $\mathbf{Q_p}$ taken from table by the catchments area (C_a).

$$Q_{pt} = Q_p \times C_a$$

Step 2. Compute the required flow cross sectional area (A) using the corresponding maximum permissible velocity **(V)**

$$A = Q_{pt}/V$$

Step 3. Decide the shape of the channel. Trapezoidal or parabolic is recommended.

Step 4. Use depth from table using V and channel gradient.

Gradient: - 1-10ha = 0.8-1%

10-30ha = 0.5%

30-50ha = 0.25%

Step 5. Find the channel discharge per unit of depth using table

Step 6 Find top width of the cutoff drain. For trapezoidal and parabolic cross-section: runoff from the catchments divided by discharge from the cutoff drain.

F. Trenches

- **length:-** 2.5-3m
- **spacing between two trenches laterally:** 25-50cm
- **catchment area /trench are ratio CA/TA** is 3-5:1 (based on rainfall and tree water requirements)-
- **2-3m distance between lines of trenches**.
- **Constructed in a staggered position one from another (triangle).**

G. Herring bones

- **Spacing:-** the structures are placed 3m a part (max 4m in very dry places) along the contours and have extended arms conveying water towards the planting area.
- **water collection ditch** (1m x 1m x 0.3m depth at lower side) is dug behind the planting pit
- (40 cm diameter x 50 cm depth); The tips of the extended arms are 2.5 -3m apart (average).
- **Embankment: -** max. Height down slop (0.4-0.5m) and decreases to 20cm at the end of the side arms.

H. Half-moons

- **diameter**:- min 2m and max 2.5m
- **lateral spacing**:- 50cm
- **consecutive spacing**:- 3-6m or more
- **C/CA** = 1.5:1 – 4:1

I. Stone check dams

- **spacing =** height (m) x1.2
  - gradient (decimals)
- **side key & foundation:-** 0.5m depth x width of check dam
- **height**:- min 1m & max 1.5m excluding foundation
- **base width**: min 1.5m & max 3.5m
- **stone face:-** 1:3/1:4 for increased stability
- **spillway (trapezoidal)**:- with 0.25m free board and 0.25-0.3m permissible depth, width min 0.75m & max 1.2m
- **Drop structures:-** on steep slopes (above 15%) before the apron (ladder placed stones up to half the height between apron & spillway level).
- **apron:-** at least 50cm wider on both sides of spillway fall (total width 1.5m-2m) and length towards water flow of minimum 1m, with stones placed vertically with alternate slopes, provided with a sill (15cm high)
- **work norm**:- 0.5m^3/pd/day

Identification and developing specifications of necessary resources

1. Level soil bunds

A. technical preparedness: land use, soil and topography assessed

B. min surveying & tools requirements: one water line level, two range poles graduated in an and 11m of string (a team of three people layout approx 2-3 ha/day), shovels, pick axes and wooden compactors

C. work norm (150 PDS/km):-

- Precise lay out along the contours using line level.

- scratching or removal of grasses from where embankment is constructed for better merging & stability
- excavation of trench or channel, & ties along channel (as necessary)
- embankment building, shaping & compaction (essential)
- Compacting the top of the bund.

2. Level stone bunds

A. minimum surveying & tools requirements:- the same as sol bunds +crow bars, sledge hammers, pick axes of shovels

B. work norm (250 PDS/KM)

- precise layout along the contours
- collection of stones
- excavation of foundation
- placement and building of stone walls (larger stones for foundation)
- filling of voids between walls with smaller stones and sealing of upper side with soil as required
- small stone ties every 5m (optimal)
- Reinforcement in depression points.

3. Stone faced soil bunds

A. min surveying & tools requirements:- the same as soil bunds+ crow bars sledge hammers

B. work norm (250 PDS/km)

- precise layout along the contours
- collection of stones for stone wall
- excavation of stone riser foundation
- building of stone walls (larger stones for foundation)
- excavation of soil and building of bund along stone riser construction
- reinforcement in depression points
- compaction & check of level

4. Level fanya Juu bunds: the same as soil bunds but with a work norm of 200PDS/km

5. Cut off drain (work norm: 07m^3/PD)

- precise layout
- removal of grasses from place of embankment
- -excavation of soil
- shaping & compaction of embankment
- provision of scour (1-2% slope)
- checking of gradient using levels

6. Water collocation trenches

a. Technical preparedness

- Training required (DAS and HHS) on how to use A-frame & space structure along the contours
- Agree with farmers on type of trenches, uses rights, other catchments protection works and on the job training in layout & construction.
- Test the measure first.

b. Minimum surveying & tools requirement

An A-frame level or water hose level linked to two poles placed at 3m distance. If not available use the normal water level hooked to a string linked to range poles placed at 5m distance. Tools such as crow bars pick axes & shovels (1 crow bar: 2 pick axes: 2 shovels ratio are necessary).

7. Herring bones

a. Technical preparedness:

Depth of soil and slop assessed. Discuss and agree with farmers on species and integration with other measures as required.

b. Minimum surveying and tools requirements

One A- frame can directly provide the shape of HB when laid down at ground level. Water line level not as good as A-frame but can be used for making major contour lines then proceed with direct assessment by sight and adjusting orientation of HB based on micro slopes. Shoves and pick axes are required.

C. Work norm (4HBs/PD)

Worm norm elements include precise layout (using A-frame or other level), excavation of collection ditch and planting pit, embankment building and compaction.

