CROP PRODUCTION

Level-II

Learning Guide-76

Unit of Competence: Assist erosion and sediment Control activities

Module Title: Assisting erosion and sediment Control activities

LG Code: AGR CRP2 M 12 (LO1-L04)

TTLM Code: AGR CRP2M12 0919V1

LO 1: Align work site practices

Instruction Sheet	Learning Guide #76

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

- Adhering erosion and sedimentation legislation at the work site
- Applying procedures relating to erosion and sediment control activities

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**:

- Adhere Erosion and sedimentation legislations for the work site.
- Apply procedures relating to erosion and sediment control activities.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 5.
3. Read the information written in the information “Sheet 1, and ,Sheet 2, ”.
4. Accomplish the “Self-check 1, and, Self-check 2,” **in page -3, -13,** respectively.
5. If you earned a satisfactory evaluation from the “Self-check” proceed to “Operation Sheet 1,and, Operation Sheet 2 ” **in page -4, and,13.**

Information Sheet-1	Adhering erosion and sedimentation legislation at the work site

1.1 **Adhering Erosion and sedimentation legislations**

Definition of legislation:-

- Legislation means laws and rules made by the government.
- Written and approved laws developed by the legislative branch of government referring to the power of political bodies.

Why legislation is needed

- Under the general law, a person may obtain rights or be subject to obligations because of a particular legal relationship with another person. The relationship may arise because of agreement or because of a document made by a person conferring a power over the person's property on another person. It may be a legal relationship found to exist because of a civil wrong committed by a person. These relationships are essentially narrow in their ambit and cannot be unilaterally created under the general law for all citizens or for all citizens of particular classes.
- Only legislation properly authorized and made, can unilaterally create or change rights and obligations of citizens generally, or change or affect the operation of the general law.
- Legislation may also be an option chosen by its maker to present a policy in a particularly powerful way or to create a state of affairs that can therefore only be further changed or brought to an end by legislation.
- Legislation provide framework for agricultural support services to farmers in order to ensure sustainable development and management of agricultural resources.
- Without law, there would be no reason for some people to remain as 'decent' or 'good' people. There would be people out there who would steal without a second's thought or rape people without even feeling guilty. Legislation ensures that the people who continue to do these horrible things are caught and punished, and is also there to ensure that people are put off and discouraged from doing these things. **Why are they put in place**? To help you remain safe. Of course there are many benefits to putting laws in place, but they are initially there to protect the people. The government is there to protect the people and act in favor of the people. That is why laws are there.

  Laws, too, are a reflection of what the people want. Different parties represent different opinions and depending on the size of a party in the administration and in Congress, different opinions will mean different votes. So of course, the feeling of the nation overall will be reflected in the laws that are passed in the United States legislature

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 sediment control legislations? (6 pts)

***Note:* Satisfactory rating – 3 points** **Unsatisfactory – below 3 points**

Answer Sheet

Score = ___________
Rating: ____________

Name: ___________________________ Date: ________________

Short Answer Questions

1.____-

Information Sheet-2	Applying procedures relating to erosion and sediment control activities

2.1 Applying erosion and sediment control procedures

Erosion and Sediment Control Plan

In planning, implementing, and maintaining an erosion and sediment control system, it is important to understand the difference between erosion prevention and sediment control.

Erosion prevention is any practice that protects the soil surface and prevents the soil particles from being detached by rainfall or wind. Erosion prevention, therefore, is a source control (i.e., a prevention technique) that treats the soil as a resource that has value and should be kept in place.

Sediment Control is any practice that traps the soil particles after they have been detached and moved by wind or water. Sediment control measures are usually passive systems that rely on filtering or settling the particles out of the water or wind that is transporting them. Sediment control treats the soil as a waste product that must be removed from where it has been transported and accumulated and disposed of at another location.

Which are more effective, erosion or sediment controls?

- Generally speaking, erosion prevention controls are more effective than sediment controls, and are preferred because they keep the soil in place and enhance the protection of the site resources.

Whenever possible, the primary protection at the site should be erosion prevention controls, with sediment controls used as a secondary system.

The sand and gravel general permit requires the permit tee to develop, maintain, and comply with their erosion and sediment control plan (ESCP) as a part of the Site Management Plan.

The ESCP must contain information on all the best management practices (BMPs) and structures that control storm water from:

1. Portions of a site where mining has temporarily or permanently ceased;
2. Portions of a site with exposed soils, cleared in preparation for mining or other industrial activity.

Properly managed, storm water will typically not require treatment. However, stormwater cannot be allowed to discharge to surface water if it exceeds the turbidity limit. Visual monitoring is required and if turbidity is a problem, treatment may be required. The information below provides general guidance on permit requirements and useful information for permit compliance. It does not examine every aspect of permit requirements identified under Special Condition. Erosion and Sediment Control. The permit tee is responsible for reading the full text of the permit and complying with all applicable permit requirements.

It should be noted that the concepts and BMPs may also be of use to smaller projects, such as those disturbing less than one acre of soil and projects involving single lots or small developments. The most effective way to minimize the discharge of pollutants in runoff from any construction activity is to implement pollution prevention BMPs such as erosion prevention controls, sediment controls, non-storm water pollution controls, and runoff controls. For small projects, minimum BMPs to consider include:

- Scheduling to avoid earth disturbing activities during wet weather.
- Perimeter sediment controls.
- Storm drains inlet protection.
- Site entrance and exit controls.
- Non-storm water pollution controls, such as materials use and waste management BMPs.
- Covering or otherwise protecting stockpiles
- Projects that include slopes susceptible to erosion should also include runoff and erosion prevention measures. BMPs should be inspected regularly to identify areas in need of maintenance or improvement to minimize pollutant discharges.

Permit Requirements

The ESCP must include information about all the best management practices (BMPs) that are used to control storm water and prevent erosion from adding sediment to the storm water. BMPs must include:

- **Stabilization Practices:**
  Stabilization practices help prevent erosion that contributes sediment to storm water. Typical stabilization practices include seeding, mulching, geotextiles, sod stabilization, vegetative buffer strips, protection of trees, preservation of mature vegetation, and decreasing slope angles or lengths.
  Structural Practices:
  Structural BMPs divert flows from exposed soils, store flows, or otherwise limit runoff and the discharge of pollutants from exposed areas of the site. Such practices may include silt fences, earth dikes, drainage swales, sediment traps, check dams, subsurface drains, pipe slope drains, level spreaders, storm drain inlet protection, rock outlet protection, reinforced soil retaining systems, gabions, and sediment basins.

- **Inspections:**
  At active mine sites and all asphalt batch and concrete batch plants, you must conduct a visual inspection of all onsite erosion and sediment control measures at least once every seven days, and within 24 hours after any storm event of greater than 0.5 inches of rain per 24 hour period. Keep a log of these visual inspections, recording the date and pertinent observations (e.g., 12/7/99 - very heavy storm but no significant turbidity in runoff).

Typical BMPs

- **Temporary and Permanent Seeding:** Exposed soil is highly subject to erosion. Seeding the area to develop a vegetative cover can significantly reduce erosion.
- **Protect Areas of Exposed Soil:** Divert runoff from exposed soils. Dike or ditch the runoff, place a bream around the exposed area, or convey drainage through pipes or culverts. Runoff can be directed to a grass lined swale for infiltration.
- **Control Runoff Velocity:** Slow down runoff to minimize its erosive capacity. Vegetative buffers, slope management, check dams, and filter fabric fences are a few of the ways that you can impact runoff velocity.
- **Minimize Channel Erosion:** Use grass lined channels to convey water through the site. If grass alone cannot control erosion, consider the use of riprap. A pipe slope drain may also be used to move water down a steep slope.
- **Trap Sediment:** Barriers and temporary ponds may be used to trap sediment. Straw bales, brush, and silt fences may be used as barriers to intercept sheet flow or low level, low energy channel flow and reduce the sediment load. Temporary ponds may also be used to trap sediment. These measures do not typically provide adequate control of turbidity and should not discharge directly to surface water.

Periodic Plan Review

The plan is not intended to just sit on the shelf after completion. The permit requires periodic review and updates to keep the plan current. The plan should also be used during employee training. The plan is intended to become a part of doing business at a site and to be a living document.

2.2. Erosion and sediment impacts and control principles

A. Describe impacts of erosion and Sedimentation

Damage from sedimentation is expensive both economically and environmentally. Sediment deposition has the following impacts:

- ✓ destroys fish spawning beds
- ✓ reduces the useful storage volume of reservoirs
- ✓ clogs channels and streams
- ✓ May carry toxic chemicals, and requires costly filtration for municipal water supplies.
- ✓ Suspended sediment can reduce in-stream photosynthesis and alter a stream's ecology.
- ✓ Damage to infrastructures and buildings e.g fill culverts, damage bridges

Many environmental impacts from sediment are additive, and the ultimate results and costs may not be evident for years. The consequences of off-site sedimentation can be severe and should not be considered as just a problem to those immediately affected. On-site erosion and sedimentation can cause costly site damage and construction delays. Lack of maintenance often results in failure of control practices and expensive cleanup and repairs. While sedimentation is off-site effects of erosion, on-site effects include the following:

- ✓ Soil loss
- ✓ Reduction of soil depth
- ✓ Reduction of soil fertility
- ✓ Reduction of crop yield
- ✓ Dissection of farm lands, etc.

Some of the in-stream and off-stream impacts of turbidity and sedimentation are provided below.

Sedimentation Impacts - In-stream Damages

- Destruction of spawning areas, food sources, habitat (elimination of aquatic invertebrates, filling of gravels with sediment)
- Reduction of foraging abilities in turbid water
- Direct toxicity to wildlife (suffocation of eggs, irritation of gill tissue leading to disease or death, reduction in biodiversity of invertebrates)
- Lake degradation
- Siltation of navigation channels
- Impacts to commercial fisheries
- Reduction of water storage capacities

Sedimentation Impacts - Off-stream Damages

- Clogging of streets, streams, and storm drains with sediment
- Increased flood hazards
- Decreased capacity in conveyance facilities and/or pipeline damage
- Resultant road failure and/or traffic problems
- Increased water treatment costs
- Fugitive dust impacts from wind erosion
- Health and safety risk of contaminated sediment transport/exposure

Turbidity from Suspended Solids

- Transports nutrients, pesticides, bacteria, toxic substances
- Harms aquatic wildlife
- Reduces beneficial uses

These in-stream and off-stream impacts may be translated into specific environmental impacts, as summarized below:

- **Resource Base Impacts:** Loss of soil as a resource results in the elimination of potential for future use and decreased biological diversity.

- **Agriculture Impacts:** Loss of soil results in reduced crop production and higher management costs (such as seed and fertilizer).
- **Water Quality Impacts:** Sediment can cause damage to fish and wildlife resources, water supply quality, recreational values, and habitat values.
- **Air Quality Impacts:** Fugitive dust can cause public health and safety problems such as airborne contaminants and traffic impacts.

B. Identify erosion and sediment control principles

The following principles are not complex but are effective. They should be integrated into a system of control measures and management techniques to control erosion and prevent off-site sedimentation.

I. **Fit the development to the existing site conditions (topography, soils, and vegetation)** Ensure that development features follow natural contours. Steep slopes, areas subjected to flooding, and highly erodible soils severely limit a site's use, while level, well-drained areas offer few restrictions. Any modification of a site's drainage features or topography requires protection from erosion and sedimentation.

II. **Minimize the extent and duration of exposure** (**Minimize disturbance and retain natural vegetation):** Scheduling can be a very effective means of reducing the hazards of erosion. Schedule construction activities to minimize the exposed area and the duration of exposure. In scheduling, take into account the season and the weather forecast. Stabilize disturbed areas as quickly as possible.

III. **Protect areas to be disturbed from stormwater runoff** Use dikes, diversions, lined channels, waterways and temporary slope drains, etc to intercept runoff and divert it away from cut-and fill slopes or other disturbed areas. To reduce on-site erosion, install these measures before clearing and grading.

IV. **Stabilize disturbed areas** Removing the vegetative cover and altering the soil structure by clearing, grading, and compacting the surface increase an area's susceptibility to erosion. Apply stabilizing measures as soon as possible after the land is disturbed. Plan and implement temporary or permanent vegetation, mulches, or other protective practices to correspond with construction activities. Eg. seeding, mulching and matting, etc.

V. **Keep runoff velocities low** Increasing vegetation cover and/or the surface roughness and reduces runoff velocities and volumes. Use measures that break the slopes to reduce the problems associated with concentrated flow volumes and runoff velocities and diverting storm water at non erosive velocity to safe disposal area.

VI. **Retain sediment on the site** Whenever possible, plan and construct sediment traps and basins before other land- disturbing activities.

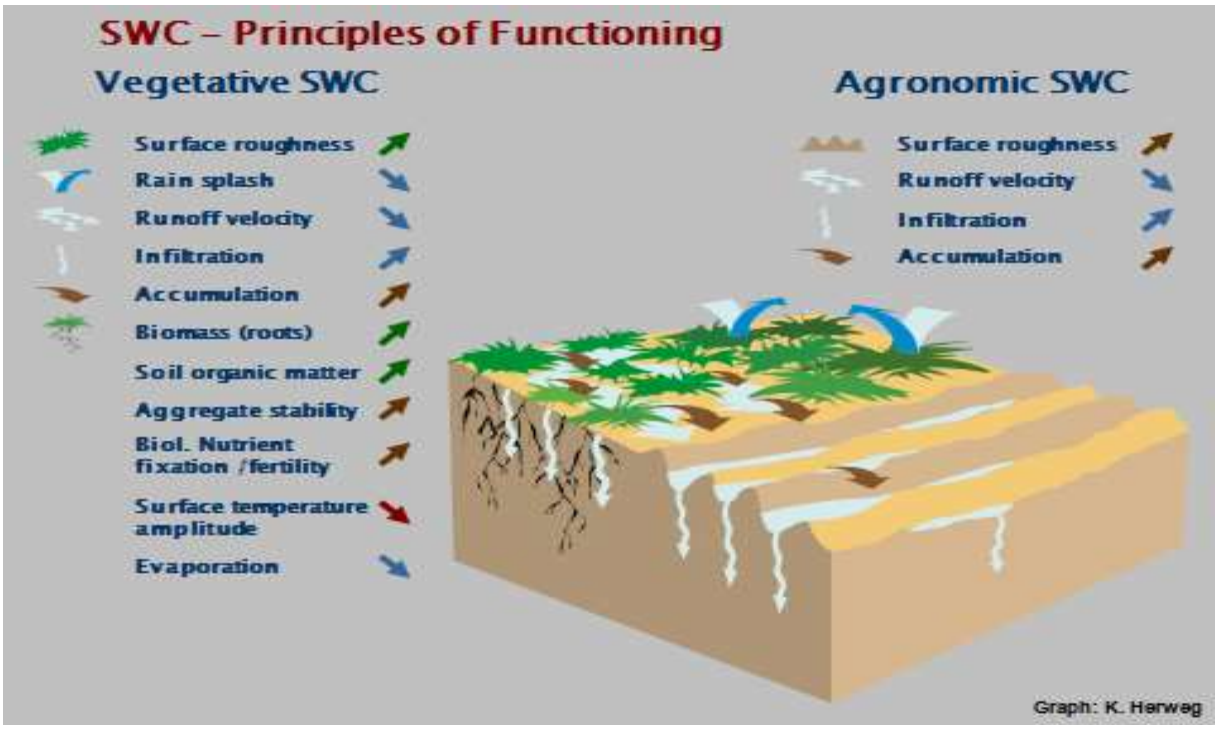
VII. **Inspect and Maintain** If not properly maintained, some practices may cause more damage than they prevent. For example, a large sediment basin failure can have disastrous results; low points in dike can cause major gullies to form on a hill slope. Always evaluate the consequences of a measure failing when considering which control measure to use, since failure of a practice may be hazardous or damaging to both people and property. It is essential to inspect all practices to determine that they are working properly and to ensure that problems are corrected as soon as they develop.

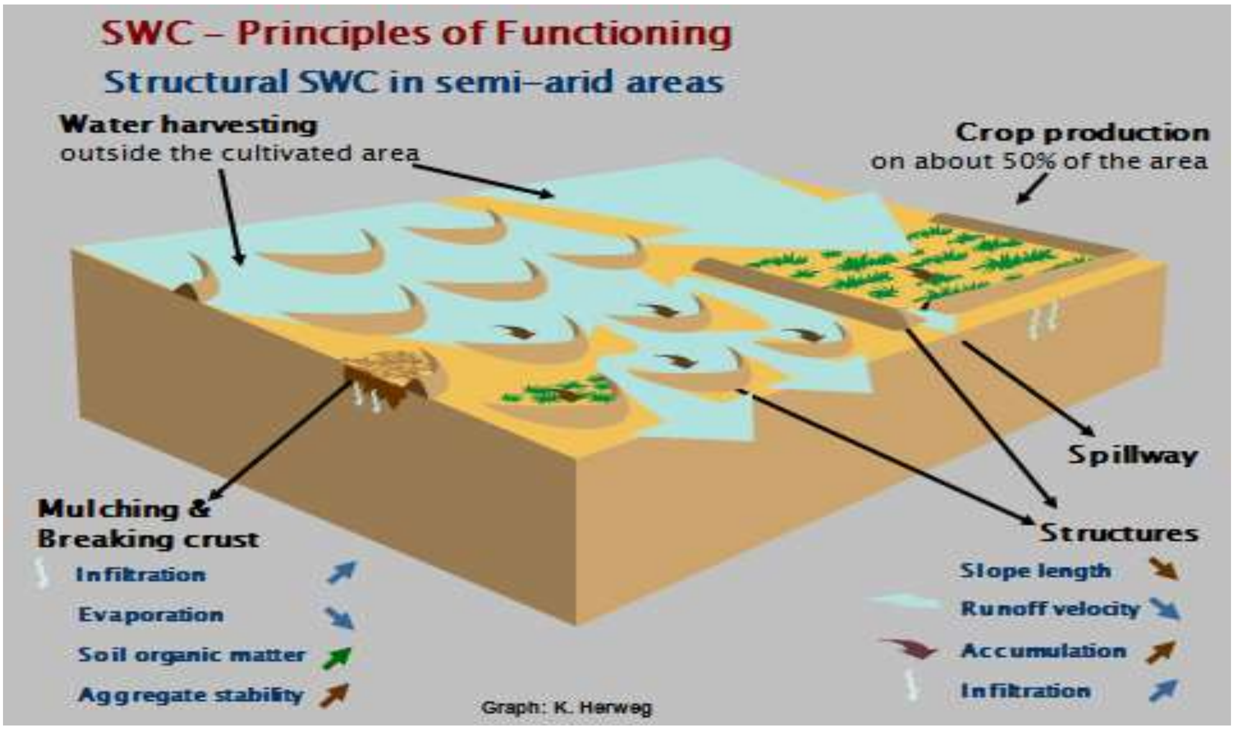
Develop Erosion and Sediment Control Plans prior to commencing works and continually amend these plans to minimize environmental harm.

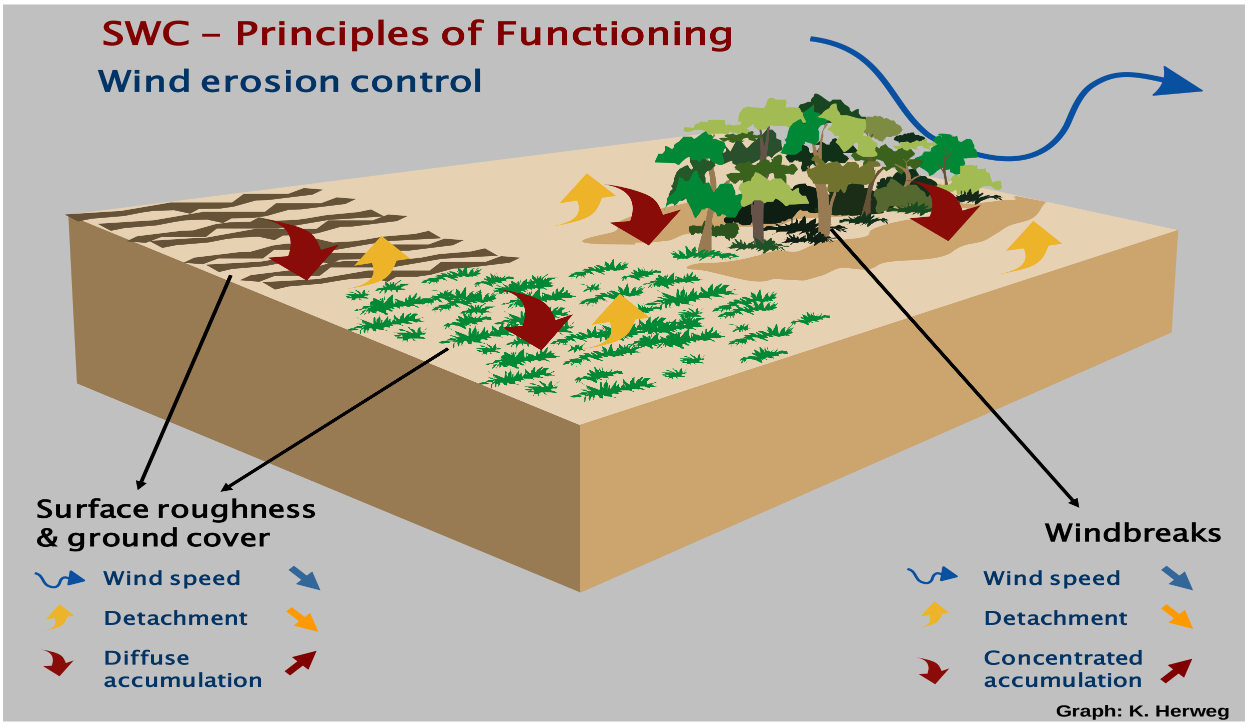
- ✓ Minimize disturbance.
- ✓ Divert water around the work area.
- ✓ Protect the soil against erosion initiated by raindrops, wind, or concentrated flows.
- ✓ Control storm water flows onto, through and from the site.
- ✓ Use sediment controls to prevent off-site impacts.
- ✓ Stabilize disturbed area progressively.
- ✓ Inspect and maintain control measures.