8. Half- moons: - the same as herring bones.

9. Compost making

a. Technical preparedness

- preparation of available materials kept under shade (cow dung, ashes, etc,) until compost is done
- training of groups of farmers in compost making necessary (demonstration)

b. Minimum surveying and tools requirements

- Select shaded places and availability of composting materials (link with area closure and homestead re- vegetation if necessary). Tools such as shoves and pick axes for excavation and containers are required.

C. work norm: 10pds/pit (4mlx 2mwx1.5md) for pit & 1pd/linear meter (2mwx 1. 5 height)

10. Grass strips (work norm= 30PD/km of strip)

The work norm includes precise layout, seedbed preparation, sowing & planting and compaction.

2.2 Applying practices for erosion and sediment control

Understanding the Practice of Erosion and Sediment Control (ESC) as a Whole System

It is important that the designer and contractor recognize that successfully implementing ESC measures requires a good understanding of the principles of the ESC process by both design and field staff. Installing correctly to specific site conditions and ongoing timely upgrading and maintenance are essential for a successful outcome. The planning strategies and presented in this document are as equally important as the understanding of the principles of their implementation to achieve good construction performance and protection of the environment. It is essential to understand that the objectives of the ESC measures begin with education and interaction throughout the planning, design, construction and post construction stages.

Sediment Control Practices: Once soil erosion occurs, sediment trapping or removal techniques can reduce the amount of sediment and associated pollutants that leave the site, thus protecting nearby streams, wetlands, and lakes. Sediment controls are usually placed around the perimeter of a disturbed area and where concentrated water leaves the site. Sediment control BMP's should be in place before land clearing and grading begins. It is important to note that sediment controls, if poorly maintained, can become sources of sediment and other pollutants during larger storms. Erosion and sediment control activities may include Land shaping including batter stabilization, banks, channels, and sediment basins, traps, filters, and fences. Also includes revegetation.

Sediment Basin: A temporary sediment basin has one or more inflow points and baffles to spread the flow, wet storage and dry storage, a securely anchored riser pipe, a dewatering device and an emergency overflow spillway. The sediment basin serves drainage areas less than 10 acres and has a design life of approximately 1-year. Basins are large facilities that treat runoff from large drainage areas. Because of this, basins have limited application on linear construction projects. The applications, advantages and disadvantages of basins are included here for the designer's edification. Combining with Permanent Drainage Facilities

• If a project includes a permanent storm water retention/detention pond, the rough graded or final-graded facility could function as a basin during construction. Design features of the permanent structure, such as surface area, retention time and outlet control, should meet the design requirements of the temporary facility. Completion of the permanent facility should occur only when all upstream control structures are in place and stabilization of contributing drainage areas is complete.

• If a project includes an infiltration facility, the roughly excavated facility could be used as basin, providing the facility provides the surface area and retention time required by the basin. Excavate the sides and bottom of the facility to a minimum of 2 foot above final grade with a backhoe working at "arms length" to minimize disturbance and compaction of the infiltration surface.

• Any required pretreatment facilities should be fully constructed prior to any release of sediment-laden water to the facility. Pretreatment and shallow excavations are intended to prevent the clogging of soil with fines.

Advantages

- Protect downstream riparian properties from sediment deposits.
- Prevent reduced downstream capacity due to sediment deposition in a stream channel.
- Prevents clogging of downstream facilities.
- Remove particles up to medium silt size 0.02 mm.
- Surface water conveyances can be connected to the facility as site development proceeds.

Disadvantages

- May become an attractive nuisance. Care must be taken to adhere to all safety practices.
- Failure of a basin which is not properly located could result in loss of life, damage to homes or buildings or interruption of services such as transportation or power.
- Maintenance and sediment removal is essential for adequate performance.
- Does not reduce turbidity resulting from fine silts and clays in runoff.

Basins are more effective when used in conjunction with other measures such as seeding and mulching.

Design Criteria

• Water temperature in the basin may be too high for direct release. Always moderate the water temperature before it drains into a lake, stream or waterway. Whenever possible, release the trap discharge onsite onto a relatively level, densely grassed area at least 50 feet from a waterway or wetland.

• Require installation of a staff gauge to aid in determining sediment depth.

• The designer may want to route surface water collected from disturbed areas to a sediment basin prior to release from the site. A qualified engineer should design temporary sediment basins.

Sediment Fence: Temporary sediment trap consisting of an entrenched geotextile stretched across and attached to supporting posts. Sediment fences are adequate to treat flow depths consistent with overland or sheet flow. Standard or heavy duty sediment fence fabric must meet specific requirements.

Advantages

- Reduces runoff velocity.
- Requires minimal ground disturbance to install.
- Relatively inexpensive.

Disadvantages

- Applicable to small drainage areas and overland flow; not applicable to concentrated flows.
- Incorrect geo textile or installation decreases sediment fence performance.
- Requires frequent maintenance and inspection.

Design Criteria

• Sediment fence should only be used for sheet and rill erosion

• Standard or heavy-duty sediment fence filter fabric shall have manufactured stitched loops with 2”x 2”x4’ posts. Stitched loops shall be installed on the uphill side of the sloped area.

• Sediment fences should be installed a minimum of 3 feet from toe of slope in order to maximize storage.

• A trench should be excavated 6 inches deep along the line of the posts.

• Trench should be backfilled and the soil compacted on both sides of the sediment fence.

• Posts should be spaced a maximum of 6 feet apart and driven securely into the ground a minimum of 12 inches.

• When sediment fence approaches its termination point, turn fence uphill and extend one full panel (6 ft).

• When joining two or more sediment fences together, join the two end stakes by wrapping the two ends at least one and one half turns and driving the joined stakes into the ground together.

• Height of a sediment fence should not exceed 3 feet. Storage height and ponding height should never exceed 1.5 feet.

Sediment trap: A sediment trap consists of a small, temporary ponding area, with a rock weir or perforated riser pipe at the outlet, formed by excavation or by constructing a weir. The sediment trap serves drainage areas 5 acres and smaller. They are a retention structure designed to remove sediment from runoff by holding a volume of water for a length of time, allowing particles 0.02 mm and large to settle out. Sediment retention should be used as a last line of defense when included in a ESCP and never used by itself.

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• If a project includes an infiltration facility, the roughly excavated facility could be used as a trap or basin providing the facility provides the surface area and retention time required by the trap or basin. Excavate the sides and bottom of the facility to a minimum of 3 foot above final grade with a backhoe working at"arms length" to minimize disturbance and compaction of the infiltration surface.

• Additionally, any required pretreatment facilities should be fully constructed prior to any release of sediment-laden water to the facility. Pretreatment and shallow excavations are intended to prevent the clogging of soil with fines.

Advantages

- Protect downstream riparian properties from sediment deposits.
- Prevent reduced downstream capacity due to sediment deposition in a stream channel.
- Prevents clogging of downstream facilities.
- Remove particles up to medium silt size (0.02 mm).
- Surface water conveyances can be connected to the facility as site development proceeds.

The designer may want to route surface water collected from disturbed areas of the site through a sediment trap prior to release from the site.

Disadvantages

- May become an attractive nuisance. Care must be taken to adhere to all safety practices.
- Maintenance and sediment removal is essential for adequate performance.
- Serves limited areas.
- Does not reduce turbidity resulting from fine silts and clays in runoff. Traps are more effective when used in conjunction with other measures such as seeding and mulching.

Design Criteria

• Construct prior to any upslope clearing and grading.

• Locate in a low area where the trap will intercept all or most of the runoff from the disturbed area before it enters a waterway, considering safety in case structure fails.

• Locate the trap so that it is readily accessible for maintenance.

• Provide for diversion dikes and ditches, as needed, to collect and divert water toward the trap.

• Sediment storage volume can be calculated using the USLE assuming a minimum one year sediment accumulation period for design purposes. To convert tons of sediment as calculated to cubic feet, multiply 0.05 tons per cubic foot. Determine the bottom surface area of the sediment trap using the calculated sediment volume and the maximum 1.5 depth.

• Determine the total trap dimensions by adding an additional 2 feet of depth for settling volume (before overtopping of spillway) above the sediment storage volume, while not exceeding 3:1 side slopes.

• Design the trap with a level bottom, 3:1 or flatter side slopes and a L:W ratio of 3.

• Construct the trap as the first step in the clearing and grading of the site.

• Form the trap by excavation or by construction of compacted embankment. If the trap is formed by embankment, the designer should note that dam safety regulation may apply to heights exceeding 5 foot. The embankment should be stabilized using a cover method such as seeding, mulching or erosion control matting.

• Water temperature in the trap may be too high for direct release. Always moderate the water temperature before it drains into a lake, stream, wetland or waterway. Whenever possible, release the trap discharge onsite onto a relatively level, densely grassed area at least 50 feet from a waterway or wetland.

• Evaluate the release areas on a site-by-site basis in order to determine appropriate locations for and methods of releasing runoff. Do not use vegetated wetlands for this purpose.

Constant maintenance is essential for proper functioning.

- Remove sediment from the trap when it reaches one-third the storage capacity.
- Repair any damage to the trap, the embankments or the slopes.

Sidewalk Sub-grade Gravel Barrier: A sidewalk sub-grade gravel barrier is an application that provides storage and filtration from run-off on sites with mild slopes. It can be used on all types of projects but generally on single family. Normal installation occurs when excavating for footing and foundation.

Advantages

- Easy to install
- Very economical
- Can retain suspended soils

Disadvantages

- May require additional measure depending upon soil type
- May need periodic maintenance for removal of suspended materials
- May not be acceptable by local jurisdiction for sub-base material when pouring sidewalk

Design Criteria

- Install where the site slopes to a street with curbs and slopes are 5% or less
- Plug all weep holes in curb
- Sidewalk sub-grade must have a minimum 4-inch depth and a 4-foot width.
- A 2 inch layer of approved sub-base material must be installed
- A gravel filter berm may be installed along the inside edge, or toe of slope to increase filtration
- Install sediment barrier on the downhill corner of property to intercept run-off
- On development sites, install sidewalk sub-grade as part of post construction
- On single family sites, install as part of the footing/foundation dig out
- If sidewalk concrete is to be poured prior to establishment of permanent site cover, approved sediment barriers must be installed prior to pouring sidewalk

Inlet protection: Prevents coarse sediment from entering storm drainage systems by filtering runoff and retaining sediment before it reaches a drainage inlet or storm sewer system. There are many options and variations of inlet protection available.

Fig 2.1 Inlet protection

Advantages

- Prevents sediment from entering the storm drain system.
- Reduces amount of sediment leaving the site.

Disadvantages

- May result in ponding of water above the catch basin.
- Sediment removal may be difficult under high-flow conditions..
- Short-circuiting of flow may occur if not properly installed.
- Useful only for low flows having low sediment loading.
- Improper installation, maintenance or removal may introduce sediment into the storm drain system.

Design Criteria

- Place inlet protection in areas where water cans pond, and where ponding will not have adverse impacts.
- Inlet protection must allow for overflow in a severe storm event.
- Addition measures must be considered depending upon soil type
- Inlet protection types include:

Sand Bags: Sandbags are manufactured from durable, weather resistant tightly woven Geo textile fabric material sufficient to prohibit leakage of the filler material. The bags should measure 24 x 12 x 6 inches and be filled with firmly packed sand weighing at least 75 lbs.