See pictures below for more elaboration of erosion and sediment control principles

↘ Downward arrow refers to decrease ↗ Upward arrow refers to increase


SWC – Principles of Functioning
Vegetative SWC
Surface roughness
Rain splash
Runoff velocity
Infiltration
Accumulation
Biomass (roots)
Soil organic matter
Aggregate stability
Biol. Nutrient fixation /fertility
Surface temperature amplitude
Evaporation
Agronomic SWC
Surface roughness
Runoff velocity
Infiltration
Accumulation
Graph: K. Herweg


SWC – Principles of Functioning
Structural SWC in semi-arid areas
Water harvesting
outside the cultivated area
Crop production
on about 50% of the area
Spillway
Mulching &
Breaking crust
Infiltration
Evaporation
Soil organic matter
Aggregate stability
Structures
Slope length
Runoff velocity
Accumulation
Infiltration
Graph: K. Herweg


SWC – Principles of Functioning
Wind erosion control
Surface roughness
& ground cover
Wind speed
Detachment
Diffuse
accumulation
Windbreaks
Wind speed
Detachment
Concentrated
accumulation
Graph: K. Herweg

Self-Check 2	Written Test

Name: ____________________ Date: ________________

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

1 What is the difference between erosion prevention and sediment control? (4 pts)

2 Write sedimentation deposition impacts ? (4 pts)

***Note:* Satisfactory rating – 4 points Unsatisfactory – below 4 points**

Answer Sheet

Score = ___________

Rating: ____________

Name: _____________________________ Date: _________________

Short Answer Questions

1____

2.____

CROP PRODUCTION

Level-II

Learning Guide-77

Unit of Competence: Assisting erosion and Sediment control activities

Module Title: Assisting erosion and sediment control activities

LG Code: AGR CRP2 M 12 (LO2)

TTLM Code: AGR CRP2M12 0919V1

LO 2: Implement erosion and sediment control principles

Instruction Sheet	Learning Guide #77

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

- Noting and reporting breaches of erosion and sediment control legislation structures
- Applying industry practices for erosion and sediment control by industry people.

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**:

- Note and report breaches of erosion and sediment control legislations *structures.*
- Apply industry practices for erosion and sediment control in work places.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information "Sheet 1, Sheet 2,".
4. Accomplish the "Self-check 1," **in page -18, and 72,** respectively.
5. If you earned a satisfactory evaluation from the "Self-check1" proceed to "Operation Sheet 1, Operation Sheet 2 and " **in page -16,and 19.**
6. Do the "LAP test" **in page – 72**.

Information sheet 1	Noting and reporting breaches of erosion and sediment control legislation structures

1.1. Note and report Breaches (Violations) of erosion and sediment control legislations

Erosion and sedimentation can result in impacts to public infrastructure such as creating both nuisance and larger scale problems when streets, streams and storm drains are clogged with sediment and are then prone to flooding. These impacts can result in problems that affect public safety and result in permanent infrastructure damage such as road failure and pipeline damage, as well as environmental impacts. Uncontrolled erosion is costly; violates state and Federal pollution laws; and exposes developers, contractors, and landowners to legal liabilities.

Natural erosion is generally considered to be due to the influence of climatic forces on the surface of the earth. While we can learn from the processes of natural erosion, the practice of erosion prevention is usually limited to sites where human activities accelerate this natural process.

Erosion problems can be accelerated by a variety of human activities, including unrestricted development, overtaxed resources, removal of surface cover (such as vegetation), increased imperviousness (such as paving and rooftops) that increases runoff, and poor stewardship. Accelerated erosion as man-induced, land-disturbing activities that result in increased sediment delivery to down slope/downstream water bodies. Sedimentation impacts on in-stream and off-stream water quality are illuminated along with other resource base, agricultural and air quality impacts. Consequently, it brings economic and environmental destruction. Therefore, such kind of activities should closely followed, noted, reported and treated according to erosion and sediment control legislations.

- ✓ Breaches (Violations) of erosion and sediment control legislations refers to: an act of disregard /contrary of erosion and sediment control legislations such as a law, contract, or agreement, especially in a way that produces significant effects; disturb or interrupt something in a rude or violent way; treat something sacred with a lack of respect. Somebody who fails to respect erosion and sediment control legislations will be sentenced accordingly which will be allocated/imposed a punishment to somebody convicted of a crime, usually stating its nature and its duration.
- ✓ Therefore reporting and noting violations of erosion and sediment control legislations would help to bring somebody who convicted of a crime against erosion and sediment control activities will in turn reduce the incidence of crime and correct the person who had convicted of a crime.

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 the difference between natural and accelerated erosion? (6 pts)

Note: **Satisfactory rating – 3 points** **Unsatisfactory - below 3 points**

Answer Sheet

Score = ____________
Rating: _____________

Name: _____________________________ Date: _________________

Short Answer Questions

1____

Information sheet 2	Applying industry practices for erosion and sediment control by industry people

2.1. Apply erosion and sediment control industry practices

Sequences in planning soil conservation.

Soil conservation programs must be well designed if they are to reduce erosion effectively and not fail. The planning is important to identify major areas of erosion and to select suitable conservation measures so that the farmers are willing to implement it.

Brief sequences in planning soil conservation:

I. Beginning with through assessment of erosion risk using techniques of erosion hazard assessment such as, rainfall agressivness, erodibility, topography or practices.

II. Followed by land use plan by adopting land classification methods, so that the land is used in accordance with its capability. This enables to identify which area is suitable or not for particular purpose under present or proposed economic, social and production technology. At this stage you could be able to identify where erosion is likely to occur etc.

III. Once the appropriate land use has been determined, the conservation measures proposed must be relevant to the farming system, and the nature of the erosion problem.

IV. The final stage is to quantify the impacts of the proposed land use and associated conservation strategy on the crop production and environment. Ideally economic evaluation can be made, but the benefits related to minimizing adverse environmental impacts are difficult to quantify.

Table. Best Management Practices (BMPs) Implementation and Sequencing

Step No.	Description	What to Do
1	Before Construction	Identify, mark, and protect (by fencing off or other means) critical riparian areas and vegetation including important trees and associated rooting zones and vegetation areas to be preserved. Identify vegetative buffer zones between the site and sensitive areas (e.g., wetlands), and other areas to be preserved, especially in perimeter areas. Hold a pre-construction meeting to discuss the specifics of erosion and sediment control measures and construction limits.
2	Site Access Areas (construction entrances, roadways equipment parking areas)	Stabilize site entrances and access roads prior to earthwork.
3	Install Sediment Control Measures	Install perimeter sediment control, including storm drain inlet protection as well as all sediment basins, traps, and barriers. These should be in place before vegetation is disturbed.
4	Non-Stormwater Pollution Control Measures	Concurrent with establishing construction access controls and sediment controls, the contractor must establish material and waste storage areas, concrete washouts and other non-storm water controls prior to the start of construction activities.
5	Runoff Control	The next phase is to stabilize streambanks and construct the primary

		runoff control measures to protect areas from concentrated flows.
6	Land Clearing and Grading	Begin land clearing, excavation, trenching, or grading after installing applicable sediment and runoff control measures. Install additional control measures as work progresses as needed.
7	Surface Stabilization (temporary and permanent seeding, mulching)	Apply temporary or permanent soil stabilization measures immediately on all disturbed areas as grading progresses.
8	Construction and Paving (install utilities, buildings, paving)	Erosion and sediment control measures should remain in place for the duration of construction, including protection for active storm drain inlets and appropriate non-storm water pollution controls.
9	Final Stabilization and Landscaping	Provide permanent erosion prevention measures on all exposed areas and remove all temporary control measures as areas are stabilized.

SOIL CONSERVATION AIM AND EROSION CONTROL.

Soil conservation should be interpreted in its broader sense to include both control of erosion and maintenance of soil fertility. To achieve this, control of erosion is one necessary, but by no means sufficient condition. Equally important is maintenance of physical, chemical and biological properties, including nutrient status which together lead to soil fertility.

A broader field is that of soil and water conservation, since reduction in water loss through runoff is an integral part of soil conservation.

Therefore: soil conservation = maintenance of soil fertility. This requires

-control of erosion
-maintenance of organic matter
-maintenance of soil physical properties
-maintenance of nutrients
-avoidance of toxicities.

The purpose of soil conservation is to obtain the maximum sustained level of production from a given area of land whilst maintaining soil loss to predetermined level, theoretically a balance, at which the rate of soil loss and soil formation occurs, known as soil loss tolerance which is an acceptable level of erosion. In geological erosion, this acceptable level is in the order of magnitude of 1-10tons/ha/year, corresponding to 0.08-0.8mm of topsoil disappearing annually.

In addition, there may be a need to reduce erosion to control the loss of nutrients from an agricultural land and replace those lost by any case; to decrease of the rates of sedimentation in reservoirs, rivers dams etc; and to limit crop damage by flood or wind.

Some of the economic benefits accrued from an aggressive soil stabilization plan for a construction site may include:

- Reduced potential for fines
- Lower maintenance costs
- Reduced soil loss
- Enhanced public opinion
- Decreased liability exposure

Some of the environmental benefits of effective erosion and sediment control can be:

- Protection of fish spawning areas, their food sources and habitat

- Reduction of toxic materials in the environment
- Lowered impact on commercial fisheries
- Improved water storage capacities
- Protection of soil as a resource
- Protection of human and wildlife uses of receiving waters

Developing and Implementing an Erosion and Sediment Control Plan (ESCP) (10-Step Process)

In developing the comprehensive erosion and sediment control system, the designer must answer three key questions:

- Where is erosion and sediment control needed?
- What kind of erosion and sediment control measures are appropriate?
- How much is enough?

To answer these questions, the designer must conduct an erosion control study which:

- Identifies potential erosion problems
- Develops design objectives
- Nominates and evaluates alternatives
- Selects the most appropriate erosion and sediment control measures
- Presents a comprehensive ESCP

The essential steps to be followed in developing (Steps 1 – 7) and implementing (Steps 8 – 10) an ESCP are as follows:

Step 1. Identify Issues and Concerns
Step 2. Develop Goals and Objectives
Step 3. Collect and Analyze Data
Step 4. Develop BMP Selection Criteria
Step 5. Nominate Candidate BMPs
Step 6. Screen and Select BMPs
Step 7. Develop ESCP
Step 8. Implement the ESCP
Step 9. Operate, Monitor, and Maintain the System
Step 10. Update the Plan

Step 1 - Identify Issues and Concerns: The identified issues and concerns may include the following:

- The nature of the project
- Public opinion, environmental interest groups
- Contact with public agencies
- Proximity of sensitive receiving waters
- Regulatory environment

Step 2 - Develop Goals and Objectives: Once the issues and concerns are established, the goals and objectives for the project should identified. These may include the following:

- Meeting storm water discharge permit conditions (Federal, State, and local)
- Minimizing disturbed soil area
- Stabilizing slopes

- Reducing short-term erosion
- Reducing long-term erosion
- Reducing sediment leaving the site
- Minimizing negative public opinion
- Reducing long-term maintenance
- Reducing or eliminating irrigation costs
- Maximizing the use of cost-effective solutions
- Improving aesthetics
- Enhancing the environment
- Decreasing liability exposure
- Establishing permanent vegetation

Step 3 – Collect and Analyze Data

Sedimentation evaluation. This generally involves the following steps discussed below:

- Data collection
- Identification of critical areas
- Identification of timing of soil-disturbing activities
- Identification of site factors influencing erosion and evaluation of erosion potential

Data Collection: Data collected should, at a minimum, include the following:

- Topographic information
- Photo documentation
- Field survey and evaluation
- Climate and rainfall information
- Identification of drainage areas and receiving waters
- Identification of critical habitat or sensitive areas
- Soils information

  What are the best sources of information?

  - City and County - regulations and ordinances, prior land uses, adjacent and downstream uses, storm drain system information, rainfall data
  - NRCS/District Conservationist - soil survey, climatological information, vegetation/habitat, water management, recreation potential, aerial surveys
  - National Climatic Data Center (NOAA), National Weather Service, and Oregon
  - Climate Service - climate data.
  - Department of State Lands
    - Professional associations
    - USGS - topographic maps, major waterways, rainfall and stream gauge data

- State - regulations, stream surveys, pollution control programs, habitat/endangered species, wetlands, archaeological sites

Identification of Critical Areas

In developing an effective ESCP, the next step is to identify the critical areas of the site to be developed. This would include points of ingress/egress; graded slopes; areas where vegetation is to be removed; sensitive habitat areas; and sensitive receiving water bodies. These must all be explicitly addressed in the plan.

Consideration of Timing of Soil-Disturbing Activities

The timing of soil-disturbing activities and the timing of implementation of BMPs are both critical to the prevention of accelerated erosion and transport of sediment off site. The scheduling of grading should take into account the rainy season and should attempt to minimize the length of time that soils are left exposed. Scheduling should also address reducing the total area of soil that is exposed at any given time during the rainy season.

Identification of Site Factors and Evaluation of Erosion Potential

Once background information is gathered and reviewed, critical areas are identified and timing of soil disturbing activities is considered, the erosion and sedimentation potential for critical areas should be evaluated. The most common method of evaluating erosion potential is to estimate annual erosion rates using the Revised Universal Soil Loss Equation (RUSLE), which is a semi-empirical equation based on 10,000 plot-years of data.

REVISED UNIVERSAL SOIL LOSS EQUATION

A = R x K x LS x C x P

where

A = Annual rate of erosion in tons per acre per yea

R = Rainfall Factor
K = Soil Erodibility
L = Length of Slope
S = Slope Steepness
C = Cover Factor
P = Conservation Practice Factor

Step 4 - Develop BMP Selection Criteria

The next step in the erosion and sediment control planning process is to develop the criteria that will be used to select the most appropriate BMPs. Examples of selection criteria include:

- Effectiveness
- Implementation cost
- Temporary vs. permanent BMP
- Cost of temporary BMP removal

- Long-term cost (maintenance)
- Environmental compatibility
- Regulatory acceptability (state and local)
- Availability
- Durability
- Longevity
- Ability to achieve vegetation establishment within project
- schedule.
- Technical feasibility
- Public acceptability
- Risk/liability
- Suitability for the site

Step 5 - Nominate Candidate BMPs

The next step is to nominate candidate BMPs for the site. An effective EP&SC plan must include a system of BMPs that will provide layers of insurance for the site. Therefore, it is important that BMPs be nominated from each of the primary functional categories:

- Erosion Prevention Measures
- Sediment Control Measures
- Runoff Control Measures
- Non-Storm Water Pollution Control Measures

This will preclude development of a plan that is reliant on only one type of BMP, which would not meet regulatory requirements nor result in an effective plan.

Step 6 - Screen and Select Best BMP Alternatives

Screen the Alternatives: The purpose of screening the alternatives is to eliminate those alternatives that are not feasible for use at a particular construction site, or within a watershed.
Selection Criteria: After screening the nominated alternatives, the six factors below highlight the six characteristics that most designers consider in the selection process: cost, availability, feasibility durability, Compatibility and Operation

Select the Best Alternatives: Once the alternatives have been screened so that the remaining alternatives are those that are feasible and appropriate for the given conditions, then the best alternatives must be selected. This is a challenge because in some cases there may still be a range of alternatives available to be applied to a given area of the site. In this situation, the most important selection criteria can be used to identify the best alternatives, a matrix can be developed with weighted selection criteria to identify the most appropriate alternatives, or alternatives could be optimized on a cost-effectiveness basis across an entire site or watershed to optimize erosion protection and sediment reduction based on available funding. It is up to the engineer/designer to establish an appropriate process for making final BMP selection.

Step 7 - Develop ESCP

In preparing the ESCP, the following factors should be considered:

- The plan should be adapted to the resources (i.e., labor, equipment and materials) available.
- The plan should minimize disturbed soil areas.
- The plan should emphasize erosion prevention measures with sediment control measures used as a last line of defense.
- To the extent possible, the BMPs should fit the existing terrain.
- Recommendations should be realistic, practical, easily understood, and easily implemented.
- Recommendations should be cost-effective and consider all other relevant criteria.
- The plan should have some flexibility to reflect possible changes in site conditions between plan development and plan implementation.
- The plan should include an effective maintenance program emphasizing preventative practices.
- The plan should include monitoring of BMP performance and off-site impacts.
- The plan should include procedures related to terminating construction including removal of temporary BMPs, complete stabilization of the site, and completing regulatory paperwork (NOT) and record keeping.

Step 8 - Implement the Plan

In scheduling and implementing an ESCP, the following are important:

- Means for open communication between engineer/designer, contractor,
- and municipality
- Clear and simple reports and instruction
- Clear schedule

Step 9 – Operate, Monitor, and Maintain the System

The ESCP must include a description of maintenance guidelines for all BMPs identified in the plan and should also identify minimum monitoring and inspection requirements as specified in the NPDES 1200-C General Permit.

Step 10 - Update the Plan

It is the nature of construction sites that they change as they progress. The difference between the schedule for the ESCP and the actual progress of the project is one of the single most common sources of problems with erosion control at construction sites.

APPROACHES TO SOIL CONSERVATION MEASURES.

Since erosion is a natural process, it cannot be prevented but it can be reduced to an acceptable limit. The soil conservation techniques used to combat and control erosion must be designed to do their job efficiently. Their design, layout and construction must be carried out even more accurately.

More damage can be caused by improperly surveyed and constructed structure than when there was no any protection measure at all.

Their ultimate success depends on how well the nature of the erosion problem has been identified and on the suitability of the conservation measures selected to deal with the problem and relate to as a part of an integration for the whole area or land use rather than working for individual piece of arable land.

In addition, maintenance of organic matter and soil physical properties should be incorporated in soil conservation practices to increase infiltration capacity of the soil; reduction of runoff; improving the aggregate stability of soil.

Soil conservation measures can be grouped as follows:

1-Cultural/biological/agronomic

2-Physical/mechanical

3-Land/Soil /farm management

1. Cultural Measures (Refer to learning guide 5)

When deciding what conservation measure to employ, preference is always given to cultural treatments. The measure includes all farming practices in which vegetation helps to minimize erosion that is reducing splash erosion, runoff velocity .Also it aims at a good fertility and structure of soil including improvement in infiltration. If cultural measures are sufficient to keep erosion down no physical measures will be needed (Refer to learning guide 5).

2. Mechanical measures.

Mechanical works may not be necessary to the solution of an erosion protection or they may be one solution, but not necessarily the best. Physical methods are normally employed in conjunction with cultural measures which are equally important for maintenance of physical, chemical, biological properties, including nutrient status which leads to soil fertility.

Before considering the detailed design of mechanical protection works, some general principles will be discussed as the method is expensive and time consuming, and so deserves careful thought and planning.

a. Arable land is in general vulnerable to erosion and when it is difficult to keep erosion under control without restoring to mechanical works. That is physical works can be used when impossible to prevent erosion by cultural methods.
b. Mechanical protection works should be confined to arable land. The reason is that the works are expensive and the value of arable land justifies the additional expense.
c. The primary objective of the works must be identified related to particular site conditions.

    e.g. -Reducing runoff velocities and intercept the overland flow between bands of terraces

    -Retain water/conserve water by storing it on the surface.

    -Safe disposal of runoff.

d. Maintenance Wear and tear is inevitable, regular maintenance at suitable interval is essential.
e. By improper design of inadequate channel gradient, depths etc to the particular site conditions the risk of channel over-topping is greater resulting in total failure.
f. Integrated planning. Physical works should be planned as a part of an integrated plan for the whole area/watershed rather than for an individual piece of farmland.

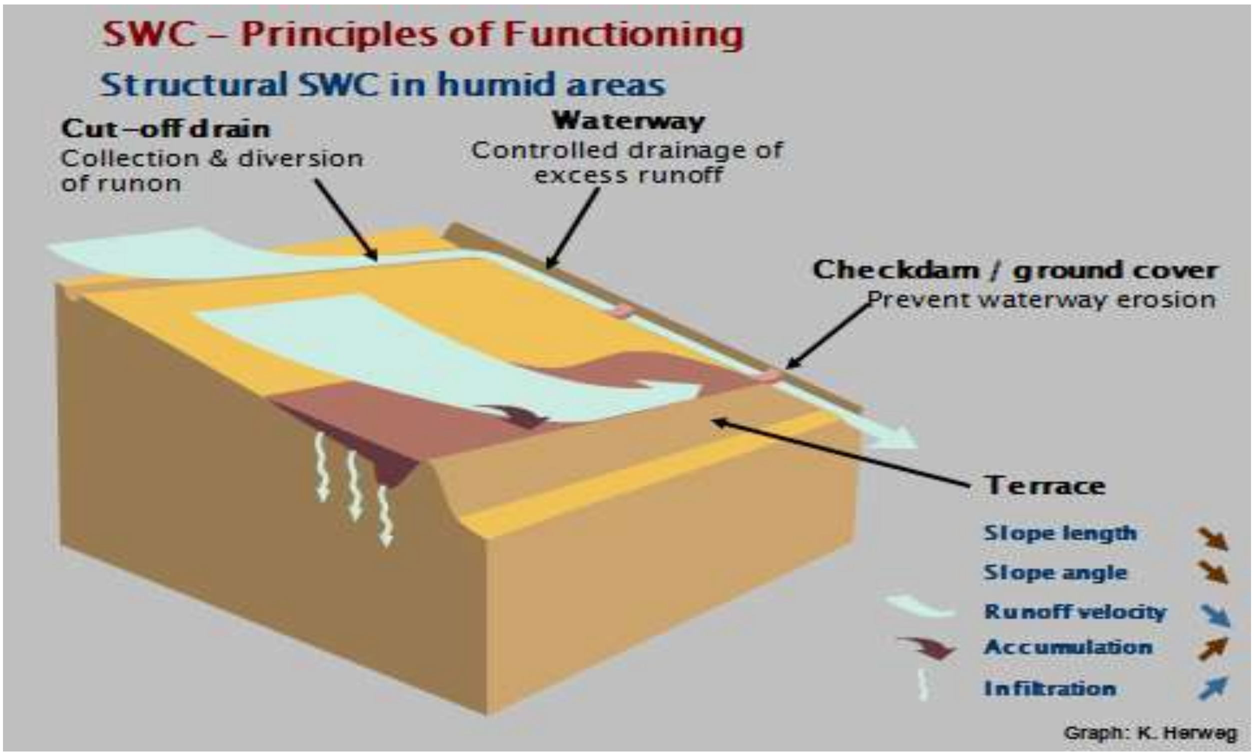
Main Types of Physical Measures.

a. Cutoff drain /diversion ditch.

b. Terraces.

c. Waterways.