Advantages

- Relatively low cost.
- Installation is simple, can be done by hand.
- Bags are easy to move, replace and reuse on paved surfaces.
- Are good short-term solutions in situations where concentrated flows are causing erosion.
- Can be used to divert and slow velocity of small flows.
- Can be used in concrete lined ditches capture sediment and reduce water velocity.

Disadvantages

- Generally effective for only a few months.
- Can be easily damaged by construction equipment or by traffic in paved areas.
- Can contribute sediment to runoff if bags rupture.
- Cannot be staked and are not appropriate on steep slope applications.
- Not effective in steep swales, channels or ditches.
- If improperly installed can allow undercutting or end-flow.
- Not effective where water velocities or volumes are high, can get washed away.

Design Criteria

- Generally used in ditches and/or swales as a check dam.
- Can be used on highway or road projects to divert run-off.
- Ends of bags must be tightly abutted and overlapped to direct flow away from bag joints.

Compost berm : Can be used in place of sediment fence, straw wattles, etc. (For sheet Flow only.)

Advantages

- Very efficient method for sediment removal.
- Reduces runoff velocity.
- Compost retains a large volume of water
- The mix of particle sizes in the compost filter material retains as much or more sediment than traditional perimeter controls, such as sediment fences, while allowing a larger volume of clear water to pass through the berm.

- Low removal cost as compost berm can be spread/tilled into surface as a soil amendment when no longer needed or can be seeded and left in place.

Disadvantages

- Initial cost may be higher than some other more commonly used measures.
- Clogging from mud and soil may make maintenance difficult.
- Has a limited life span.

Design Criteria

- Use mature, good quality material with sufficient particle size distribution.
- Berm Dimensions:
- Height and side slopes: 1 -1.5 feet high and 2-3 ft width at base.
- If used as slope application, use Table 4-8 for spacing.
- Used solely for sheet flow and installed along contours of slope

2.3 Carrying out routine work with control measures and structures

Identification of erosion effects

The following are some of the common indicators of erosion:

- erosion pedestals and pavements
- over wash (deposits of loose soil in micro-depression)
- exposed plant /tree roots
- exposed sub soil and parent material
- soil deposits in cut- off drains and retention ditches, at the foot of slopes and in valleys
- rills and gullies
- surface litter accumulation or washed away
- Accumulation of soil a above stones, hedges, grass strips, fences, etc on sloping land.
- breaches in conservation structures
- increased turbidity of streams and rivers where the water appears reddish brown or grey

- over blow, i.e. usually white, loose sand in micro-depressions where top soil has been blown away
- accumulation of sand against grass stems, hedges, etc
- dust storms
- ripple marks on sands soils
- formation of sand dunes

Conservation Measures

The adoption of various soil conservation measures reduces soil erosion by water, wind and tillage. Tillage and cropping practices, as well as land management practices, directly affect the overall soil erosion problem and solutions on a farm. When crop rotations or changing tillage practices are not enough to control erosion on a field, a combination of approaches or more extreme measures might be necessary. For example, contour plowing, strip-cropping or terracing may be considered. In more serious cases where concentrated runoff occurs, it is necessary to include structural controls as part of the overall solution – grassed waterways, drop pipe and grade control structures, rock chutes, and water and sediment control basins.

Erosion and sediment control measures

Erosion and sediment control measures are classified into the following categories:

- Temporary measures;
- Permanent measures;
- Minimum requirements (Planning Strategy); and
- Best management practices (BMP).

Each of these categories and BMPs are described in the following sections.

Temporary and Permanent Control Measures Erosion and sediment control measures can be classified into two broad categories.

Temporary Measures: Those measures during the construction phase that will be completely removed once permanent measures are installed and/or vegetative cover is established; and

Permanent Measures: Measures incorporated into the overall design to address long-term, post construction erosion and sediment control.

Erosion and sediment control measures

Temporary erosion and sediment control measures should be installed at the start of the construction phase. Additional measures will likely need to be installed throughout the construction phase. Permanent erosion and sediment control measures can be installed during or at the end of the construction phase. Examples of temporary measures include top soiling, seeding, slope texturing, synthetic permeable barrier, mulching, RECP coverings, silt fence, rolls, wattles, straw bale barriers, etc. Examples of permanent measures include off take ditch, energy dissipater, berm interceptor, gabion, rock check, sediment pond/basin, etc. Dependent on site conditions, some temporary measures will be retained for a longer duration to render its life span more permanent.

2.4. Performing erosion and sediment control measures

Development and construction can lead to significantly increased erosion rates, which have many negative effects. Not only can erosion make slopes and embankments unstable, which directly impacts any structures recently built near them, but it also can result in destroyed ecosystems, degraded water supplies and increased flood hazards. This is why erosion control on construction sites is such a focus and a primary objective. There are four basic principles of erosion control and properly implementing all of them is the only way to ensure effectiveness.

Erosion control measures

Your primary course of action is to keep the soil on your site in place. In order to do that, you need to limit vegetation removal when possible. You can also try to cover bare soils by seeding and covering with straw. Additional provisions are necessary when working in a sensitive habitat, or on a steep slope. Erosion control blankets are typically best applied on steep slopes and can be used to cover soil after seeding has taken place.

Sediment control measures

Think of sediment control as a back-up, or secondary defense, to erosion control. Should the erosion control measures fail, sediment control measures are designed to capture eroding soil and keep it on site.