The designs of these measures have to begin with the thorough assessment of erosion risk using all available information. These include collection of sufficient records about the rainfall amount and behavior; the soil type and identify areas threatened by excessive soil loss; survey of the topography; farm conditions; and other generalized and semi-detailed assessments should be examined.



a. Cutoff drain/diversion ditch.

This is a ditch/channel placed up slope of areas where protection is required to intercept flood water/runoff from top of hillside to prevent large flows down the slope. It is built across slope at slight grade so as to convey the intercepted runoff to a suitable outlet. Cutoff drains, which are only a part of the mechanical methods of erosion control. They should be combined with other measures. They are vital protection system since all the structures lower down will be designed on the assumption that it will effectively control all the runoff outside the arable land.

Principles and design procedures:

Cutoff drains are needed where protection from water flow coming from areas outside a farm. They can also be used for gully control. They should be constructed only where the need is quite evident with great care.

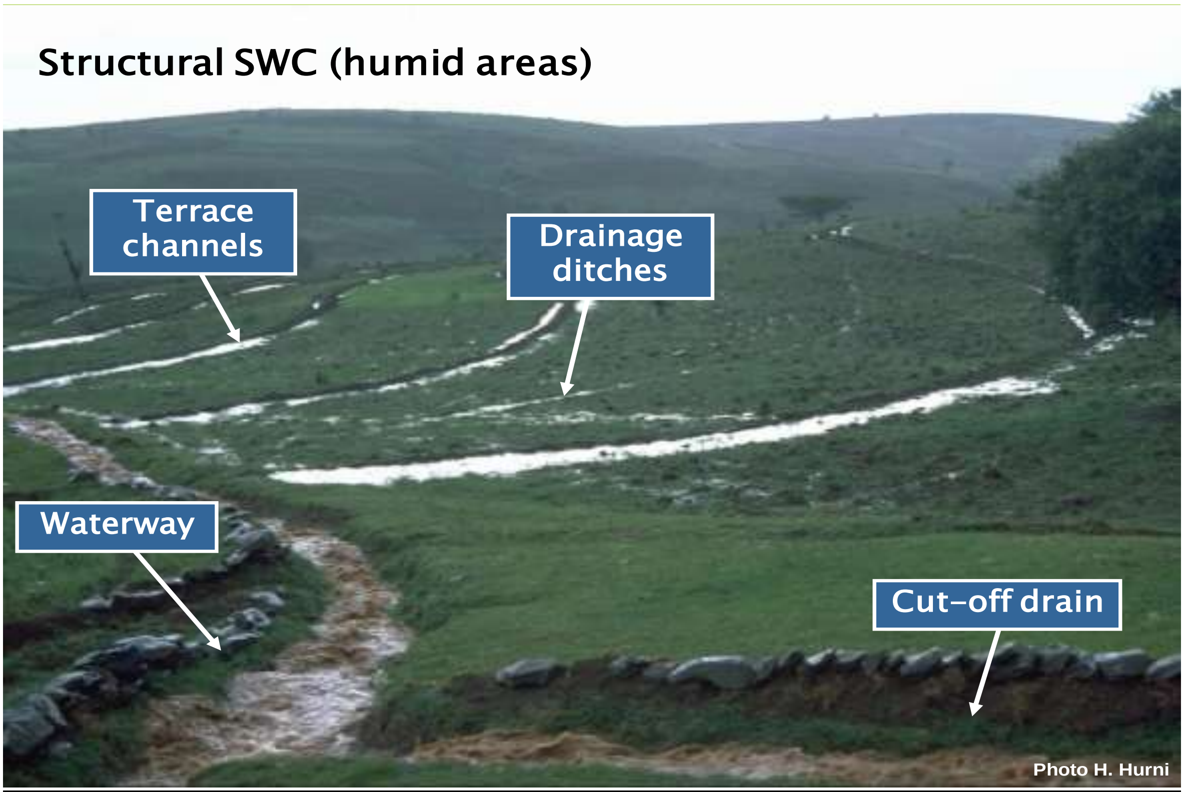
- **Survey of site:** As the aim is to collect water flow before it flows out over a cultivated land, locate them at break point of the slope; where long slope changes into flatter land. If no break points, in the middle of the slope and not on the lower section of the slope. If the slope is very long, it may be convenient to dig more than one cutoff drain on the same slope.
- **Suitable disposal point**: The water diverted by CoD up slope can be discharged: into a river, or onto non erodible rocky ground, or onto well established grass land, or into an artificial waterway, or into a natural waterway. If water is discharged onto grassland widen the outlet of CoD to dissipate the energy of the water. Frequently there is no suitable natural watercourse and one must be artificially made. This should be regarded as a continuation of the CoD. Do not discharge the water to farms and other sensitive areas. If you cannot discharge the water safely, do not construct CoD.
- **Determine the catchment's area of the CoD**: Catchment's characteristics based on the vegetation, soil type, and slope condition to find out runoff generating characteristics.
- **Dimensions:** Decide the top width or top and bottom width. The dimension must provide sufficient capacity to confine a the peak runoff from a storm with a certain return period (ten-year)
- **Grading:** Cutoff drains must always be graded in the longitudinal direction of the slope. It is preferable if the same gradient is used along the whole length of the line.

  To minimize the risk of flooding CoD should be as short as possible especially on erodible soils.

*Hint.	Clay soils	other soils
Normal length	400m	200m
Max. length	450m	450m

- The digging of CoD should start from the outlet point because rock or boulders can hinder further digging.

NOTE! When the above procedures and guides you can calculate the dimensions of CoD.Using tables from various soil conservation textbooks. Remember that different books have their own methods of calculation of the CoD size and may give you different results.



b. Terraces.

A terrace, cutoff drain and a waterway system must be designed to give the most efficient layout possible in terms of farming practice. Terraces are earth embankments constructed along the contour for controlling the flow of surface runoff down slope and to shorten slope length. Terraces are needed on slopes with erodible soils, where contour farming, crop rotation, and/or strip cropping are not sufficient measures to protect an undesirable loss of soil.

Depending on the particular site conditions and objectives, terraces may be on slight gradient (graded terrace) with the intention that the surplus runoff will flow gently off the farmland at non-erosive velocities to a place where it can be safely discharged. Or they may be on a true contour, ie, flat along their length with the intention of holding the water so that it infiltrates into the soil (retention terrace.) If the gradient of the terraces is too steep it will scour, if too flat it will flow sluggishly and there will be a danger of silting.

The choice of a grade, which will result in non-scouring velocities of flow under all conditions, is not easy.

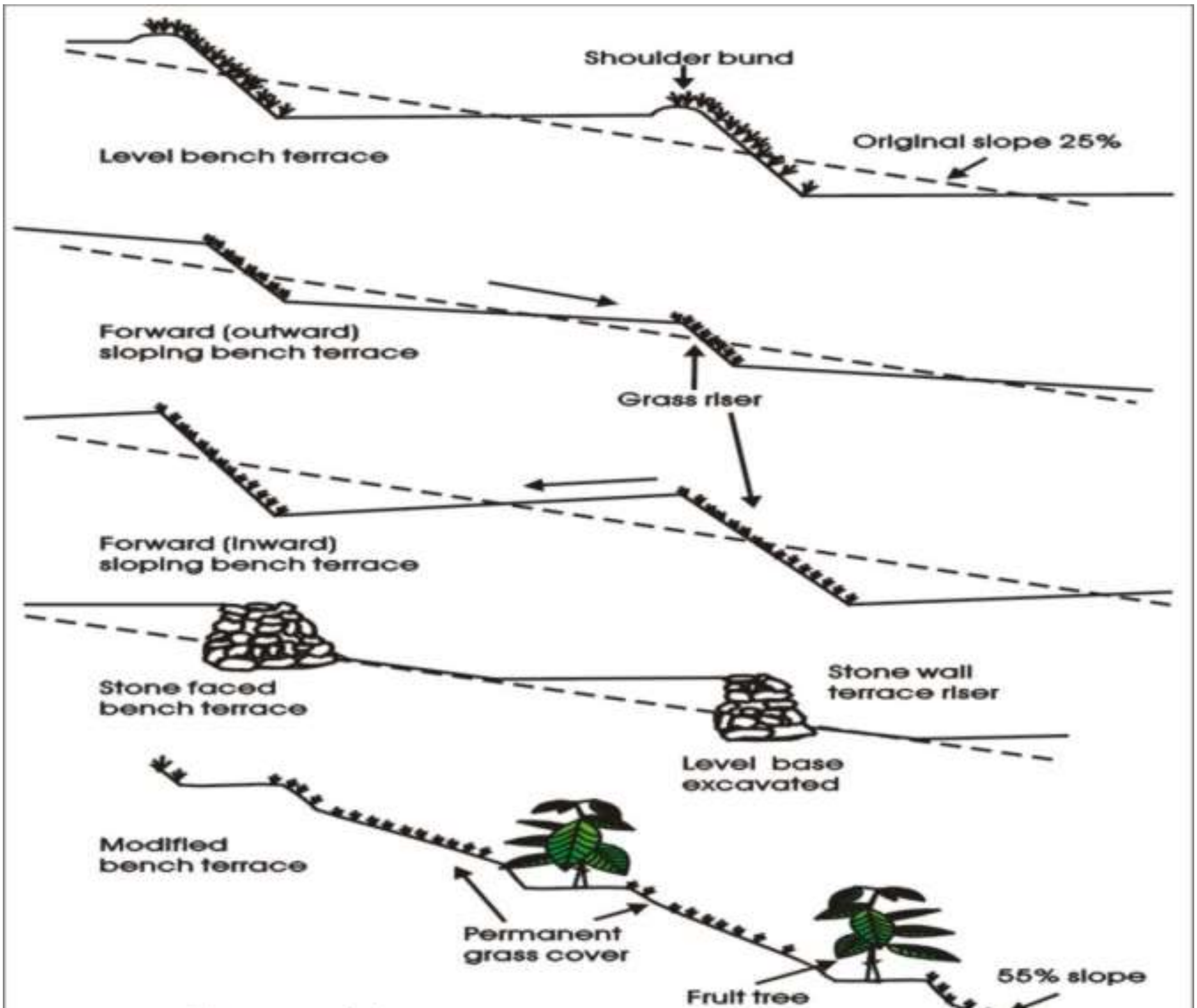
Spacing: The distance between terraces may be measured either as the difference in elevation between two terraces VI or as the distance between them on the ground HI, but for convenience it is measured not horizontally but down the slope.

Similarly, where the slope of the land is described as a percentage S, it is the fall in meters over a horizontal distance of 100m.

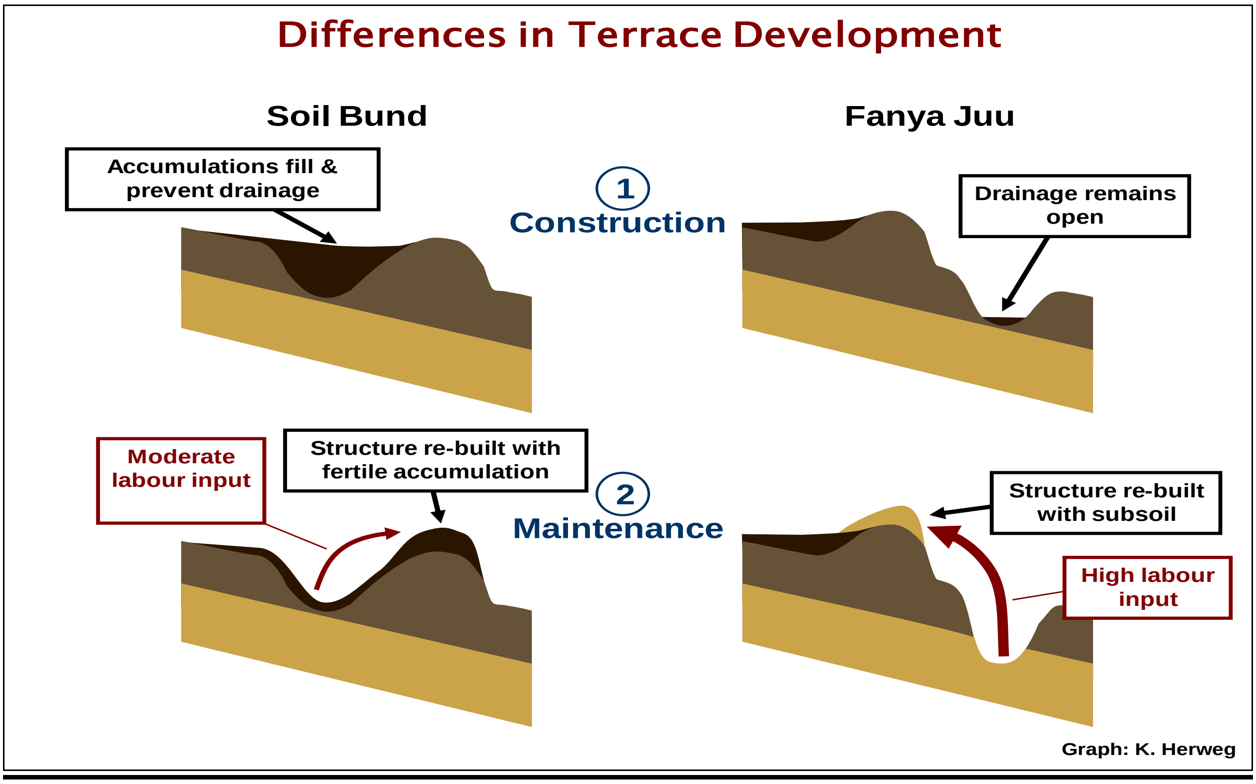
$$HI = \frac{VI}{S} * 100 \quad \text{where S is \% slope}$$

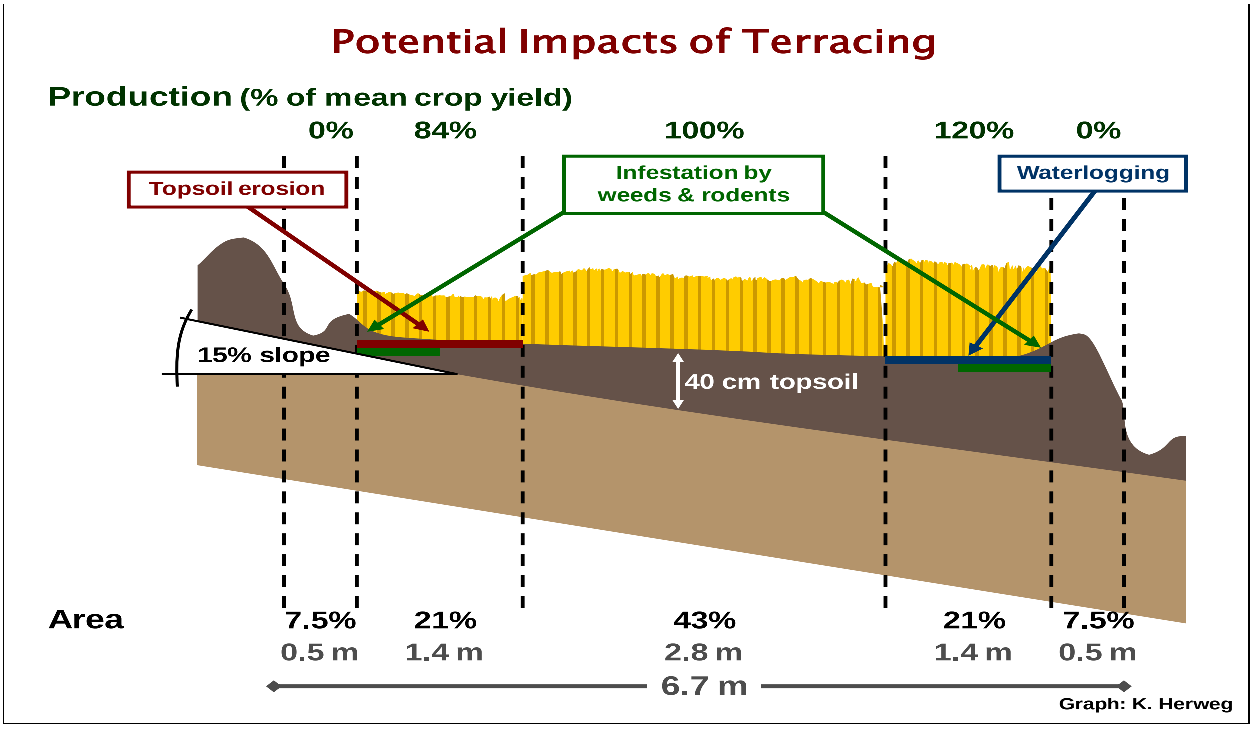
Note that: although the VI increases with slope, the HI decreases more so that the terraces are closer together on steeper slope.

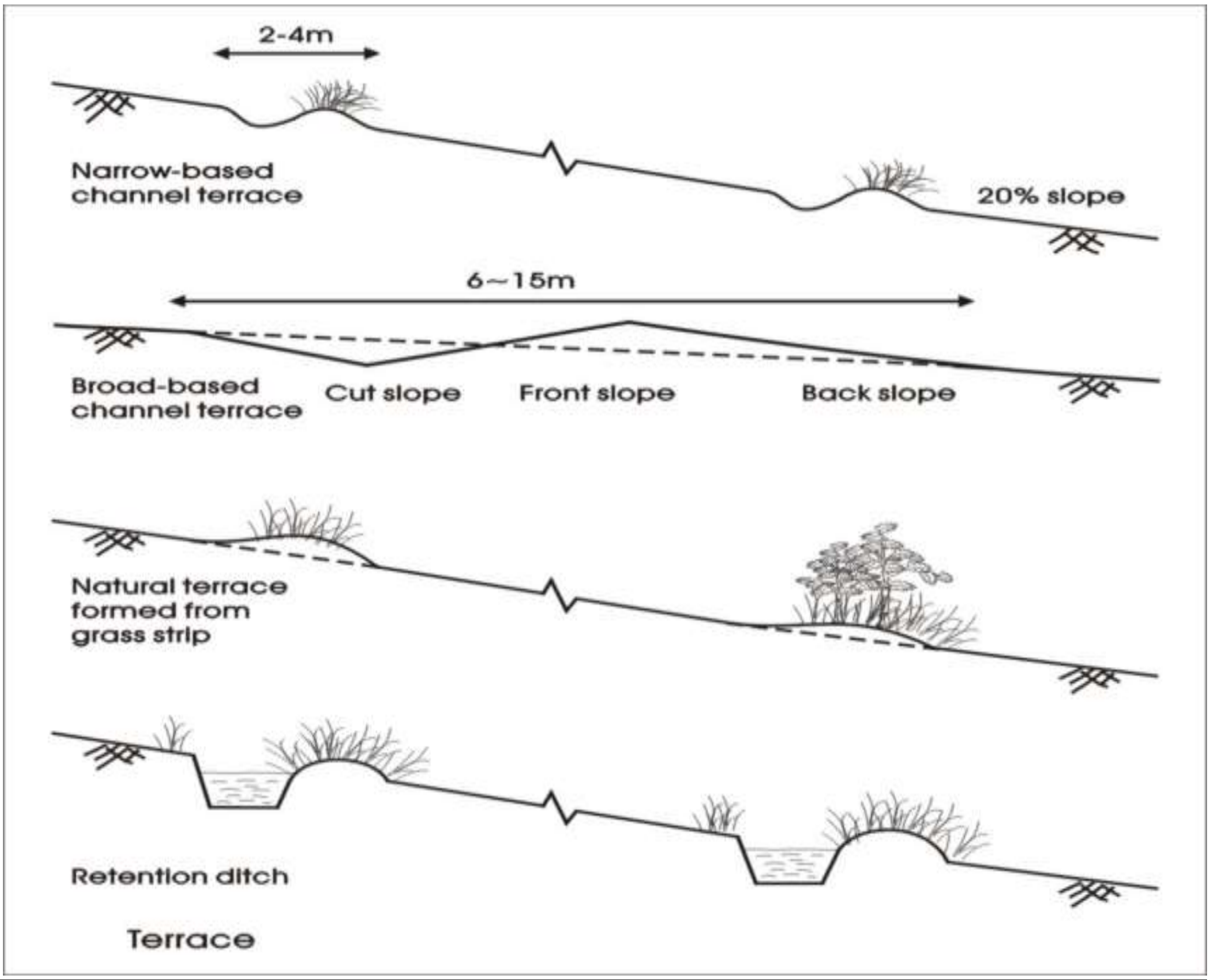
Length: After spacing has been decided, the next step to consider is the maximum length. Care should be taken that damage and failure were closely correlated with long terraces.

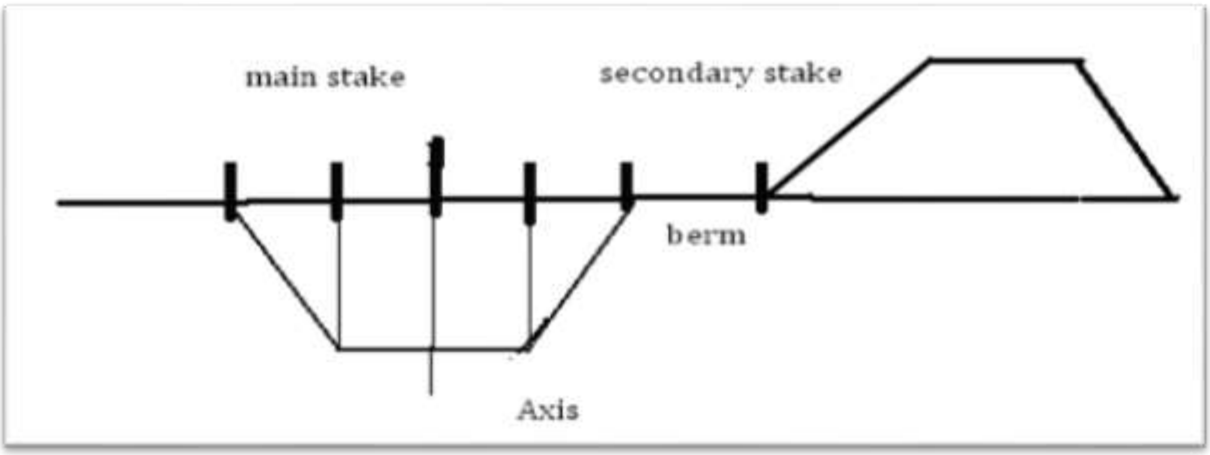


Terrace (a)


Differences in Terrace Development
Soil Bund
Fanya Juu
Accumulations fill & prevent drainage
1 Construction
Drainage remains open
Moderate labour input
Structure re-built with fertile accumulation
2 Maintenance
Structure re-built with subsoil
High labour input
Graph: K. Herweg


Potential Impacts of Terracing
Production (% of mean crop yield)
0%
84%
100%
120%
0%
Topsoil erosion
Infestation by weeds & rodents
Waterlogging
15% slope
40 cm topsoil
Area
7.5%
0.5 m
21%
1.4 m
43%
2.8 m
21%
1.4 m
7.5%
0.5 m
6.7 m
Graph: K. Herweg





Types of terraces for cultivated land.

Level bund: it is an embankment along the contour, made of soil and/or stones with a basin at its upper side. Used to reduce the velocity of overland flow and consequently soil erosions Specifications.

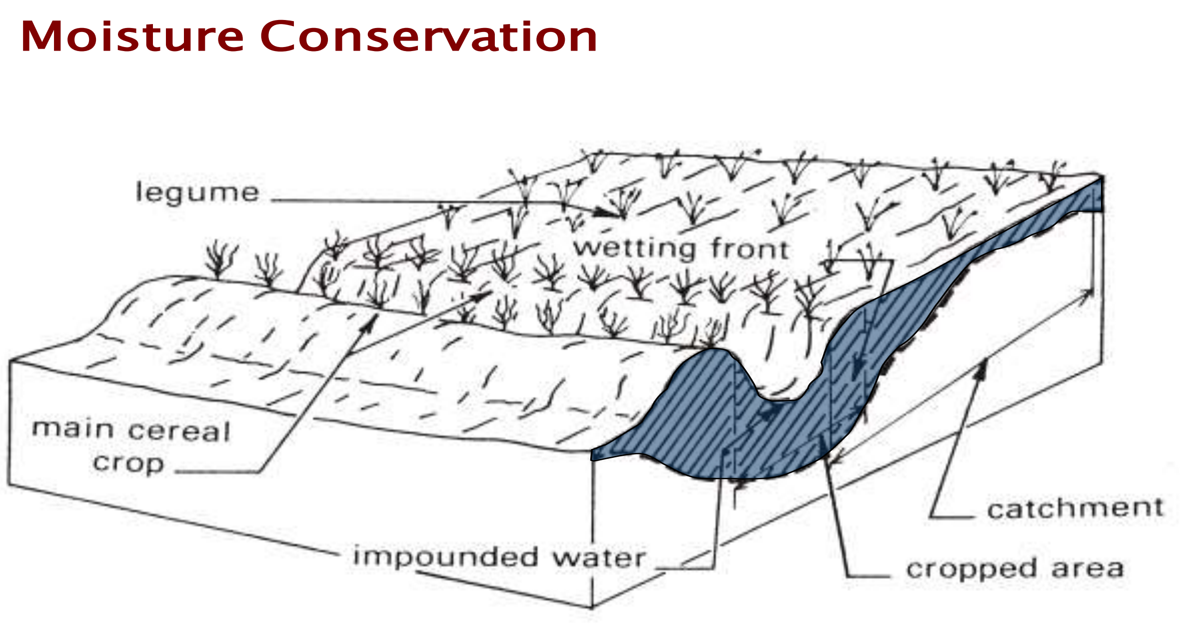
Agro climatic zones; moist wurch, dega/weyna dega and kolla.

- ✓ slope; 3-50%
- ✓ soil; all depths of more than 50cm
- ✓ VI; for slopes < 15%=1m, >15%= tow and half times the soil depth.
- ✓ Height of the bund 50-70cm
- ✓ Bottom width 100- 150cm (figure 6)

Capacity of contour bunds to reduce erosion in Wallo province, Eth

Bund form

- slope (in degrees)	6	14	27	33
- height(m)	0.20	0.20	0.20	0.20
- width(m)	1.90	0.70	0.40	0.30
- storage capacity(m^2)	0.19	0.07	0.04	0.03
- spacing(m)	20	15	10	8
- predicted soil loss ($kg/m^2/y1$)	3.0	11.5	11.5	12.5
- capacity of bunds to				
- store soil(kg/m^2)	11.4	5.9	4.8	4.5
- percentage of soil loss behind bunds in first and second year	100(1) 100(2)	51(1) 0(2)	42(1) 0(2)	36 0

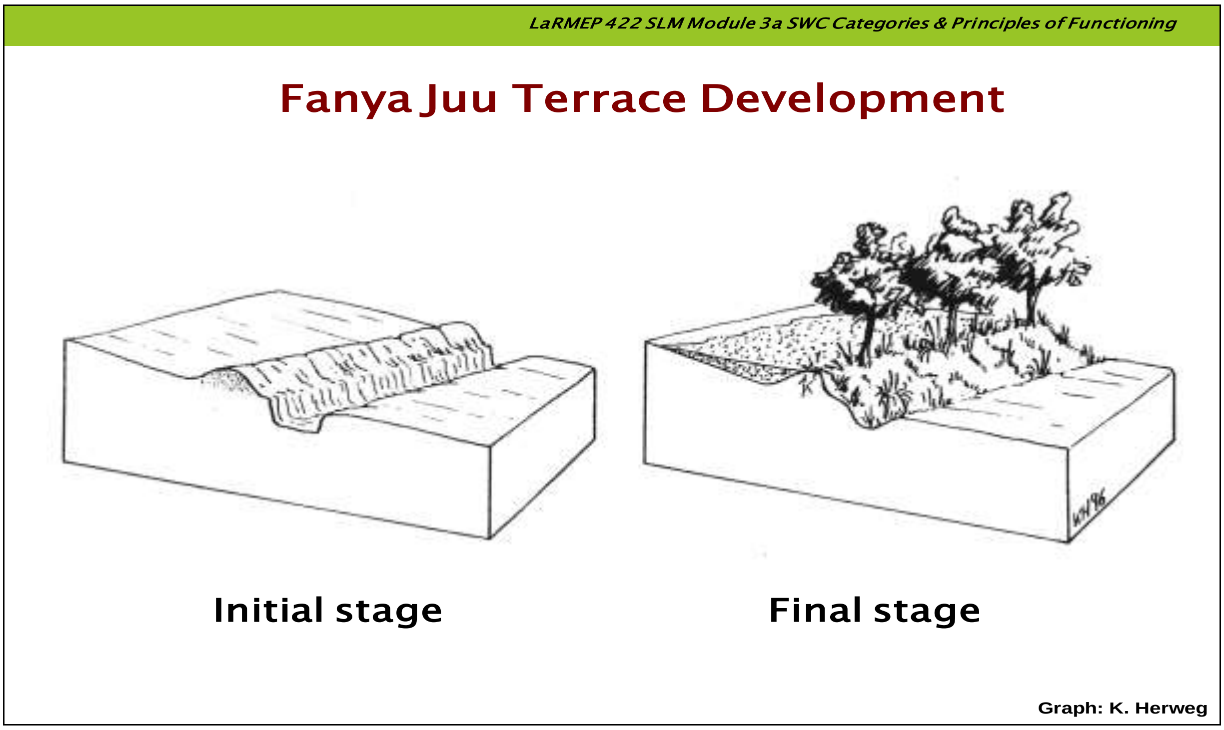


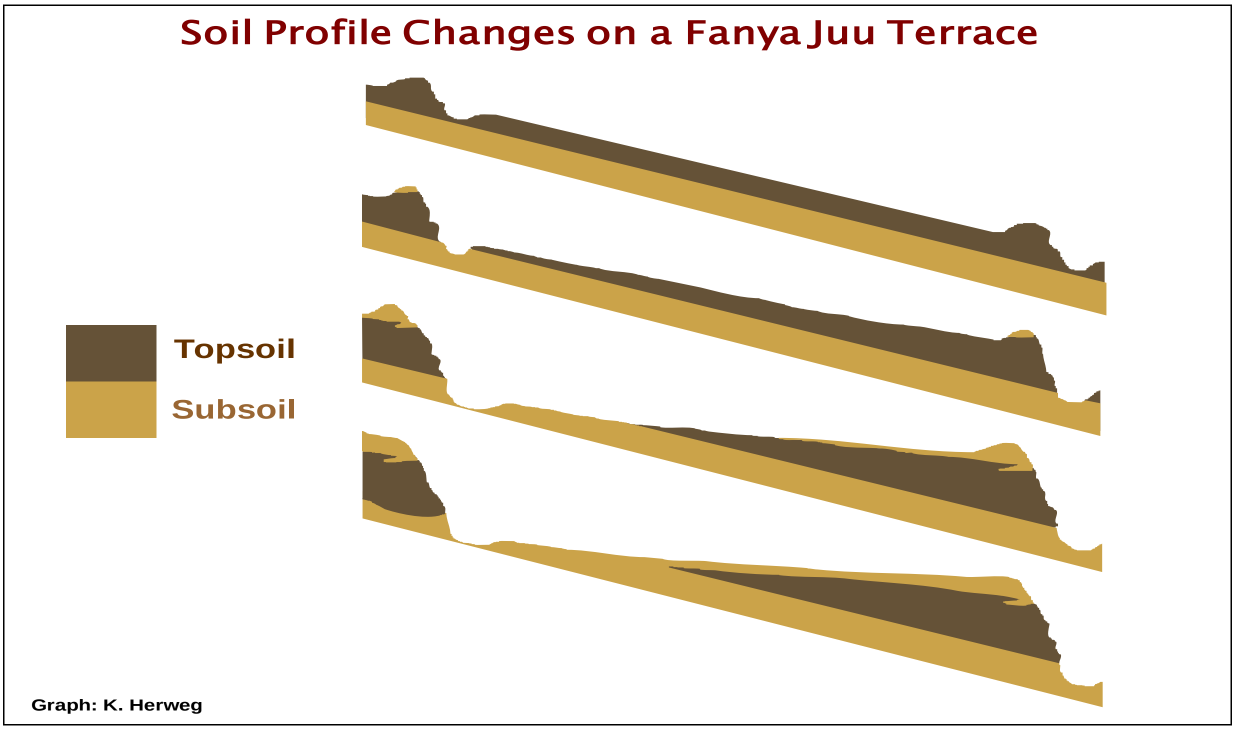
Source: Pacey & Cullis 1986

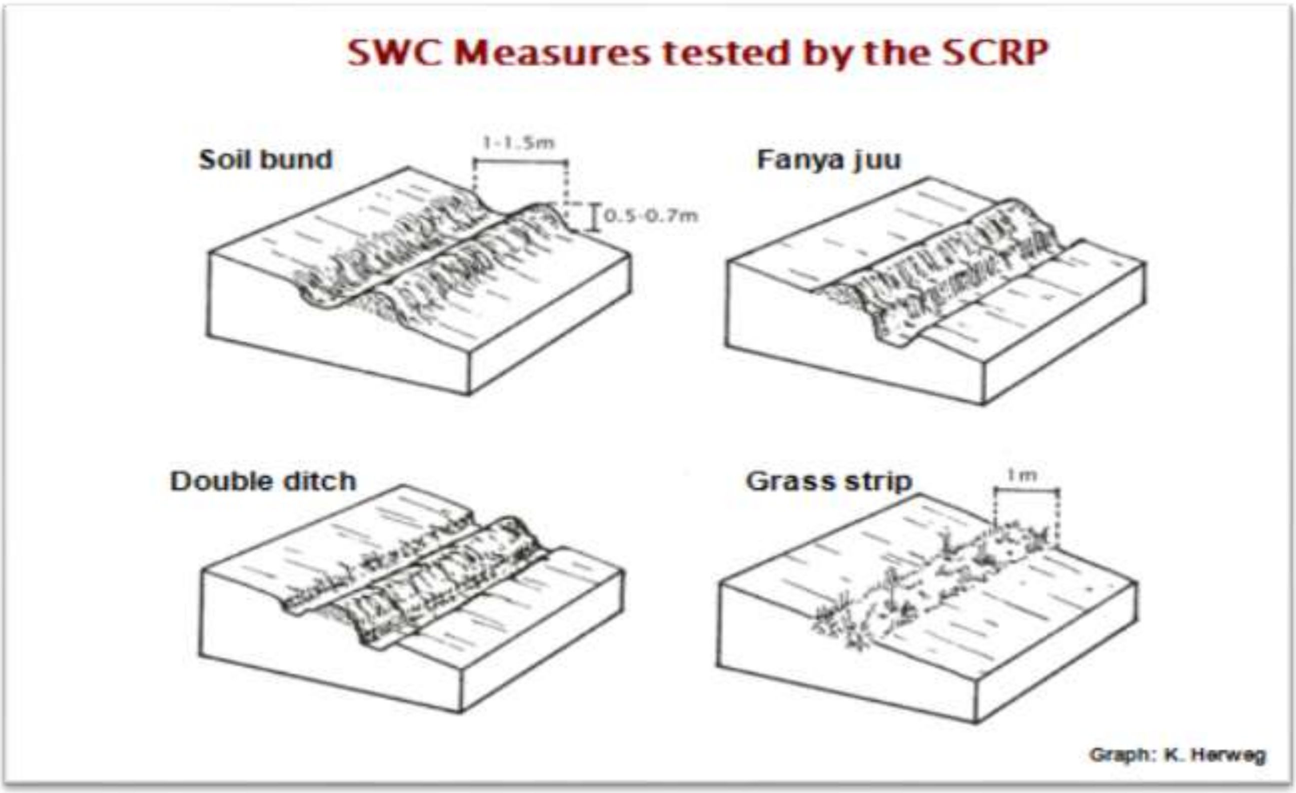
<u>Level Fanya juu.</u> ("Throw uphill" in Swahili language) is an embankment along the contour, made of soil and/or stones, with a basin at its <u>lower side</u>. Reduces runoff and consequently soil erosion. In difference to the level bund, the soil in fanya juu is moved up slope and the basin is at its lower side of the wall.

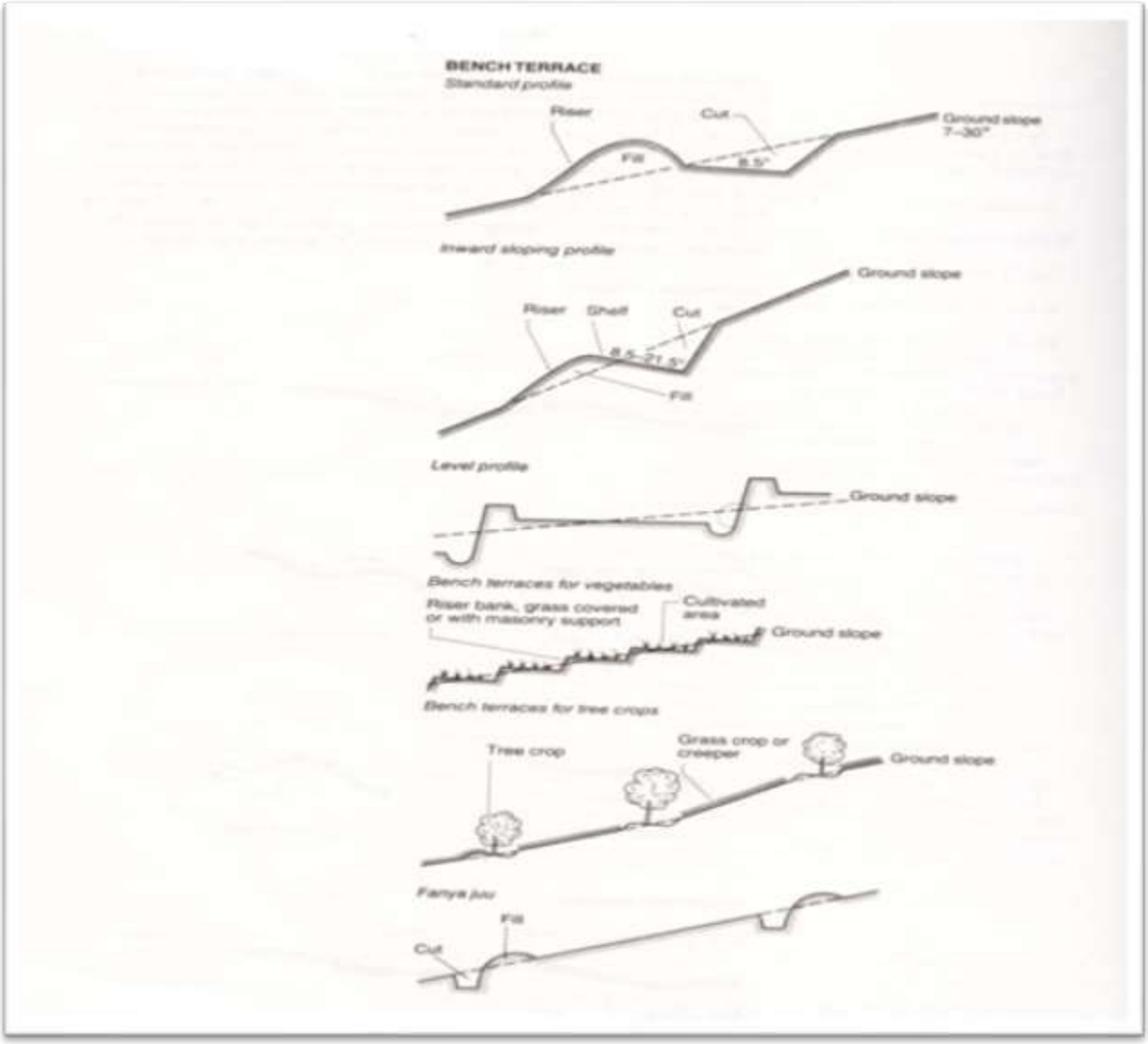
Specifications.

- Agrocliamatic zone; similar to level bund
- Slope;3-50%
- Soil; all depths more than 50cm
- VI; for slopes <15%=1m, >15% two and half times soil depth
- Height 50-75cm
- Depth of ditch about 50cm




Soil Profile Changes on a Fanya Juu Terrace
Topsoil
Subsoil
Graph: K. Herweg


SWC Measures tested by the SCRP
Soil bund
1-1.5m
0.5-0.7m
Fanya juu
Double ditch
Grass strip
1m
Graph: K. Herweg



Graded bund. Like a level bund, with only differences that is slightly graded sideways up to 1% towards a waterway or river. The gradient is to drain surplus runoff.

Specifications.

- agrocliimatic zone;wurch,dega,wet and moist weyna dega and kolla.
- slope; 3-50%
- soil; wet, clay soil in moist agroclaimatic zone
- VI; for slopes <15%=1m,>15% two and half times soil depth
- height and depth not different from level bund

Graded fanya juu. Similar to level fanya juu with the only difference that is slightly graded sideways towards waterway up to 1%.The gradient is to drain surplus runoff.

Specifications.

- agroclaimatic zone; similar to graded bund except in wurch zones.
- slope; 3-50%
- soil; all deep clay, wet soils
- Height and depth of level fanya juu are also applicable for graded fanya juu.
- VI; for slopes<15%=1m,>15%=tow and half times the soil depth.

NOTE! Don't confuse the cross sections of cutoff drains with that ditches dug for fanya juu terraces.The CoD can be wide and shallow. The ditches in fanya juu terracing should be as narrow as possible so as not to waste too much cultivated land, as the main aim is to provide earth for the embankment. Also the ditches in fanya juu are placed below/lower side of the embankment while in CoD it is placed above the/upper side of the embankment. In addition there may be a difference in gradient.

Bench terraces. A bench terrace is a conservation structure where a slope is converted into a series of steps, with a horizontal cultivated area on step riser between two steps. In Ethiopia, it is either constructed directly on a slope or gradually developed from bunds and fanya juu. They are level along the contour in dry to moist agroclaimatic zones. In moist to wet areas, they are graded to drain excess runoff to waterways or river.