This can be done be using straw rolls on slopes or at the bottom of slopes. Or, silt fences can be placed at the bottom of slopes, provided they don't impact drainage. Gravel bags, particularly around drainage inlets are also commonly used. Finally, rocked driveways and entrances prevent soil and sediment from being tracked onto adjacent roads. Remember, none of these measures are meant to initially stop erosion. Rather, they're intended to capture soil that has eluded erosion control measures before it can cause any damage.

Runoff control measures

The primary enemy in erosion control is water. That means controlling storm water, and keeping it away from bare soils, is essential to preventing soil erosion. Your first option will be to find a vegetated area that can withstand increased runoff. This can be done by diverting the runoff from any bare soils and newly disturbed areas. When dealing with a large concentration of water, it's unwise to concentrate all of your runoff to one area. Find multiple locations for drainage and ensure your development won't cause additional erosion after construction is completed. It's also important to avoid fill slopes in favor of cut slopes for drainage. If that's impossible, try breaking up drainage in order to create sheet flows over the slope. If you're implementing pipe, conduits or channels for runoff, be sure to install energy dissipators such as a collection of rocks, which reduces flow velocity and helps prevent scour and downstream erosion.

Maintenance measure

Because there's typically no sure-thing in erosion control, it's important to continually check on the measures you've put in place, particularly when it rains. You should be able to spot areas that may need additional reinforcement, or need a new plan all together. In order to help the ability of the erosion control measures, try to regularly clear out silt that has built up around silt fencing or drainage inlets.

2.5 Identification of appropriate soil and water conservation techniques

The planning of conservation structures must be based on the catchment approach. This means that the movement of water from the highest point of the land to the lowest point must be taken into consideration. In planning the first step is to demarcate the areas of arable land which are suitable for cultivation and the areas which are non- arable. The next step is to identify the natural waterways or drainage lines that will carry run off during heavy storms. If there in no natural, artificial water ways will be required. Soil and water conservation in its wider significance includes soil fertility and moisture management as well as run off and erosion control through of an entire set of integrated physical and biological measures. Besides, soil and water conservation is mostly water harvesting based if arid and semi-areas considered.

2.5.1 Physical techniques

Physical conservation techniques are permanent features formed from earth, stone or masonry that are designed to protect the soil from uncontrolled run off and erosion and to retain water where it is needed. They are particularly important on steep slopes where annual crops are grown and in marginal rainfall areas where there is a need to conserve rainfall in-situ. Physical techniques have the prime purpose to divide the natural length of a hill side in to shorter sections. The selection and design of physical techniques depend on many factors such as:

- Climate and the need to retain or discharge runoff
- Farm size and system (large or small – scale, mechanized or non-mechanized)
- Cropping pattern (perennial or annual, with or without rotates)
- Slope steepness
- Soil characteristics (erodibility, texture, drainage, depth, stoniness and risk of mass movement)
- The availability of an outlet or waterway for safely discharging runoff away from cropland.
- Labor availability and cost
- The availability of materials, e.g. stone
- The adequacy of existing agronomic or vegetative conservation measures.

1. <u>Level soil bunds</u>

A level soil bund is an embankment constructed along the contours (points of the same elevation), made of soil, with a collection channel or basin at its upper side. Soil which is eroded between two bunds is deposited in behind the lower band. Whenever the basin or space behind the bund is full of sediment, the bund should be raised until forming a terrace. The main disadvantage and constraints are:-

labor intensive activity (labor availability, capital investment or incentives may be required), may be a problem for construction and maintenance of bund spacing taken out of production by the bunds if too narrow spaced (2-10% depending on slope and intervals). Rodents or other pests may be harbored by bunds. Most of the disadvantages would be compensated by accurate design and modifications as required.

2. <u>Level stone bunds</u>

A level stone bund is an embankment made of stone constructed along the contours across sloping lands, without a collection channel or basin at its upper side. Its function is identical to soil bunds. They are preferred to soil bunds in areas having abundant stones and are recommended for slopes higher than 15-30% for their superior stability and resistance against runoff. Its disadvantages and constraints are the same as soil bunds. However it requires increased labor and additional skills for the stone dry masonry work.

Fig 2.2 level soil bund

3. <u>Stone faced soil bunds</u>

Stone faced soil bunds are soil bunds further strengthened on one or both sides of their embankment with a stone wall or riser. The strengthening of soil bunds with stones throughout their entire length is recommended wherever farmers tend to increase the spacing between structures and stones are available. Their disadvantages and constraints are the same as soil bunds + increased labour. They require additional skills for the stone dry masonry work.

4. <u>Level FanyaJuu bunds</u>

A level FanyaJuu (throw uphill in Swahilli language) bund is an embankment constructed along the contours, made of soil or soil strengthens with a stone riser, with a collection channel or basin at its lower side. Runoff velocity is reduced but overflow may overtop the bund and accumulate (with some sediments) inside the downstream channel.

Main advantages are as for the soil bunds. However, another main advantage is that FanyaJuu bunds bench more rapidly than level soil bunds. By raising the bund, a bench terrace will develop in the course of fevrer years (3-5 years based on slopes and types of soils).

Disadvantages and constraints with regards to moisture deficit are only suitable for upper limits of semi-arid environments (rainfall 700-900mm) and deep soil (over 75cm), and on slopes < 15%, above which soil and stone bunds are preferred. A main problem is that FanyaJuu do not accommodate much runoff, especially during heavy showers that characterize dry lands. In this care, FanyaJuu bunds can easily be destroyed in series.