Specifications:

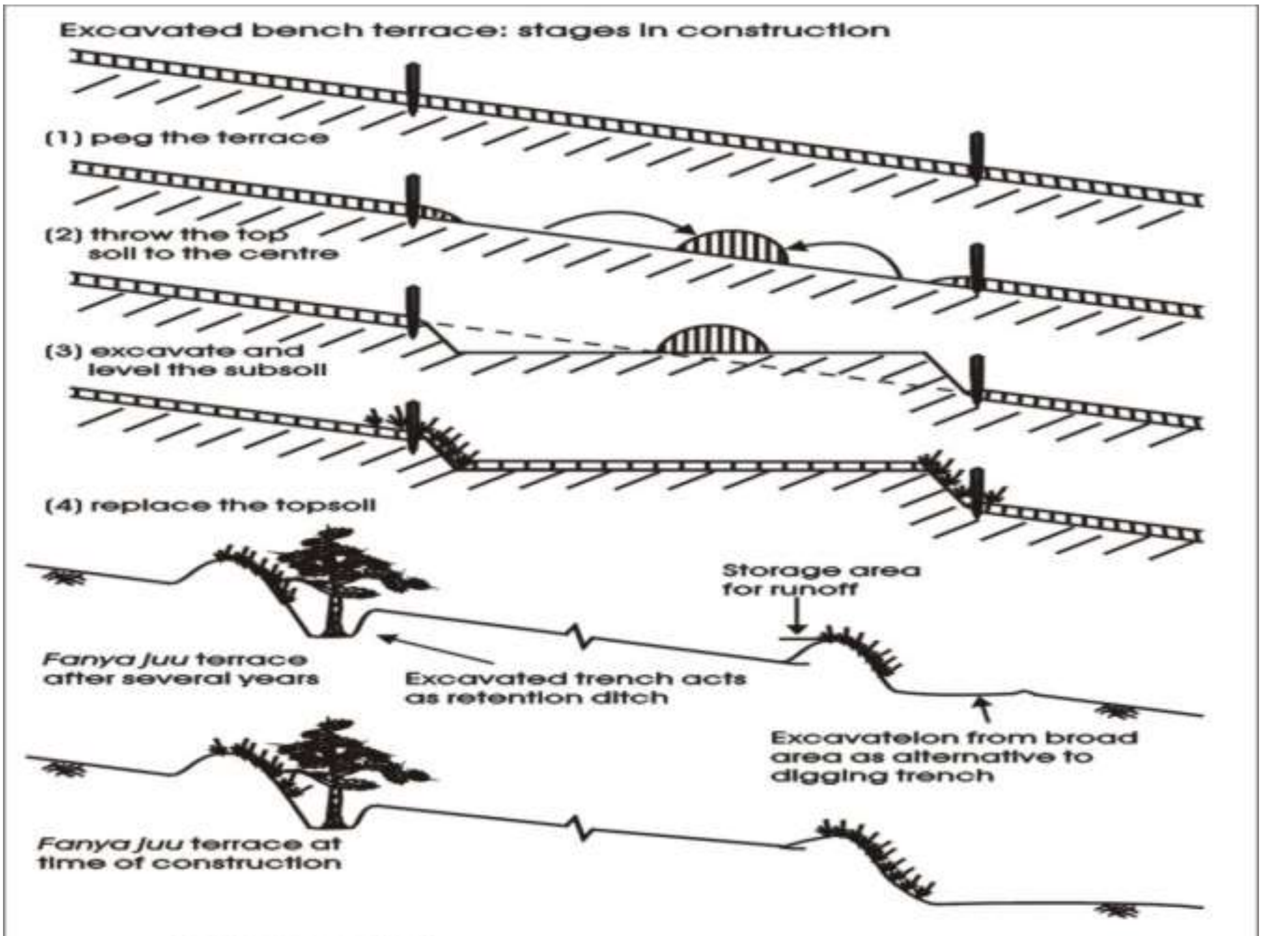
- slope; up to 50%
- soil; very deep soils
- VI; two and half times the depth of re-workable soil depth.

Table: The width of a cultivated area (in meters) on a bench terrace is determined by the gradient and the soil depth as shown in the table below.

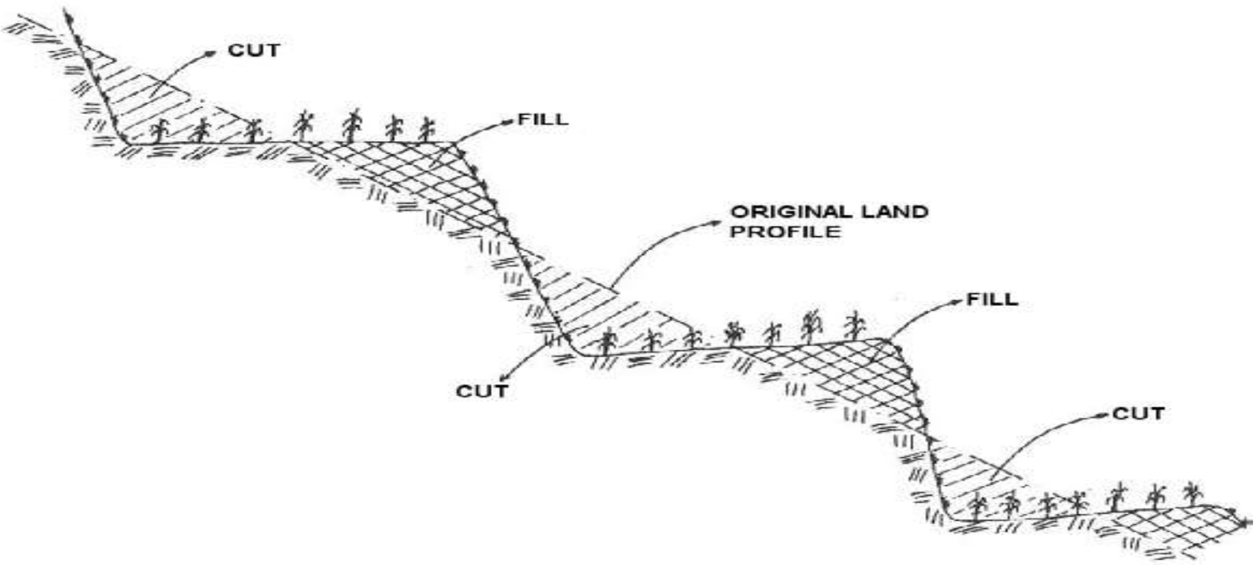
Slope gradient (%)	Soil depth in (cm)					
	25	**50**	**75**	**100**	**125**	**150**
20	2.81	5.63	8.44	11.25	14.06	16.88
30	1.77	3.54	5.31	7.07	8.85	10.63
40	1.25	2.50	3.25	5.00	6.25	7.50
50	0.94	1.88	2.81	3.75	4.69	6.63

NOTE! Bench terraces are employed when too steep slope land is to be cultivated. Therefore, bench terraces are not preferable in shallow soils. During digging infertile subsoil will be brought up to the surface unless special measures are taken.

- An enormous amount of labor is required for the construction, so that valuable crop should be grown.
- They may be constructed on the contour or with slight gradient, the difficulty is to discharge any surface runoff down the steep slope without causing erosion.


Excavated bench terrace: stages in construction
(1) peg the terrace
(2) throw the top soil to the centre
(3) excavate and level the subsoil
(4) replace the topsoil
Storage area for runoff
Fanya juu terrace after several years
Excavated trench acts as retention ditch
Excavateion from broad area as alternative to digging trench
Fanya juu terrace at time of construction

Terraces (a)


CUT
FILL
ORIGINAL LAND PROFILE
FILL
CUT
CUT

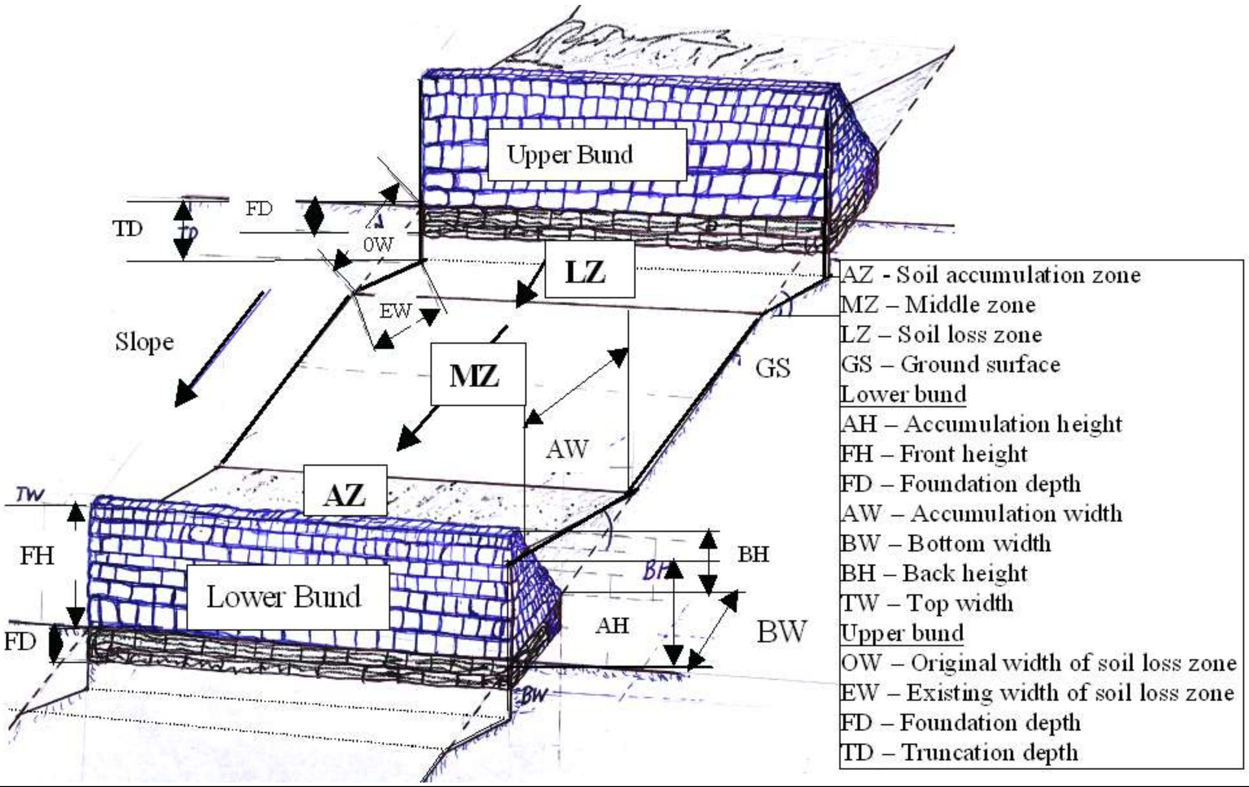


Fig. : Stone bunds and their role in soil conservation

C. Waterways.

It is a natural or artificial drainage channel along the steepest slope or in the valley /depression used to accommodate a runoff. The runoff intercepted by terraces (graded terraces) and CoD must be able to discharge the water into a water course. Frequently there is no suitable natural water course or non erodible areas to discharge the water and one must be made artificially.

Therefore, artificial waterways are designed to transport down slope the runoff too empty into the natural river system. Usually they are best located between two farmers boundary, preferably in natural depression whenever possible. If it is difficult to find a good site,it may be better and perhaps cheaper to dig a long CoD.

The waterway should have a cover of thick grass to prevent erosion. Usually it will take 2 years to establish a good grass cover .It is best to construct artificial waterways first and CoD and terraces 2 years later, but this is not always possible. Therefore discharging into waterways should if possible be blocked up during the 2 year period.

Specifications:

- Agro climatic zone, all wurch,dega wet and moist weynadega, moist kolla.
- Slope; 3-50%
- Soil; all, care on deeply weathered subsoil.
- Cross section; should be gentle (wide and shallow 3-5m)

3. Land/soil management.

The amount of soil erosion which occurs under a given condition is influenced not only by the soil itself but by the management it receives.
A soil might loss several hundred tons per hectare when used up and down on steep slope for cultivation, while with the identical situations but under well management the soil loss is a few tones.

Soil management aims at the optimum land use for farms considering both cultural and physical measures. The aims of sound soil management are to maintain the fertility and structure of the soil. Highly fertile soils result in high crop yields, good plant cover and, therefore, in conditions which minimize the erosive effects of raindrops and runoff. These soils have a stable structure, which does not break down under cultivation and a high infiltration capacity. Soil fertility can thus be seen as a key to soil conservation.

Organic matter content.

- ✓ To increase the resistance of an erodible soil by building up organic matter is a lengthy process. One way of achieving and maintaining a fertile soil to apply organic matter. This improves the cohesiveness of the soil, increase water retention capacity and promotes a stable aggregate structure. Organic matter may be added as green manure which is normally leguminous crops ploughed in, straw or as a manure which has already undergone a high degree of fermentation with long lasting effects.
- ✓ Therefore, organic content must be raised, high fertility results in good growth of crops and crop density, is the best insurance against raindrop erosion, through reduction of the area of bare ground by intercepting the raindrop instead of directly hitting the ground.

Tillage practices.

- ✓ Tillage is an essential management technique which provide a suitable seed bed for plant growth. When managed as to maintain their fertility, most soils retain their stability and are not adversely affected by standard tillage operation. On problem soils, tillage practices should be oriented to conservation tillage techniques.

Few points about land classification.

- ✓ There are many different systems of land classification in use. There are two main approaches to classifying land with respect to its potential for land use: land capability classification and land evaluation. Both take into account the risk of soil erosion.
- ✓ LCC (Land Capability Classification) originated in the US, and has since been adapted and widely applied to land use planning in developing countries. The land is classified, usually I-VIII based on inherent limitations of erosion, wetness, soil and climate.
    - Class I-IV are "arable”, suitable for rainfed arable use,
    - Class V applied to special situations,
    - Class VI-VIII are "non arable”, considered suitable for grazing, forestry or conservation.

In this the erosion hazard limitation is usually determine /dominant/ in practice. It must be emphasized that this system is primarily concerned with the risk of erosion and not with productivity or fertility. This means that class I-IV are classified suitable for arable use in terms of the no or less erosion risk, but the soil might be infertile. In conflict with current land use, all moderately to steep slopping land(class VI-VIII) are available only for non arable uses. For many areas in developing countries such Rwanda, Burundi, Ethiopia slopping lands are already being used to grow food crops. It would be socially undesirable and impractical to attempt to change this situation.

The other approach to land classification is with respect to their suitability for a number of defined uses. Classifying in major kinds of use, such as arable, pasture and forestry based on the requirements of the use with the properties of land moisture availability, nutrient availability etc. Another example is classifying based on slope gradient in regard to its soil conservation needs. Example. Flat land 2% can usually be for use without special soil conservation OR for slopes 12-50% terracing is needed OR exceeding 50% should covered by grass or forest.

Farm planning comprises dividing of farm holdings into areas of arable, pasture, tree plantation, home stead, water supply. Roads, areas that need soil conservation measures. The planning has to consider the ground conditions eg type and credibility of the soil, present erosion conditions, suitability of land for arable, livestock, and trees, slope gradient. As can be seen soil conservation is a part of farm planning.

Therefore, land classification systems are vital tool in land use planning. Correct land use is the first step towards both good agronomy and good erosion control, to use every area of land according to its capability for sustained and economic production.

Table 5 - Land capability classes and their description.

Class	Description
	Arable or cultivated
Class I	Soils are suited for cultivation over a long period of time and have no limitations that restrict their use. They are deep, nearly level, well to moderately-well drained, and not subject to more than slight erosion.
Class II	Soils are suited for cultivation over a long period of time, but they have some hazards and limitations such as gentle slope, slight erosion, or moderate wetness that reduce the choice of plants or require moderate conservation practices that are easy to apply.
Class III	Soils are good for cultivated crops, but have severe limitation that reduce the choice of plants and/or require special conservation practices that are more difficult to apply. Terracing and other water control measures will be needed.
Class IV	Soils can be cultivated crops, but have severe limitations that restrict the choice of plants, require very careful management, special conservation or both. They are sloping, moderately eroded soils with poor characteristics. Cultivated areas should be strip tilled, terraced, and farmed on the contour. They are best suited for pasture and meadows.
Not arable or not cultivated	
Class V	Soils have little or no hazards have other limitations that make them unsuitable for cultivation. A limitation is impractical and very expensive to remove and limits their use to pasture, range, woodland, or wildlife food and cover. Limitations include very poor surface and internal drainage or frequent flooding.
Class VI	Soils have severe limitations such as steep slopes, severe erosion, shallowness, and rockiness that make them generally unsuited for cultivation and limit their use to pasture or range, woodland or wildlife food and cover.

Class VII	Soils have very severe limitations that make them unsuited to cultivation and that restrict their use mainly to grazing, woodland, or wildlife.
Class VIII	Soils have limitations that preclude their use for crop, pasture or timber production and restrict their use to wildlife, recreation, or aesthetics. This land has little or no economic value.

Table - Land capability factors (modified after Landson, 1984).

Parameters	**Class**							
	I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**
Slope (%)	0-2	2-4	4-10	11-32	**>33%**	>33%	>33%	>33%
Evidence of erosion	No sign to slight	No sign to slight	Moderate	Moderate		High	High	Very High
Surface stoniness (%)	0-5	6-14	15-39	40-79		>80	>80	>80
Soil stoniness (%)	0-9	10-27	28-59	>60		>60	>60	>60
Soil depth (cm)	>100	>80	>60	>40		>30	<30	<30
Soil drainage	Never saturated	Rarely saturated	Rarely saturated	Saturated for short period		Saturated for long period	Saturated for long period	Saturated for long period
Soil texture (*)	L, SL, LS	Si, SCL, SiCL, SiL, CL	SiC, SC	S, C		Any	Any	Any
Rock outcrops	From very few to few	Common	Many	Abundant		Dominant	Dominant	Dominant
Available water capacity	>70	50□ X□ 70	35□ X<50	20□ X>35		<20	<20	<20
Organic matter (%)	>1	>0.8	>0.6	>0.4		>0.2		
Carbonate (%)	0	<5	<20	>20		>20	>20	>20
pH	6□ X□ 8	6□ X□ 8	5-6 or 8-9	5-6 or 8-9		<5or□ 9	<5or□ 9	<5or□ 9

(*) L (Loam), SL (Sandy loam), LS (Loamy sand), Si (Silt), SCL (Sandy clay loam), SiCL (Silty clay loam), SiL (Silty loam), CL (Clay loam), SiC (Silty clay), SC (Sandy clay), S (Sand), and C (Clay)

Common soil conservation practices for cultivated land.

A risk of erosion exists on a cultivated land from the time trees, bushes and grass are removed. A risk of erosion on cultivated land occurs by:

-using too steep slopes for cultivation/farming.
-cultivating up and down the slope.
-continuous use of land for the same crop without fallow or rotation.
-inadequate fertility and organic content.

Conservation strategies are aimed at establishing and maintaining good ground cover.If the various mechanical protection structures are designed properly,they can effectively check runoff unless they are overtopped and broken.But soil conservation relies strongly on agronomic methods combined with soil management while mechanical measures play a supporting role.

Soil conservation practices on cultivated land includes:

Agronomic practices	Soil management	Mechanical
Mulching multiple cropping cover cropping strip cropping crop rotation grass strip contour farming	organic content improvement conservation tillage land classification for soil conservation and efficient utilization of farm resources.	Terraces cutoff drain waterways

A. Soil conservation measure on grazing land.

- In daily language, grazing land is described as a land, which is unfit to crop production because it is too poor, too infertile or stony. Soil erosion starts on grazing land often by mismanagement through overstocking and overgrazing often resulting poor grass cover and accelerated erosion.
- Soil erosion on grazing land can be controlled by management of the grazing land. These are directed at determining and maintaining correct, suitable stocking. In such system, the livestock can graze continuously or in rotation but controlled.
- Overstocking leads to poor regeneration of vegetation as there is no opportunity for rest period or rotation grazing. In most developing countries maintaining correct stocking rate are frequently difficult in areas where people attach social,coltural and economic value to the size of their herds.
- Rehabilitation and improvement of grass land includes all activities aimed at improving the productivity of grass in association with reduced erosion.This can be achieved by allowing natural grass to regenerate and establish a good cover or by planting and reseeding better forage species and removing undesirable species.But in areas whereby the grazing lands are communal property cannot possibly work unless there a reasonable balance between the carrying capacity and the number of stock actually present.

B. Soil conservation measures on forest land.

- Forests provide an excellent protection of soil against erosion. Apart from being the source of wood products, they maintain high rate of evapo- transpiration, interception and infiltration, and the litter layer on the surface of the soil produce low erosion rate. Increases in erosion occur where the land is permanently or temporarily cleared for agriculture, logging, or firewood cutting.
- Exploitation of a forest should aim at a good management that maintains a protective vegetation cover. During logging/harvesting the level of disturbance is related to the method of felling. The choice clear felling or selective extraction is usually decided on

economic grounds, but from conservation point of view selective felling is much less damaging and preferable. This method allows some of the trees to survive and natural regeneration that restrict erosion.

- Clear felling may be suitable with some species, or may be the most economic method. Since this method remove the tree entirely, particularly on a steep hillside expose the land to continued erosion. In fact a more important issue is not the extent of damage, but the restoration afterwards.

C. Tree planting:

- Tree planting for conservation is an activity to improve the vegetation cover of the ground thereby reducing erosion and producing wood.
- Tree planting for afforestation or reforestation is a soil conservation measure because the canopy intercepts the raindrop, the litter covers reduce splash erosion and the tree roots stabilize the soil.

D. Micro basin:

- It is a small structure with a shape of half or full circle excavated to obtain a small basin for planting a tree. Micro basins have sizes according to their designation to conserve water,for moist areas(1m diameter), and large in dry areas(2m) to harvest water on gentle slopes. They can be applied to dissected or even gullied lands with varying depth of soil.
- The spacing /distance between basins along contour line is 2.5m where as the distance along the slope(perpendicular to the contour line)will be 2.5m.For aligning micro basins along the contour a line level has to be used. It is not necessary to align every row of micro basins precisely with line level. Once the "key" row has been staken out, the next four rows downhill can be established by measuring with measuring tape and the position of individual basins is marked very carefully with a peg. Every fifth row alignment is carried out again with line level.
- After alignment the initial excavation/cutting must be made above the" center point" peg. The fill is placed at downhill side of the point. After every 15cm of fill, the soil should be compacted

E. Hillside terrace:

- Is a structure along the contour where a strip of land is leveled for tree planting. Hillside terraces are up to 1m wide and constructed at about 2-5m VI. Hillside terraces are only applied if there is a strong necessity justifying their construction.
- They are laid out along the contour and are mainly used to prevent damage of flood below steep slopes.Hillside terraces help to retain runoff and sediment on steep sloping land.to accommodate tree seedlings to be planted on them.and also effective on badlands and in areas with low rainfall to conserve water.fig

Gully erosion and its control

A gully can be defined as a steep sided eroding watercourse, which is subjected to intermittent flash flood. It is often used as a characteristic symptom of severe erosion. They also carry a large sediment load.

Development of gullies:

- Gullies could develop by surface runoff as enlarged rills. When a number of rills grow together forming gullies, bigger deeper and wider.
- Another way in which gullies are initiated is by sub surface flow of water in pipes and when heavy rain provided sufficient flow to flash out the soil, causing the ground surface to subside.

Common causes of gully erosion:

- In general, the major causes of gully erosion are too much water, a condition that may be brought about by either climatic change or alteration in the land use. In the later case, heavy deforestation or burning to increase the proportion of the arable land in a catchment can result in greater runoff, gulling will occur.
- Gully formation on a rangeland result from excessive burning and overgrazing.
- Lacks of proper soil conservation practices increase the susceptibility of the land to this effect.

The processes of gully erosion can be reduced into three components:

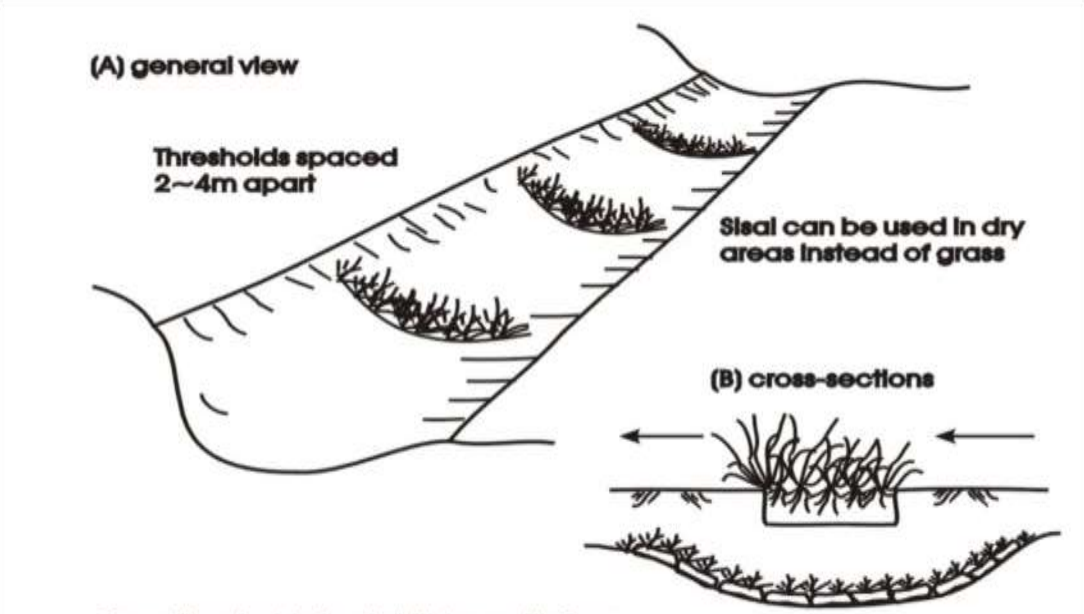
- Head cut: develops due to water directly eroding the head. Like a waterfall, it drops over steep head wall that collapses from time to time. The head cut is usually the most actively eroding part of the gully. Head cut results in the extension/progressive development of gully head in the upstream direction.
- Gully bed/floor: water flowing on steeply graded channel causing scouring of the soil resulting in deepening of the gully.
- Bank/lateral: high velocity of water flowing on the bank undercutting the walls resulting in the widening of the gully.

Damages caused by gully erosion:

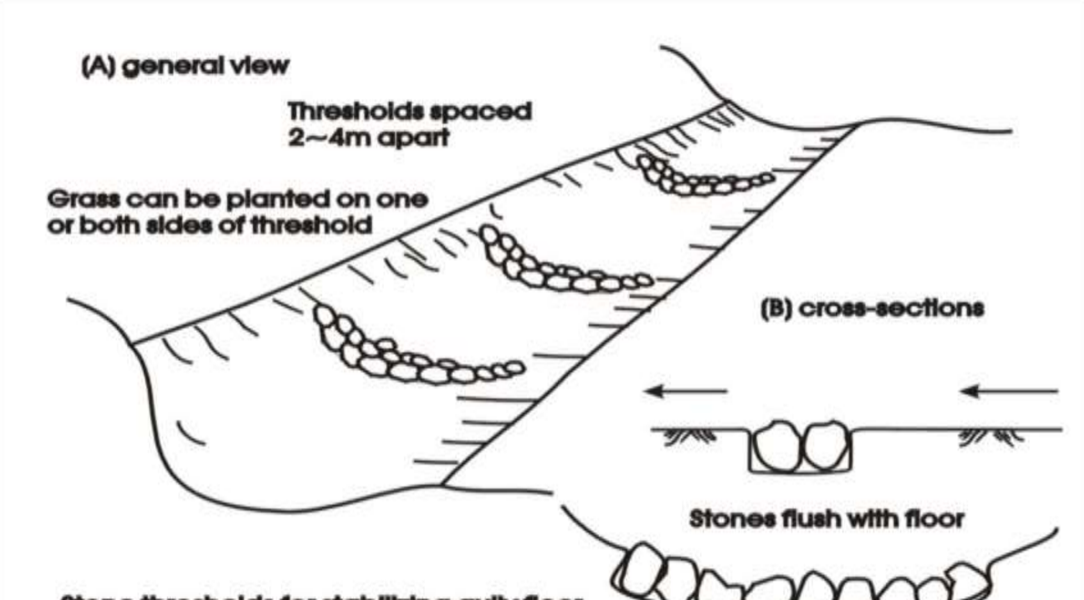
- If gullies are not reclaimed, restored, or prevented from getting any worse can reach to an irreversible situation.
- Land damage: often dissects the fertile agricultural land and grazing land, taking a tool of land (loss of land.)In addition, they make difficult farming practices.
- Sediment damage: gullies are a source of heavy soil loss. The sediment that is transported is deposited down streams on productive land, dams, roads etc.

Control measures.

- ✓ If proper land and soil conservation are followed early in the watershed soil erosion and gully formation can be prevented. Once gully becomes larger, usually restoring is difficult, require more effort, time and money. To be effective a gully treatment should be planned not only for the treatment of the gully itself but also of the watershed areas of the gully. Minor patching of the gully will not solve the problem. In addition, the plan should include the treatment of agricultural forest and grazing lands in the gully watershed area, by using proper soil conservation treatment packages. When designing strategies to control gully erosion it is important to identify suitable and effective methods. In addition, in most cases it will be desirable to fence-off the area where control measures are being applied and divert away the water flow from entering the gully.

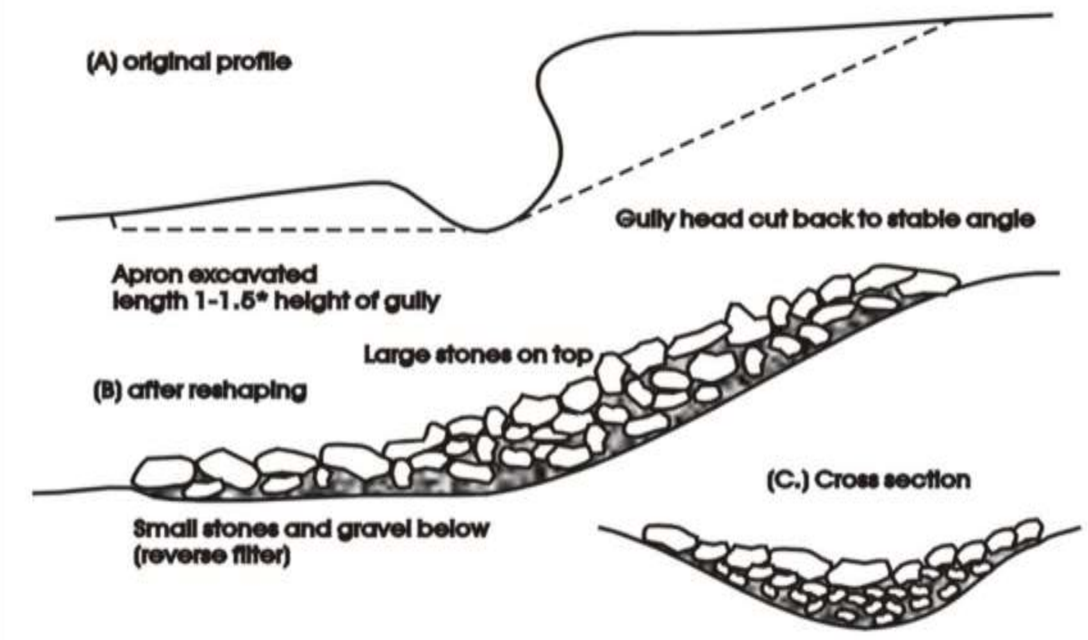


Grass thresholds for stabilizing gully floor

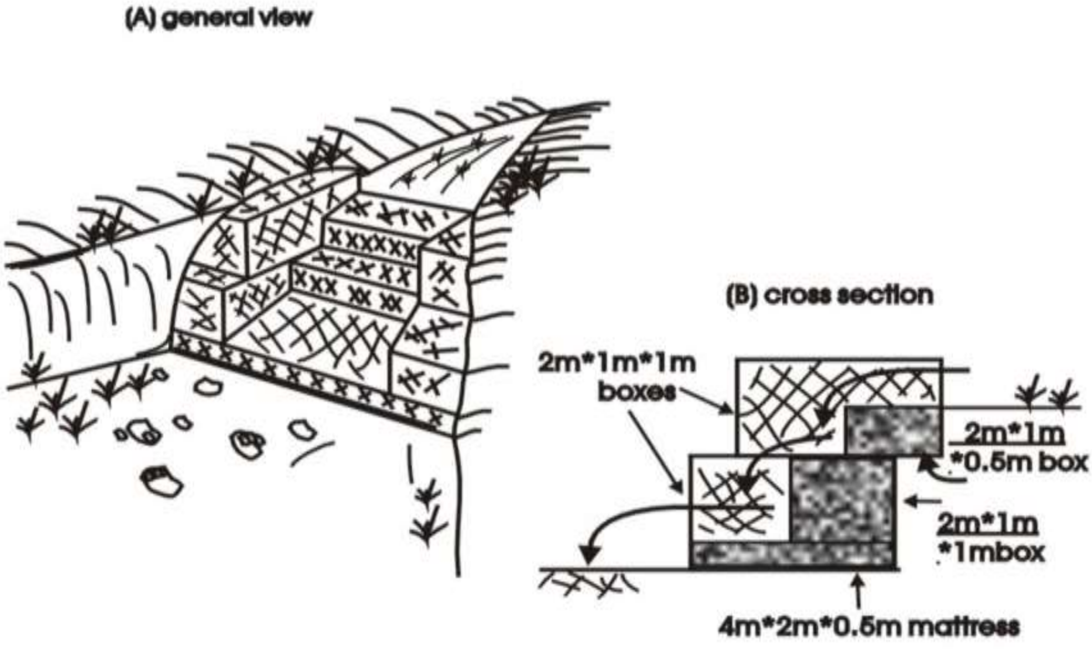


Stone thresholds for stabilizing gully floor

2

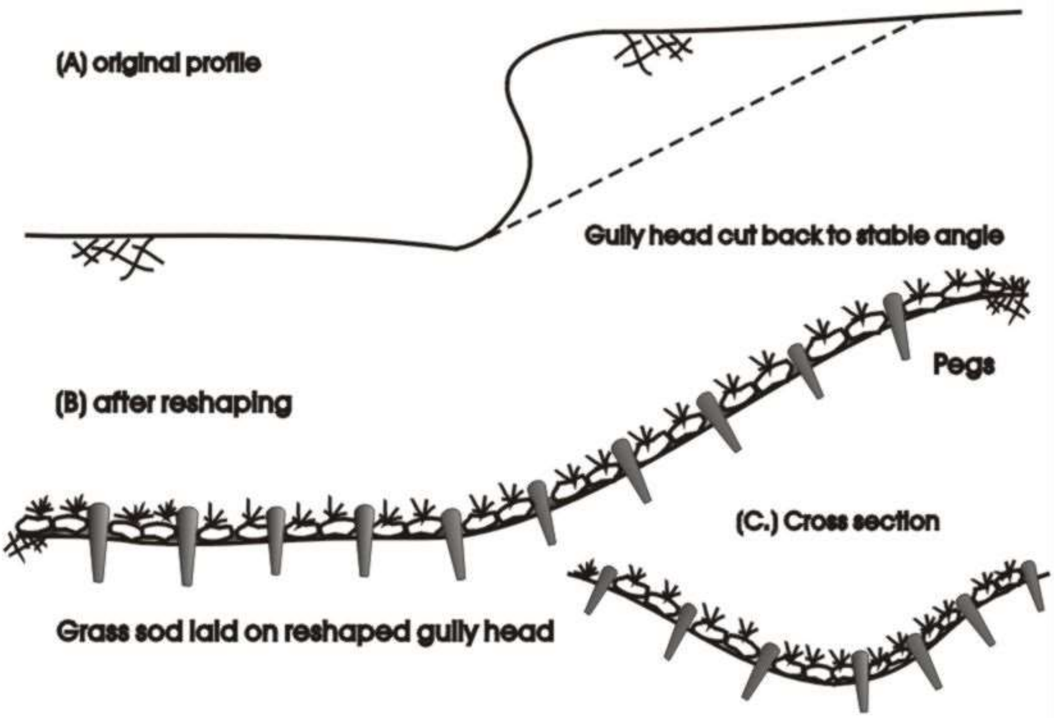


Stone chute stabilization of gully head

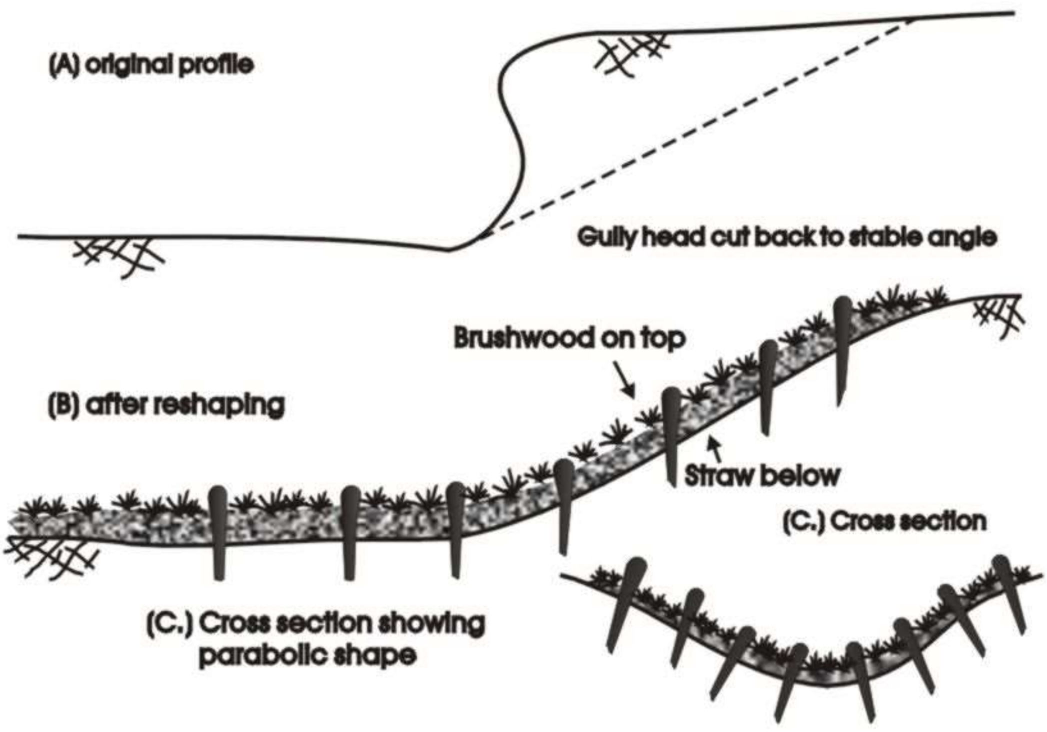


Gabion fall structure for gully head

3



Grass sod stabilization of gully head



Brushwood stabilization of gully head

A. Controlling gully by means of vegetation.

The purpose of vegetation in stabilizing gully is to provide physical protection against scour and it slows down the velocity of flow. However, the establishment of vegetation is not easy. The bed of the gully probably has no available nutrient, no organic matter, and low moisture, making difficult for any newly established plants. The sides of most gullies are vertical with topsoil washed away. Such situations do not permit the plants to hold themselves to the soil and there is always a danger of their being washed away during heavy rainstorm.

The plants to be used for gully control preferably should have the following requirements:

-should grow vigoursly on poor condition,

-give quick ground cover,

-spreading and creeping habit is better than an upright.

Plants are usually best established by planting out potted seedlings to get good initial growth or from cutting give better performance than direct seeding.

Vegetation helps prevent erosion in the following ways:

- Roots hold soil together
- Leaves and stems break up rainfall impact
- Ground cover slows down runoff and filters sediment
- out of water
- Plants evapotranspire moisture from soil

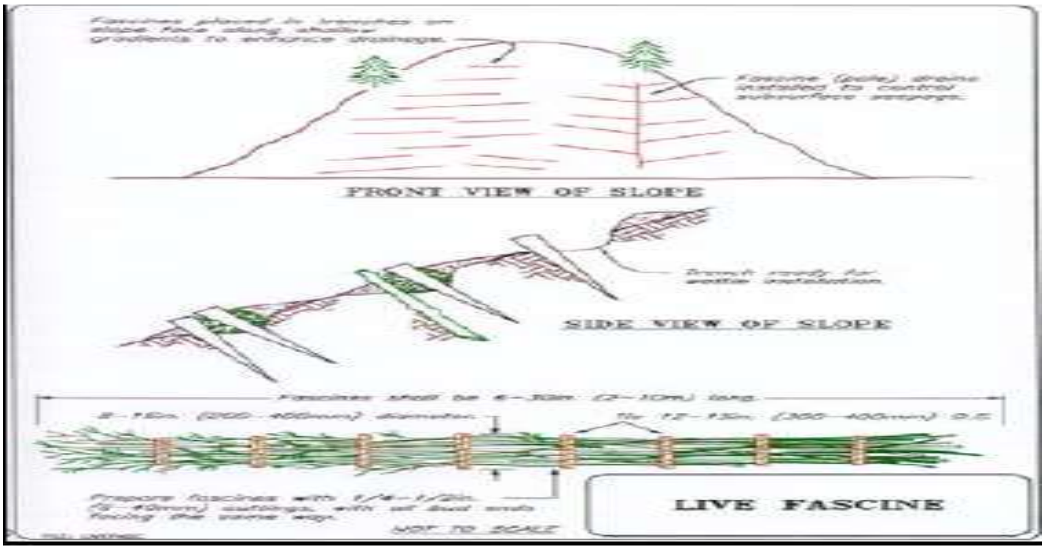
Plants are site specific in terms of their growth requirements, and success is influenced by:

- Soil moisture
- Soil chemistry
- Temperature
- Sunlight
- Maintenance
- Soil Structure and Disturbance

Planting in gullies:

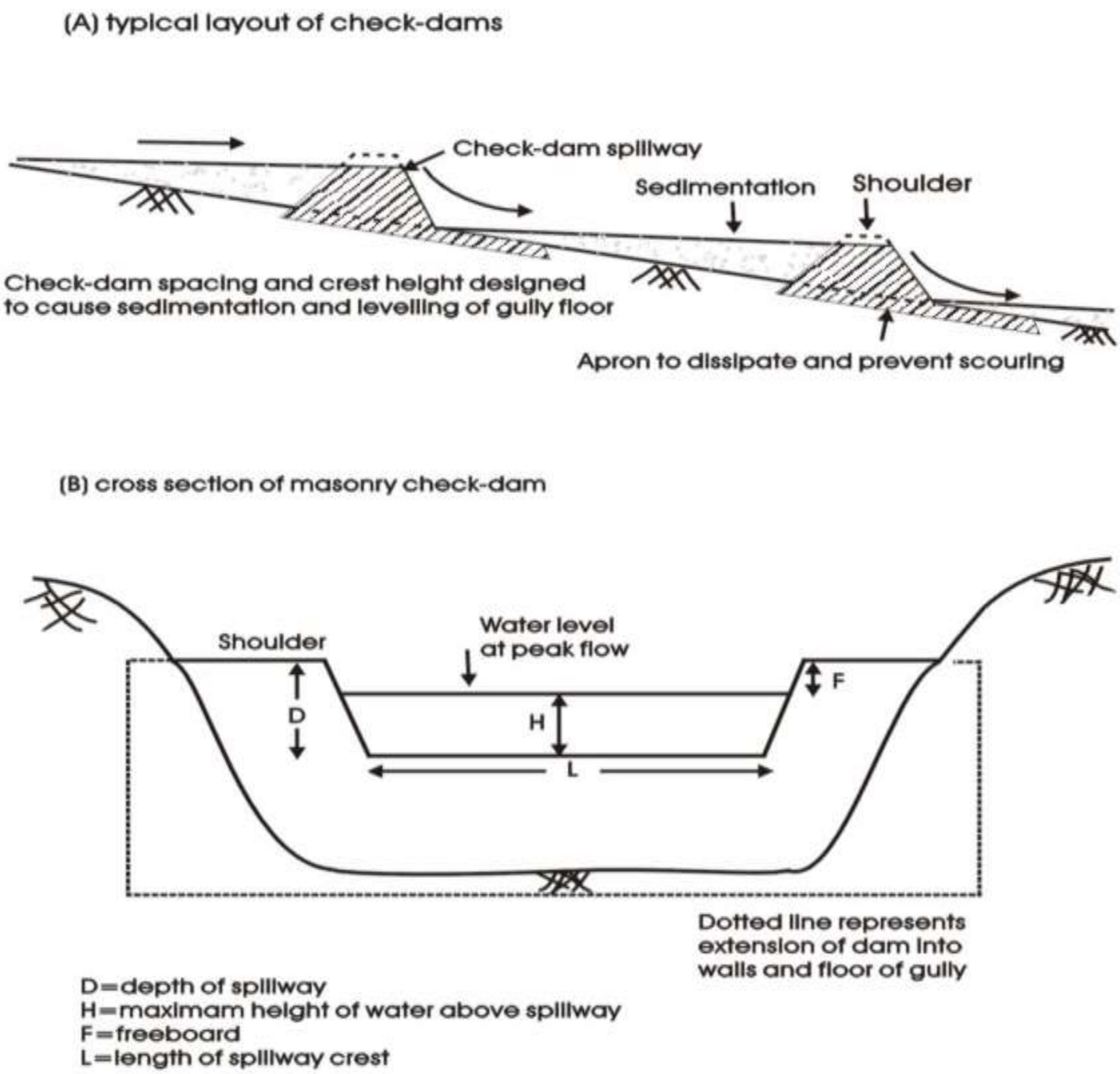
- ✓ As mentioned earlier excluding human or livestock interference surrounding the gully by fencing is necessary. Moreover, during the initial stages the water flow from the gully shall have to be diverted away to a safe place.
- ✓ Head of gully: stabilization of gully head should always be the first step to stop the gully head eating its way steadily up stream. To prevent waterfall erosion on the gully head, (for a low head of gully <1m) can be done by excavating a soil at the head and small stones are filled on the foot of the slope and compacted layer by layer. It is also possible to use a carpet of piled beds of brushwood.
- ✓ Planting in gully beds: native grasses are best suited for planting in gully beds or a group of trees and shrubs can be planted in combination.
- ✓ Gully walls: planting the sides of gully is difficult, as they are steep, unstable and eroding. There is a problem that the soil and planting material tend to be washed off before the vegetation can become established. In such case, the banks can be

leveled to gentle uniform slope by excavation, and then it can be planted. Trees in rows can be planted along the contour. In order to accelerate the establishment of vegetation, crop residues long grass can serve as the surface cover. Though efforts to stabilize gullies often rely on physical structure, vegetation can play a major role in stabilizing smaller gullies.