Another disadvantage is that spillways are difficult to insert (small upper side embankment for anchoring- overflow may be too high for next plot and bund – sill erosion and breakages).

5. <u>Cut off drain</u> A cut off drain is a channel used to collect runoff from the land above to divert it safely to a waterway, river, cultivated field, gully or reservoir. Besides, by diverting excess runoff, a cutoff drain protects the land below from erosion. In the dry lands, cutoff drains may be used mainly for the following purposes:

- Perfect cultivated land from runoff generated from sparse forest land or degraded grassland, steep slopes, etc.
- Divert additional water to cultivated plots.
- Divert additional water to 55 dams cropped areas inside gullies
- Divert additional water into reservoirs for irrigation and/or domestic uses (including water supply for livestock).

If not properly constructed may create considerable erosion. Need skilled manpower or adequate training. It is also labor intensive activity, especially if stone paved.

6. <u>Water collection trenches</u>

Trenches are large and deep pits constructed along the contours for the main purpose of collecting and storing rainfall water meant to support the growth of trees in dry zones (water harvesting systems). The trench pits collect and store considerable amount of runoff water (0.75-1m^3 of water for max rainfall event). They ensure proper catchments protection and rapid growth of trees. By their moisture conservation effect they accelerate the regeneration of natural and improved grass species and thus allow the area to supply additional animal feed.

7. Herring bones

Herring bones are small trapezoidal structures (called also A structures) constructed along the contours on gentle slopes. Their function is similar as of trenches.

They are suitable on gentle slopes and cheaper than trenches (less labour intensive). Advantages are otherwise the same.

Their disadvantages and constraints are not suitable on steep slopes and areas with rugged topography as well as soils prone to water logging and higher surface for evaporation.

8. Half – moons

Half – moons are semi-circular structures made out of soil constructed along the contours for the main purpose of collecting and storing rainfall water meant to support the growth of trees or crops (food for fodder). They are suitable for the gentle sloping and sandy areas of the dry zone. They may require some maintenance in case of intensive rains during first year.