B. <u>Structural measure (Check dams).</u>

Structural measures should be used only when other measures are not applicable or adequate. Usually medium and long gullies cannot be controlled by vegetation alone. A check dam is an obstruction wall across the bottom of the gully, which reduces the velocity of the runoff and prevents the deepening or widening of the gully. They can be made of stones, or wooden material.



Check-dam layout and cross section

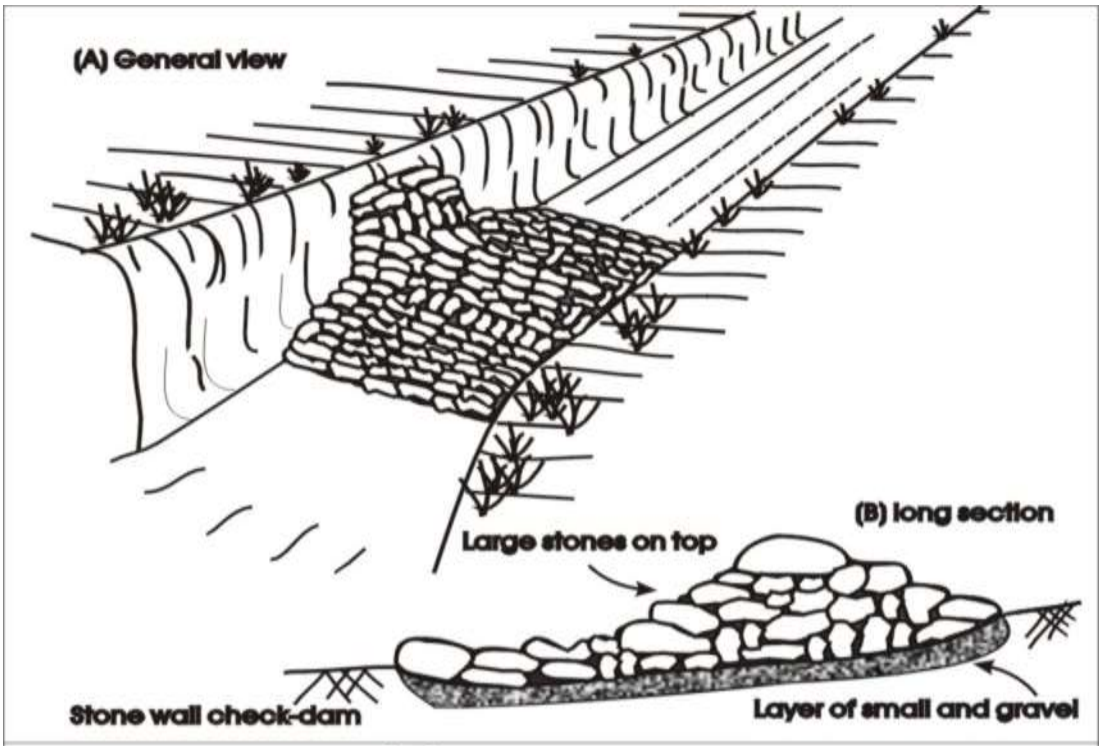
1. **Brush wood check dams**: is constructed of small wood branches and poles, interwoven together, by either by wire, rope or sisal. These are temporary structures, easy to construct, and use cheap readily available materials. The purpose of this dam is to retain sediment and to allow the runoff filter through it slowly. It is suitable method for small gullies.

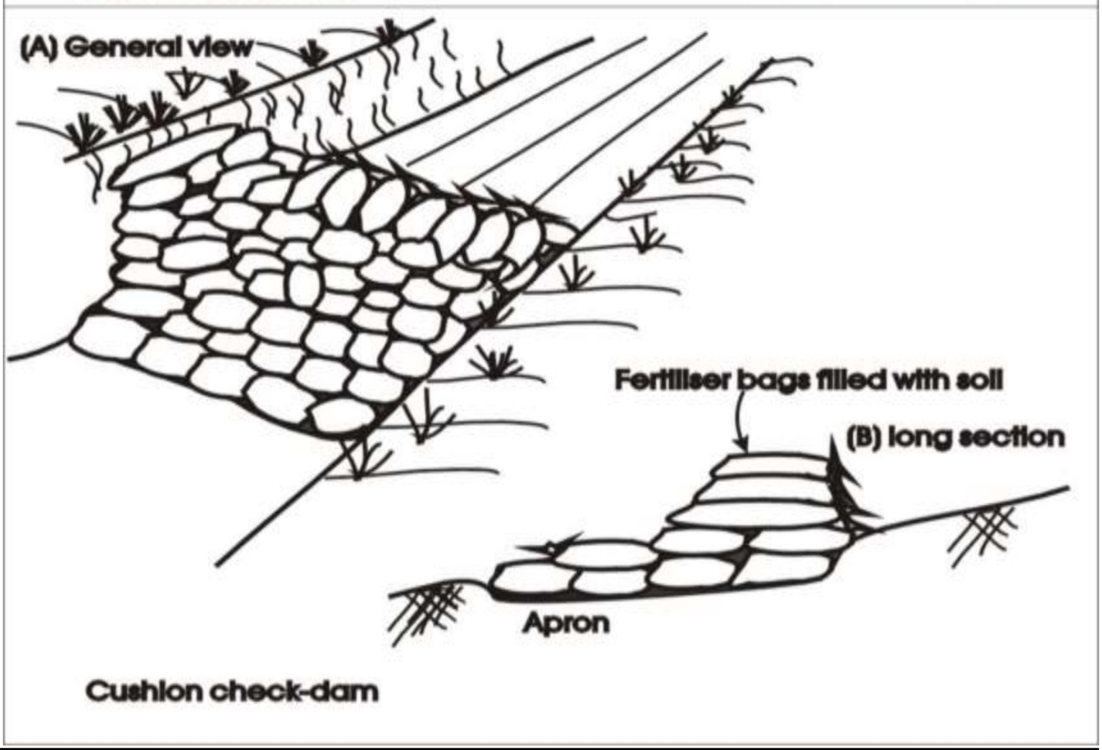
   In constructing such type of dams, the posts should be so driven in the soil, secure it firmly so that they lean slightly upslope. The thinner branches or limbs are interwoven through the posts to form a wall. Each branch should be pushed in to the banks up to 50cm to strength the dam. The soil at the both ends of the dam is carefully pecked down. If two rows of brushwood dam are constructed, the minimum distance between the rows should be about 50cm. Brush and other debris should be packed between the walls formed by the vertical posts and the interwoven branches.

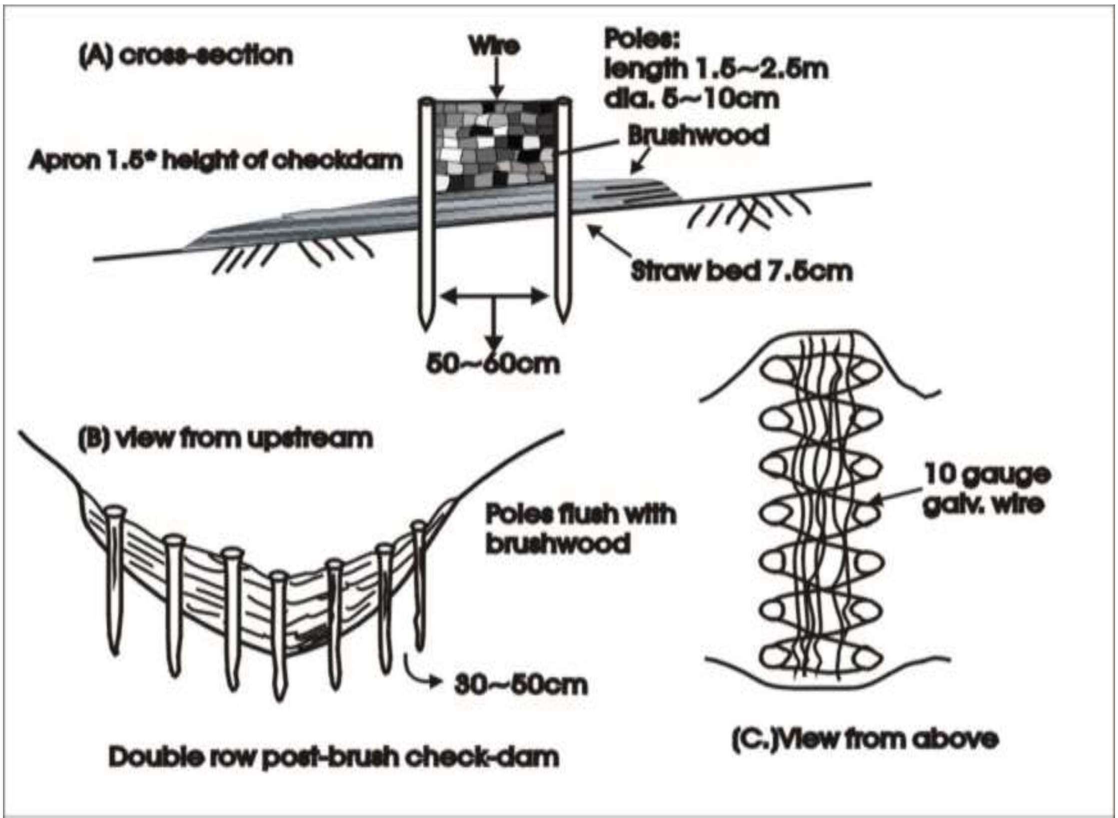
2. **<u>Rock fill (loose rock) check dams</u>**: loose rock check dams are economical type of structures for gully control.

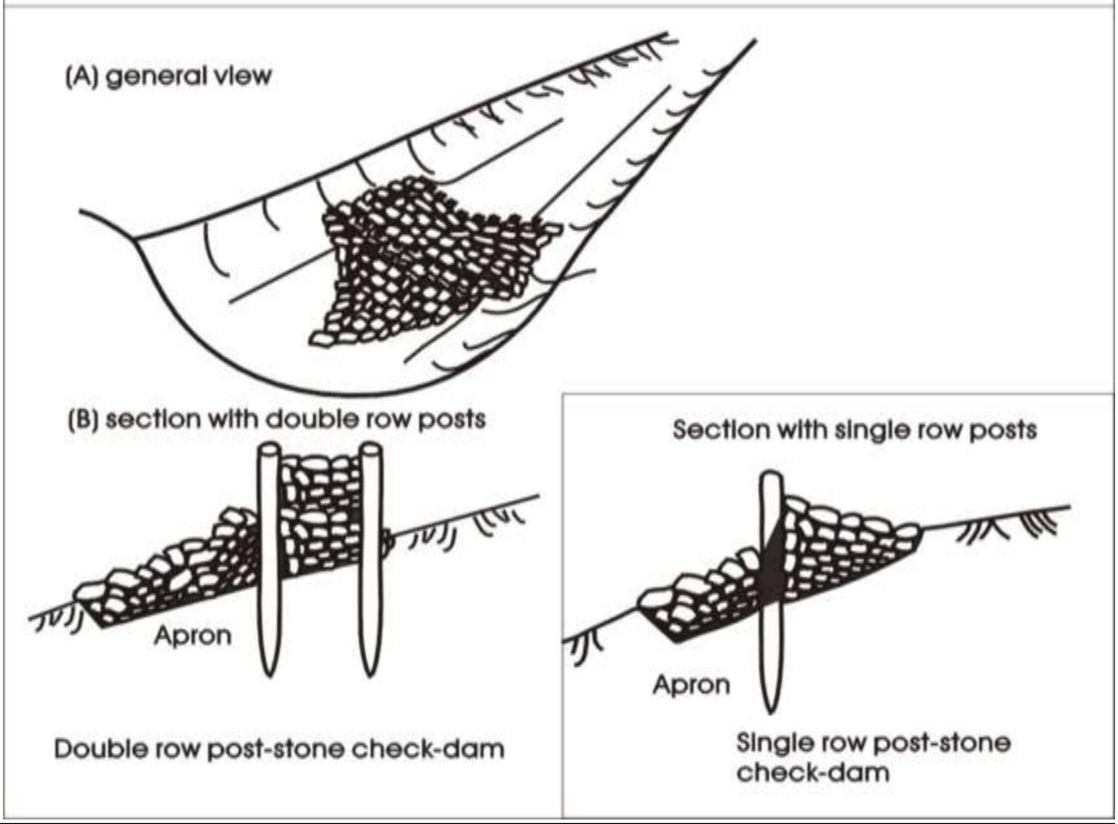
<u>Construction steps</u>.

- A trench key, 0.5m in depth at the base and another trench should extend into both abutments penetrating, up to 0.5m reaching up to the crust level of the check dam. Then the construction of the body of the check dam can be continued up to 1m height and thickness.
- An adequate spillway should be provided for safe disposal of water, without overtopping the check dam. Giving the dam crust slope towards the banks and hyperbolic shape can increase flow capacity of check dam. This will allow the water to flow over the center of the check dam.
- An apron or stilling basin at the foot of the check dam should be built to dissipate the energy the flowing water passing the spillway.
- The spacing; check dams should be installed in systems, starting from the mouth of the gully, upstream. VI between check dams is equal to the height of a check dam, it is 1m.


(A) General view
(B) long section
Large stones on top
Stone wall check-dam
Layer of small and gravel


(A) General view
Fertiliser bags filled with soil
(B) long section
Apron
Cushion check-dam





3.3 Wind erosion and its control.

On a continental scale wind erosion is mainly confined to those with low mean annual rainfall, that is in arid and semi arid climates .Not only in arid and semi arid areas, local wind erosion can occur in humid areas on cultivated land during the year when there is no rain, if there is no crop cover or any other protection. Ignoring the localized special cases the factors which in general affect erosion by wind are the soil conditions, the rainfall and the vegetation.

The physical nature of the soil will affect the ease with which particles are dislodged, but also, with the fact that only dry soils blows, and any soil will be unmoved by wind while its surface is moist. Climate, therefore has a big influence on wind erosion, particularly the extent to which the soil is will be dried by hot winds and also low rainfall.

The other factor is the vegetation, for the soil is almost immune to wind erosion when covered with a carpet of vegetation. This physically prevents the wind coming into direct contact with the soil in the same way that a good cover of vegetation reduces splash erosion.

Types of soil movement by wind.

For a given soil conditions the amount of soil which will be blown depends on, the wind velocity and roughness of the soil. Naturally a high wind velocity can move more particles than a slower wind,in the same way that the sediment carrying capacity of flowing water increases with velocity.

There are three distinct kinds of soil movement by the wind depending upon the size of the soil particles.

- ✓ **Suspension:** is the movement of very fine particles, usually less than 0.1 or 0.2mm diameter, high in the air over a long distance.
- ✓ **Surface creep**: is the rolling of coarse grains(0.5 to 1 or 2mm diameter)along the ground surface.
- ✓ **Siltation**: the movement of middle size soil particles(0.05 to 0.5mm diameter) in a series of jumps over the surface.

The control of wind erosion on agricultural land.

Wind erosion could have a series economic consequence to agricultural land.The fundamental principle in controlling accelerating wind erosion is correct land use. Since wind erosion is restricted to dry soils, and the amount is dependent upon wind velocity, the control measures are directed towards maintaining soil moisture or reducing wind velocity.

Crop management:

- Without the fundamental principle of an ecologically acceptable and correct use of land,control measures will not be able successful. Since soil only blows when it is dry anything which conserves soil moisture is beneficial.
- Moisture conservation may be achieved by cropping the same ground in alternate year's part of the land in strips, leaving the remainder on fallow. The inclusion of grass in rotations is beneficial, ensuring good infiltration, restricting soil movement, improving physical structure and increased organic matter for the crop which follow.
- Another approach to moisture conservation is maintaining a protective cover on the surface of the soil. Such as mulching is a key to wind erosion control just as it is for control of rain erosion. In addition to the beneficial effects on reduction of surface evaporation and increase in infiltration, it also slows down the wind speed.

- Harvesting methods which leave the maximum amount of crop residues are desirable. Tillage practices that do not bury the surface vegetation as a means of weed control and that keep the soil as rough as possible are also desirable.

Windbreaks.

- The other way of reducing wind erosion is to slow down the wind velocity by physical barrier in the form of planted vegetation.
- Windbreaks are narrow strips of trees and shrubs planted to protect areas usually farm fields from the wind and blowing sand. Where wind is a major cause of soil erosion and moisture lose, windbreaks can make sustainable production possible. When properly designed and maintained, windbreaks reduce wind velocity, and trap the blown soil. It can improve the microclimate in the area it protects by decreasing water evaporation from the soil and plants. In addition to these soil and water conservation effects, and provided that windbreaks are managed carefully a wide range of useful products, from poles and fuel wood to fruit, fodder can be obtained.
- Windbreaks usually consist of multistory strips of trees and shrubs planted at least three rows deep. They are placed on the perpendicular to the prevailing direction of strong wind. The orientation of the windbreaks is crucial. In areas where the direction of prevailing wind changes from season to season, the local people can decide when is the most important period to provide protection (ie.during fallow or the growing season.)
- Small living fences and boundary plantings can act as a windbreak for small sites such as around homes or farm field. However, windbreaks are distinguished from boundary plantings and living fences by their orientation, which must face the wind and by their multistory, semi-permeable design.
- A properly designed windbreak can protect a field at least ten times as long as the height of the trees on the leeward direction. However, protection diminishes with distance away from the windbreak. Remember that it will take several years before the trees reach the optimum height to protect the full area.
- Windbreaks should not be too dense or too permeable. Very dense windbreaks may do more harm than good since they will tend to create strong turbulence that will scour the soil on the windward side and damage crops on the leeward side. The most effective windbreaks provide a semi-permeable barrier to wind over their full height from the ground to the crowns of the tallest trees. Since their shape changes as they grow it is usually necessary to mix several species of different shapes and sizes in three rows.
- Windbreak will take some land out of crop production and will compete for water, light and nutrient. In general trees with narrow, vertical growth are ideal to minimize the land removed from crop production. The species selected will have to meet requirements for windbreaks as well as production priorities of the local people. Diversifying the species in the windbreak can also bring a wider variety of useful products to local people. A windbreak must be managed to maintain correct density

and structure, with harvesting carried out with care. When trees reached their full height and ensuring the wind reduction is maintained, for instance a windbreak of two rows can be pollarded fully for fuel wood along one row(50% harvest)OR alternatively, every fourth tree can be fully pollarded at height 2.5m from the ground.(25% harvest).fig.

The use of line level to soil conservation.

A line level consists of two flat wooden sticks 1.5m, a spirit level and a string of 10m lengths.

The sticks are 1.3m long and a triangular piece of wood is screwed on to the stick reaching 20cm above the foot of the stick. This help to prevent the stick from sinking into the ground and to have the graduations of the stick above the grass and other vegetation on the ground.

Above the wooden triangle the stick has 12 graduations up to 0- mark at the top of the stick,every graduation marking a distance of 5cm.

The string between the sticks shall have a length of 10m,but for tying the string on the line level sticks 1m extra string is needed (11m). The usual type of a spirit level is hooked on to the string put up between the line level sticks.

Setting: Three persons are needed to handle the line level. Person 1 holds one of the stick where the string is tied at 0-graduation mark. The second stick is held by person 2 vertically so as the distance will be 10m. Person 3 hooks the spirit level exactly onto the center of the string.

Laying out contour lines Contour lines are horizontal lines across the slope joining points of the same elevation. Contour lines are used to line out conservation measures which have to be level. Materials

The following items are needed:

- Water-level
- Thin plastic rope, 11 m long
- 2 woodeen poles, 2 m long, marked every 10 cm
- Meter-band or meter-stick
- Short poles for marking the ground

Operational procedures

Checking the accuracy of spirit level.