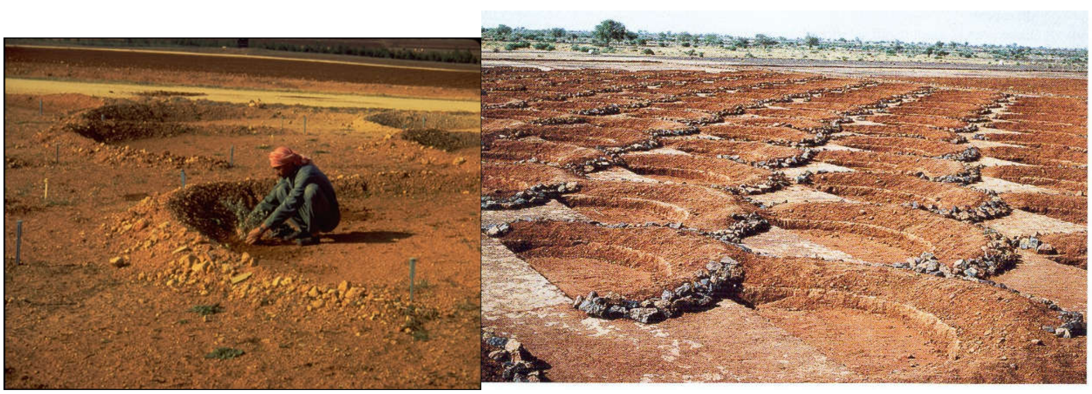

Fig 2.3 half moons

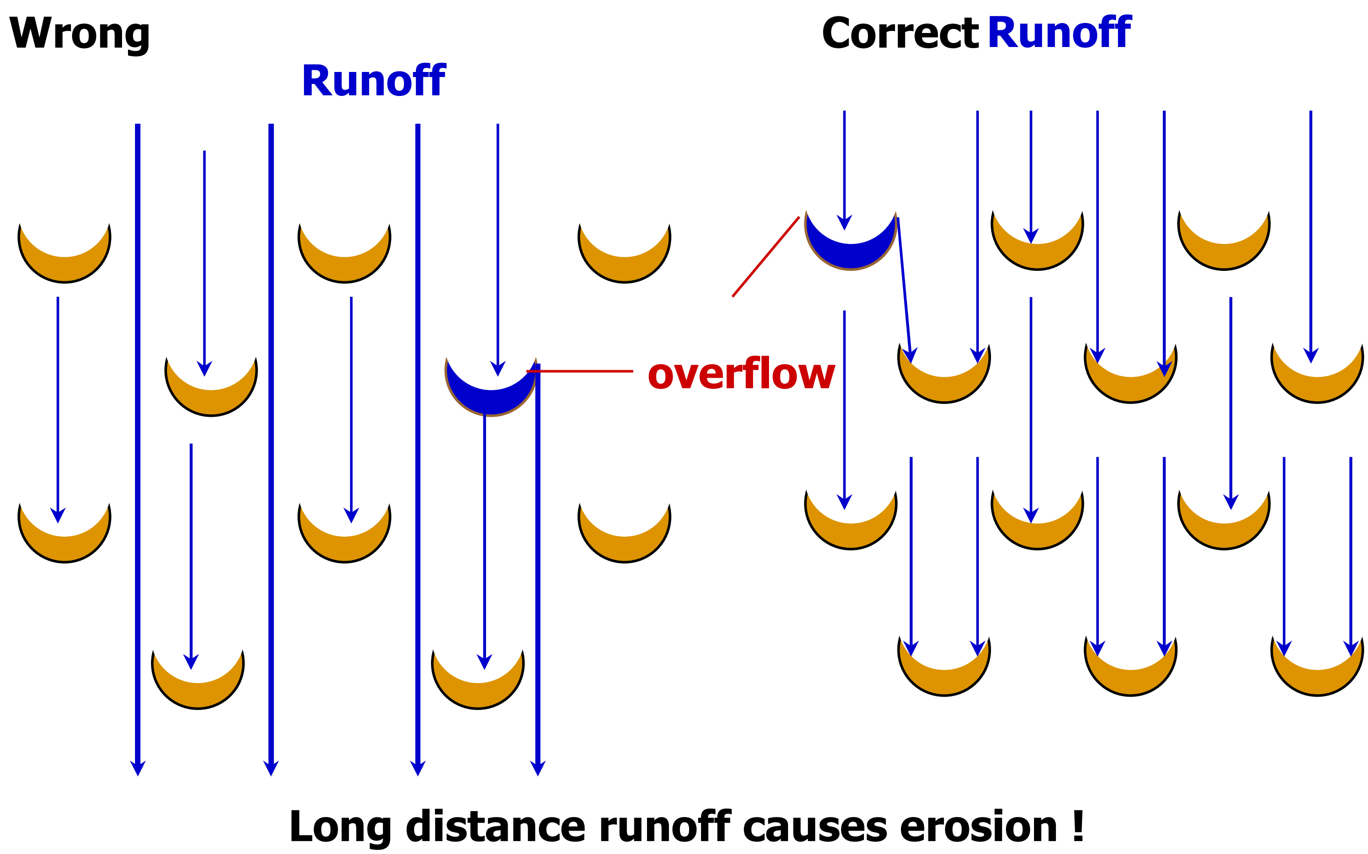

Fig 2.4 long distance run-off

9. <u>Stone check dams</u>

A stone check dam is an obstruction wall across the bottom of a gully or a small stream, which reduces the velocity of the runoff and prevents the deepening and widening of the gully.

Fig 2.5 stone check dams

10. Gabion check dams

A gabion check dam consists of galvanized iron steel wire cages, usually 2m x1mx1m size, filled with loose rocks/ stones. The cages are placed close together and tightly tied with wire. Their function is the same as stone check dams.

Fig 2.6 gabion check dams

2.5.2. Biological techniques

Biological conservation techniques can be defined as a set of conservation practices, which by In general, the practice of biological conservation is also the backbone of concepts such as land husbandry (which do not exclude physical measures but rather integrate them with an improved land use and cropping system). i.e. a rational land use by the means of proper land and crop management practices able to improve the conditions of the soil for root and plant growth and moisture storage.

1. **Agronomic conservation measures**

Agronomic measures are usually associated with annual crops, are repeated routinely each reason or in a rotational sequence, are generally of short duration and not permanent and they do not lead to changes in the slope profile. Their effectiveness arises from the control of rain splash erosion, the improvement of soil structure and fertility and the reduction of runoff rate and volume.

A. Cover /green manure crops

Cover crops are crops grown for the purpose of ground protection under row plantation crops such as pigeon peas or as a conservation crop on fallow lands during the off-season. Green manure crops are crops grown to maintain or increase the soil organic matter and nitrogen content of the soil. Before reaching their maturity or start competing for moisture with the row crops, their biomass is incorporated into the soil. They also protect the soil against erosion but not as much as cover crops.

B. Intercropping

Intercropping is a practice of growing two or more crops along the contour simultaneously in the same plot in a fixed pattern in one season. The aim of intercropping is to increase crop production and provide protection of the soil against erosive forces.

2. Soil management practices

Soil management practices are here divided into two:

A. Cultivation practices: these practices include farm operations that would improve the moisture retention capacity of the soil, control erosion and here improve yields. Most of these measures are integrated with physical structures for soil and water conservation. E.g.: contour cultivation.

B.Fertility improvement practices: they include all practices aimed to increase the amount and quality of organic matter content into the soil by improving the transformation of plant and animal residues. Examples are compost making and farm yard manure collection and management.

C. compost making Composting is the process of decomposition or breakdown of organic waste by a mixed population of micro-organism in a warm, moist and aerated environment. The final product of this process is called compost or humus.

3. Vegetative conservation measures

Vegetative conservation measures are those measures applied to potential lands to maintain their productivity or to degraded lands to restore productivity. These measures are predominantly trees, shrubs and herbaceous grass and legumes planted in different combinations or in pure stands for different purposes.

A. Grass strips

Grass strips are vegetative barriers made out of grass planted in narrow strips of 0.5-1.5m width laid out along the contour. They control erosion rather effectively in gentle slopes but above 3-5% slope their effect decreases. They cause less interference than other measures as they can easily be crossed by oxen and plough. Moreover, grass strips take out little amount of arable land and hence would not reduce crop yield.

Fig 2.7 Grass strips

2.5.6. Solving technical and organizational problems

Organizational problems

There are five main stages in the organizational problem solving process:

- Finding the Problem
- Formulating the Problem
- Making the Choice of the Solution
- Implementation of the Solution
- Audit & Review of Results of the Implementation

Organizational problem solving begins with the process of finding the problem. This is the most difficult stage because things are often not what they seem. What one sees as a problem depends on what ideas one has about organizations. Symptoms can both illuminate and mask underlying organizational problems. Finding the problem is a detective game in which the critical clue is sometimes obvious and other times subtle and intuitive, emerging only after a long process of search and elimination. Organizational problems, once found, are generally obvious and self–evident but they do not appear so at the beginning. What one wants to avoid is called a Type III error; the error of working on the wrong problem. There are usually many problems but which are really critical?

The second stage is problem formulation. This is difficult because it always involves values which need to be surfaced and dealt with in order to create a shared understanding about what is going on and how to improve. Organizations have many stakeholders with differing objectives and values. For example, stockholders seek greater dividends and profits. Management wants control, wealth, and increased growth. The workers demand more security, pay, and health benefits. Government needs tax revenues produced by the organization. Bankers and creditors want to get repaid. Environmentalists may want the organization to invest more in pollution abatement. Suppliers want continued business. Customers demand more services, greater quality, and lower prices. These competing values and objectives need to be factored in when formulating the problem to be solved.

The third stage in organizational problem solving is making the decision. This stage is relatively simple. When the two previous stages have been completed competently, the third stage involves selecting the best available alternative given the specific circumstances and constraints surrounding the problem. The new paradigm provides new insights for creating new solutions to seemingly unsolvable problems.

The fourth stage is implementing the solution. This involves implementation planning as well as the actual implementation of the solution as it is deployed throughout the organization. This is the stage during which the "rubber meets the road".

There are always problems in the implementation of a solution designed to improve an organization. This is where grand sounding concepts and theories smash up against the rocks of reality. While attention to details is important, what matters is the match between the solutions and reality. The fourth stage, if done right, improves the shared understandings required for making significant progress in becoming and remaining well–organized.

The fifth stage is the audit and review of the results of the solution deployment. The idea here is to actively monitor what is happening against the stated objectives. Always, the audit and review stage produces facts and suggestions for improving some or all of the four earlier stages. It is always valuable to verify that solutions have, in fact, worked.

These five stages are interdependent. Each is important. Bear in mind that implementation begins the day the organizational improvement process is started and not just when a solution has been agreed upon. How the assignment is approached, who has a say in the process, and the practitioner’s own deportment and character affect implementation. Clearly, the primary goal should be successful implementation which improves organizational effectiveness and the worth of the organization. The quality of the solution is generally less decisive than the process of reaching the solution and the way in which it is implemented. Of course, a quality solution is usually easier to implement because it is more acceptable. A solution which is not implementable is never a good solution.

Technical problem solving

This approach defines five **problem solving steps** you can use for most problems...

- Define the Problem
- Determine the Causes
- Generate Ideas
- Select the Best Solution
- Take Action
- Define the Problem

The most important of the *problem solving steps* is to define the problem correctly. The way you define the problem will determine how you attempt to solve it. For example, if you receive a complaint about one of your project team members from a client, the solutions you come up with will be different based on the way you define the problem. If you define the problem as poor performance by the team member you will develop different solutions than if you define the problem as poor expectation setting with the client.

Determine the Causes

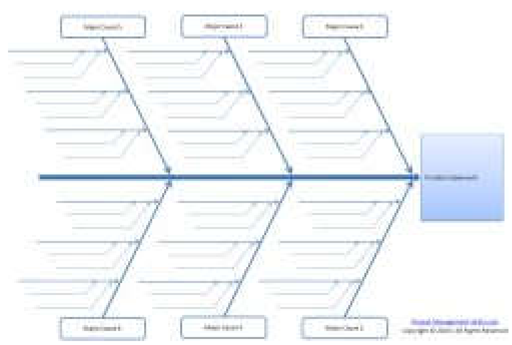

Fig 2.7 Fishbone Diagram

Once you have defined the problem, you are ready to dig deeper and start to determine what is causing it. You can use a fishbone diagram to help you perform a cause and effect analysis. If you consider the problem as a gap between where you are now and where you want to be, the causes of the problem are the obstacles that are preventing you from closing that gap immediately. This level of analysis is important to make sure your solutions address the actual causes of the problem instead of the symptoms of the problem. If your solution fixes a symptom instead of an actual cause, the problem is likely to reoccur since it was never truly solved.

Generate Ideas: Once the hard work of defining the problem and determining its causes has been completed, it's time to get creative and develop possible solutions to the problem. Two *great* problem solving methods *you can use for coming up with solutions* are **brainstorming** and **mind mapping**.

Select the Best Solution: After you come up with several ideas that can solve the problem, one *problem solving technique* you can use to decide which one is the best solution to your problem is a simple **trade-off analysis**. To perform the trade-off analysis, define the critical criteria for the problem that you can use to evaluate how each solution compares to each other. The evaluation can be done using a simple matrix. The highest ranking solution will be your best solution for this problem.

Take Action: once you've determined which solution you will implement, it's time to take action. If the solution involves several actions or requires action from others, it is a good idea to create an **action plan** and treat it as a mini-project. Using this simple five-step approach can increase the effectiveness of your **problem solving skills**. For more *problem solving strategies* and techniques, subscribe to my newsletter below.

Self-Check 2	**Written Test**

Name: __________________________ Date: ________________

Directions: **Answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers**

1. Write the difference between implementing erosion and sediment techniques and Practices for erosion and sediment control? (10pt)

2. List the physical techniques used to control erosion? (5)

3. List Risk management step process? (5pt)

4. List the steps of organizational problem solving? (5pts)

5. List the steps of problem solving clearly. (5pts)

Note: satisfactory Rating: 15and above pts. Unsatisfactory rating: below 15 pts.

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

Operation sheet #1	**Conduct erosion and sediment control activities on development sites**

Practical1: to techniques used to following procedures:

Objective: To enable the trainee with the construction of physical erosion and sediment control structures.

Procedure: -

- Use PPE
- Select the site to construct erosion and sediment controlling 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 and excavate the soil according to the dimension fixed in no.3
- 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 erosion and sediment control. 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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