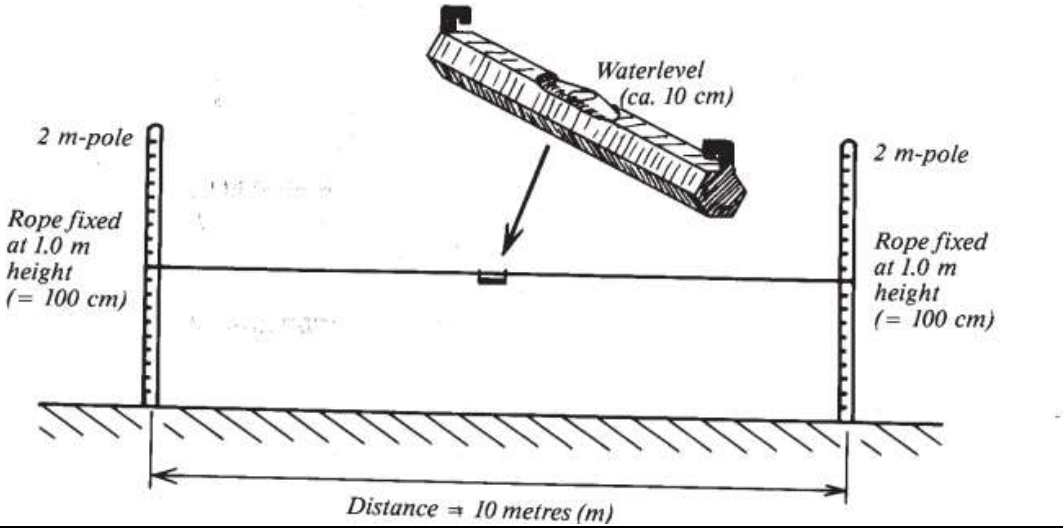
To get the same height for the two sticks, person 2 has to move his stick with the string fixed at 0-graduation until the air bubble comes to the center. After that you remove the spirit level from the string, turn it hundred eighty degree and hook it back on the center of the string. If the bubble now comes to the center again, the spirit level is accurate. If not the spirit level cannot be used.

Measuring the percentage slope.

To use line level on a slope the lower stick should always have the string fixed at 0-graduation. On the other stick the string should be moved up and down until the spirit level indicates that the bubble is exactly in the middle. Then read of the number of graduations below the 0-mark (eg.10 graduations= 105)

Marking out contour lines

Proceed across the slope as shown in the drawing below. Survey 10 m at a time, in difficult topography only 5 m (half the rope)



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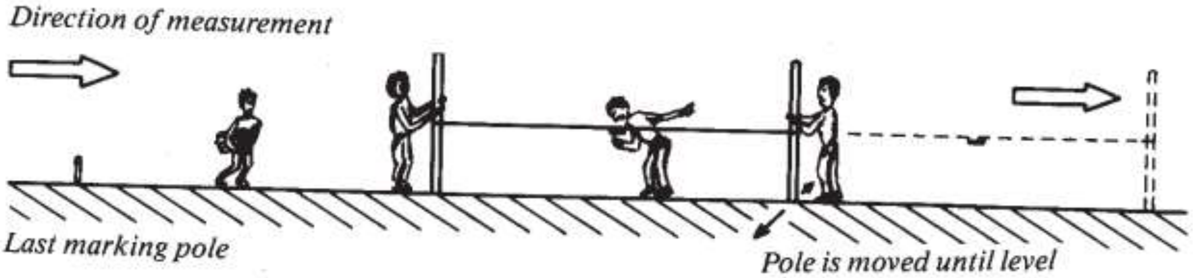


<u>Marking the VI.</u>

A vertical interval between two points is the difference in elevation between them. VI is used <u>along the slope</u> to make the spacing between two conservation measures.

VI= 1m,for slopes <15% and 2.5*soil depth, for slopes>15% fig

<u>Marking graded lines.</u>

It is used to line out conservation measures, which are graded to drain excess water.

For lay out 1% graded measure, the string has to be fixed on the poles with 10 cm difference OR 2% c difference OR 0.5% c difference.

Always start lining out from a water way or river and proceed slightly up slope. Always use the stick with string fixed higher up near to the waterway.

a) Definition:

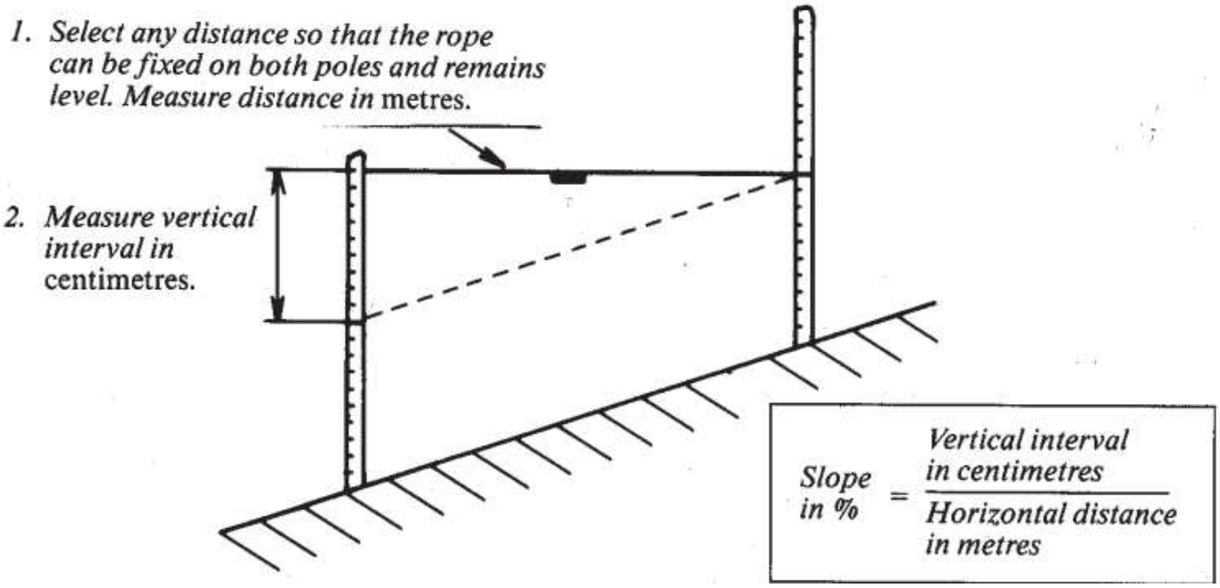
Slope gradient is the steepness of a slope. It is given as height in percentage of length (%) or in degree.

b) Materials:

The following items are needed:
- Waterlevel or this page of the book (see c) below)
- Thin plastic rope, 11 m long, meter band or meter stick
- 2 wooden poles, 2 m long, marked every 10 cm
- Small poles for marking on the ground

d) Measuring slope gradients with the line level:

Follow the steps given below and use the formula to calculate the slope percer tage. Take care that you use the correct units (1 metre = 100 centimetres, cm)



Sediment Controls

I. Sediment Fence

A sediment fence is a temporary barrier of semi-permeable geo-textile, partially installed in a trench and supported by posts.

Application

Suitable for containing course sediments in sheet flow environments. Sediment fence works by creating a small pond that allows coarse sediment particles to settle out. Recommend that the contributing catchment area should not exceed 0.6 ha per 100 m of fence.

Design/Construction Aspects

Not to be used in concentrated flow. Silt fence should be installed on the contour with the ends turned up so that the turn-up ground level is equal to the top fabric level at its lowest point. Attention should be given to the point where overflow will occur as this is a common erosion source. It needs to be anchored in a 0.2m deep compacted backfilled trench. If wire is used to secure the material to the posts, it should only be at the top of the fabric to prevent creating large holes through which water can flow. If using wooden stakes, use shade cloth fixes or metal strips.

Problems:

- The catchment is too large for the size of the fence.
- The base of the fence is not placed deep enough into the soil.
- They are placed in concentrated flows.
- The fence is not placed along the contour, and consequently concentrates the flow and creates erosion.
- Wire ties are used to secure the fence to the post resulting in holes in the fence.
- Poor quality material without UV stabilization is used in long-term installations (>3 months) resulting in failure of the fabric, and the need to replace them at regular intervals.
- Fence placed close to heavy traffic and consequently run-over.

II. Compost-Filled Filter Tubes

A high permeability filter tube of varying lengths and diameters filled with a high quality composted material. The filter tube can be purchased in biodegradable and non-biodegradable forms depending on the application and anticipated life span.

Application:

- Compost filled filter tubes can be used as an alternative to straw bales, sediment fences, rock, sand or gravel filled bags and geo-logs. Sheet flow applications include placement across the contour to reduce flow velocities, placement across the contour with a depression to pond water for sediment control, placement in a circle to filter sediment from desilting or concrete wash-down application and stacking and staking to produce bio-engineered vegetated walls.

- Concentrated flow applications include placement across channels to reduce flow velocities and retain sediment, along the edge of stream channels to protect the stream bank from erosion.
- An additional benefit over conventional erosion and sediment control products is that the compost material can attenuate some water quality problems such as elevated pH and heavy metal levels.
- Generally the filter tubes are filled with compost from a purpose built blower truck.

Design/Construction Aspects:

- ✓ The compost filled filter tubes must have complete contact with the soil surface to prevent water running under the filter tube. They must be pegged or staked to the soil surface to maintain the soil contact and prevent movement by high flow velocities. Geo grids can also be used to anchor the filter tubes to the soil.
- ✓ In sheet flow environments the filter tubes must be pegged along the contour and turned up each end.
- ✓ Care must be taken to ensure that they do not grade down slope. In concentrated flow environments the filter tubes must be installed so that water discharges over the invert and not around the sides.
- ✓ Due to the potential risks associated with bio-engineered vegetated wall failure the manufacture must be consulted in regard to design and construction applications.

Problems:

- Erosion under the filter tubes to poor installation and insufficient staking. Erosion along the filter tube/soil interface due to inappropriate down-grade installation.
- Erosion around the end of the filter tube due to insufficient channel depth or insufficient length of tube placed across the channel.

III. Buffer Zones/Filter Strips

An area of natural vegetation or re-vegetated area the purpose of which is to separate a sensitive area from a disturbed area.

Application

- ✓ A buffer zone serves to trap sediment and nutrients not contained using a conventional erosion and sediment control program. Buffer zones may also have environmental, social, and aesthetic values as well.

Design/Construction Aspects

- Environmental and planning laws often nominate buffer zone requirements. Soil Services, 1999 advise that an effective filter strip requires well established vegetation with good cover at the soil surface. Filter strips should be located along the contour with a width equal to 5 times the percentage slope, or for narrow disturbances, 1.5 times the width of the disturbed area. The minimum width of a filter strip should be 15m.
- In the application pictured, the strips should have returns at 90 degrees to stop water concentrating along the leading edge of the turf and creating an erosion issue.

Problems

- May be prone to weed and vermin infestation. Fire management may also be an issue.
- Filter strips are generally not effective during heavy storms or on slopes greater than 10% (IE Aust, 1996).

IV. Construction Exits

Consist of crushed rock pads, shaker ramps and wash down bays located at locations where construction traffic enters and leaves a site. The key features in this photo include an initial rock rumble grid, a long wash-bay over a metal shaker, and a long sealed section for drying the tires before exiting the site.

Application

- Used to reduce off site sedimentation by removing mud and dirt from tires as vehicles leave the construction site.

Design/Construction Aspects

- King, 2004 advise that cattle grids can be used to form shaker ramps. Sufficient numbers of ramps need to be placed together to allow two complete rotations of the largest truck tire anticipated to leave the site. Rock pads should be a minimum of 15m long and 200mm thick, with an underlying layer of geofabric. Rock pads should be formed with a mound to divert water away from the entry/exit point.
- The rock should be <75mm to prevent it being jammed between the dual tyres.
- If work must continue whilst internal surfaces are wet, a high quality wash-down facility, often supplemented with a high-pressure water blaster is required to prevent material being tracked from the site.

Problems

- Crushed rock pads and shaker ramps have limited effectiveness, particularly during wet weather when the mud sticks to wheels and tyres. This mud then falls off the vehicle onto the road as higher speeds are reached.
- Wash-down bays are more effective at removing sediment, although the wash-down process takes considerable time and wash-down water must be treated before being discharged. These are not suitable for moist or wet clays. In such cases, one need to have graveled haul roads, a wash-down facility, or one must stop work until the site dries out.
- Wet areas on the drive-out area result in a film of slippery material being tracked onto adjacent roads creating a safety hazard.
- Rock shakers are only suitable for controlling coarse material from the site.
- If work must continue whilst internal surfaces are wet, a high quality wash-down facility, often supplemented with a high-pressure water blaster is required to prevent material being tracked from the site.

V. Check Dams

A small temporary rock weir structure. Can also be constructed from sandbags and geo-logs*.*

Application

- Used as temporary erosion protection and limited coarse sediment retention in concentrated flow environments such as perimeter and table drains by limiting flow velocity. Not to be used in major flow lines or streams.

Design/Construction Aspects

- Rock check dams are temporary measures and therefore do not require formal design. IE Aust, 1996 suggest a maximum catchment area of 1 ha.
- According to King, 2004, the maximum height of the check dam should be 0.6 – 1m and the centre should be a minimum of 0.15m lower than the outer edge to form a spillway.
- Check dams should be installed so that the toe of the upslope check dam is the same level as the crest of the immediate down-slope dam.

Problems

- Erosion around the edge of the dams due to insufficient spillway depth. Erosion immediately down slope of the check dam due to insufficient rock protection.

VI. Gully Pit and Kerb Inlet Traps

Gully pits and kerb inlet traps are a range of temporary geo-fabric and gravel structures designed to prevent coarse sediment entering storm water drainage entry points.

Application

- Due the high intensity rainfall encountered in North Queensland and limited permeability of these measures, their use is not recommended. Source control of erosion and sediment is preferential to use of these structures due to their limited capacity and effectiveness. They will not trap fine clays.

Design/Construction Aspects:

- Maximum catchment area of 0.1ha for highly disturbed site
- A range of proprietary products are available that either prevents sediment entering kerb inlets and gully pits, or trap the sediment in the structure.

Problems:

- Due to limited capacity, the majority of measures traps very small quantities of coarse sediment and are largely ineffective.
- Water tends to flow around most of these measures often causing drainage/flooding problems.

VII. Sediment Traps

Sediment traps are measures that capture eroded sediments by slowing the velocity of water so that the soil particles settle out. They generally consist of a stable inlet and outlet, and some form of pond.

Application

- Their function is to trap coarse sediments in concentrated flow situations. They should be located immediately downstream of disturbed areas. Although designed to function in concentrated flow environments, off stream installation of sediment traps is highly desirable as it limits the amount of contaminated water to the treated, allow easier removal of sediment and allows the traps to function more effectively in high rainfall events.

Design/Construction Aspects

- Formal design of sediment traps is required – refer Landôme, 2004 or IE Aust, 1996. Sediment traps can be formed by excavating an earthen pond, or by constructing some form of structure to form a pond using materials such as rocks, logs, sandbags and rock-filled wire baskets.

Problems

- Common problems include inlet and outlet erosion due to inadequate erosion protection.
- Difficulty in cleaning out sediment due to poor location and design.
- Generally not effective in removal clay or dispersive soil particles.

VIII. Dry Sediment Basins

An earthen pond designed to contain coarse and fine sediments. Components include a stabilized inlet, pipe outlet with a riser and an emergency spillway. They tend to be permanent structures. The riser pipe has a filter arrangement to allow dewatering of the basin without allowing trapped sediment to discharge to the receiving environment.

Application

- Sediment basins tend to be the "last line of defense" in erosion and sediment control system for a particular catchment. They should not however, be the only control measure in the system. Dry sediment basins are not suitable for high clay or dispersive soils.

Design/Construction Aspects

- Sediment basins require detailed engineering design. Refer to Landcom, 2004 or IE Aust 1996 for design and construction details. Dry sediment basins should have a length to width ratio 3:1. They should be located at cut/fill lines to ensure maximum operational life and also must be located to allow removal of accumulated sediment. The inlet and outlet drains should be lined to minimize erosion. Sediment basins should be fenced where there is a risk to human life.

Problems

- Poor sediment removal due to incorrect design and sizing.
- Limited operational life due to poor location and inability to remove sediment.

IX. Wet Sediment Basins

An earthen pond with a stabilized inlet and an emergency spillway whose function is contain coarse and fine sediments. They tend to be permanent structures. Flocculants must be used to settle out suspended sediments.

Application:

- Sediment basins tend to be the "last line of defense" in erosion and sediment control system for a particular catchment. They should not however, be the only control measure in the system. Wet sediment basins are used for high clay and dispersive soils. Sediment retention is only achieved by the use of flocculants such as gypsum, poly-aluminum chloride and poly-acryl amide. Once the fine clays have settled out the clean water was be pumped from the dam.

Design/Construction Aspects:

- Sediment basins require detailed engineering design. Refer to Landcom, 2004 or IE Aust 1996 for design and construction details.

Problems:

- Not sized appropriately.
- Failure of structure at outlet.
- Flow path between inlet and outlet is too short.
- Limited access to remove sediment.

X. Flocculants

Chemical flocculation systems are used where the performance of sediment retention ponds needs to be increased to reduce the immediate effect of sediment on the receiving environment and/or reduce the cumulative effect of sediment yield within the catchment. Chemical treatment systems are also particularly useful in reducing visual impact (amenity values) and the detrimental effect on water quality resulting from highly turbid discharges (such as dispersive clays). This technique can affect clear water within a few minutes, and is therefore effective in allowing a basin to be readied prior to an imminent storm event. Where the material is extremely fine-grained, a coagulant may also be required.

Application

- Common flocculants include gypsum (calcium sulphate), alum, poly aluminium chloride (PAC), and polyacrylamide (PAM). Management is required as overdosing of flocculent can be just as harmful, if not more so, than the sediment that the system is designed to capture. It can also reduce the effectiveness of the flocculent.
- There are a number of electro-flocculent technologies available from Australia and the United States of America. The Australian electro-flocculation technology "Electropure"

bombards the sediment contaminated water with electronically generated iron and aluminum ions.

- Flocculants are used in, and upstream of sediment basins to facilitate the settlement of suspended
- Soils they are of particular importance when Type-F or dispersive soils are present, as the fine clay particles will not settle out under gravity. Most flocculants lower the pH of the treated water and lime may have to be used to adjust the water to pH 6.5-7.5, particularly if the retention time is short. If alum is used, the release water needs to be above pH 5.5.
- Flocculent blocks can be placed in channels and at the inlet to sediment basins to facilitate sedimentation. These are normally an ionic-based material such as inorganic aluminum or iron, with a commensurate low risk to the aquatic environment. However, to avoid over-dosing, they should be installed in the flow path but where they are dry during periods of non-flow.

Problems

- In sensitive receiving waters the impacts of the flocculent may be greater than that of the sediment laden runoff. Anionic flocculants can clog fish gills resulting in fish morbidity.
- Flocculants containing aluminum are not suitable where the runoff or receiving waters are likely to have a pH of less than 5.5.
- Some poly flocculants have a short shelf life (approximately 30 days).
- Over-dosing with organic polymers needs to be avoided.
- Gypsum is relatively insoluble, and requires mixing into a slurry before application to the sediment basin.
- Most flocculants will result in an acidic pH change and treated water must be pH buffered (normally with agricultural lime) prior to release. The final adjusted pH will depend on the pH of the receiving waters, but will normally be between pH 6.5 and 7.5.

XI. Sediment Curtains and Turbidity Barriers

Description

Consists of a curtain geotextile filter fabric or plastic attached to series of floats. The curtain extends from the surface of the water to stream/lake bed.

Application

- The purpose of these structures is to contain sediments resulting from disturbance to the stream bed or bank. A geo textile filter fabric curtain will contain coarse sediments. A plastic curtain will control the movement of turbid waters.

Design/Construction Aspects

- Only to be used where stream flow velocities are low. A sufficient length of curtain must be used to allow for tidal movement or wave action. The ends of the structure should be carefully anchored to the substrate to prevent leakage of contaminated water. They should not be placed across streams where they could limit fish movements or pose a navigation hazard to watercraft.

Problems

- Sediment ultimately settles out on the streambed. Removal of these sediments may increase water pollution problems.
- Deterioration of the fabric when used for long periods, particularly in marine waters.
- These are not appropriate in waterways with high flow rates**.**

XII. Straw bale sediment trap

- Rectangular straw bales placed to form a pond.

Application

- Due to their limited effectiveness in trapping sediment and their inability to withstand even low velocities, straw bale sediment traps should only be considered as a last resort.

Design/Construction Aspects

- Straw bale sediment traps do not filter sediment laden water - sediment removal is achieved by ponding water. Straw bales should be placed in a 0.2m deep trench on their edge such that they form a pond where the ends of the structure at ground level is equal to the top of the straw bale in the invert that is when full water will discharge evenly over the centre of the structure and around both sides. Each bale must be securely anchored with two pegs.

Problems

- Straw bale become weak when wet.
- Flow can remove the straw causing it to block downstream drainage structures.
- Erosion typically occurs under the straw bale sediment trap and where straw bales are butted together.
- Due to the height of the straw bale sediment traps flows can be diverted out of shallow drains.
- The use of hay instead of straw can result in weed infestations.
- Bales are often stolen for fodder.

XIII. Geo-tubes and Geo-bags

Consists of a high-strength geo-textile filter fabric sausage or bag of low permeability. Dirty water is pumped in and settles within the bag, with cleaner water seeping out.

Application

- One of the better-known applications is in coastal protection, where the bags are filled with sand slurry, dewatered, and then placed on the seabed to form breakwaters and artificial reefs. They can also be used to construct artificial islands or to build up reclaimed land.
- However a use that is generating increasing interest, due to its simplicity and cost-effectiveness, is the dewatering and containment of sludge and contaminated material. Dewatering is a three-step process. In the confinement stage, the high strength bags are filled using pumps. Depending on the scale of the project, banks of bags and sophisticated pipe manifolds can be set up.
- In the dewatering phase, excess water simply drains through the fine pores of the tube (refer to the above photograph). Depending on the nature of the contained material the decanted water may be of a quality where it can be reused or returned to waterways without additional treatment. If not, the bags can be set up in lined basins that allow the water to be treated before release or re-use. As the water drains from the tubes, the contained volume decreases and it is possible to refill them several times until they remain full.
- In the final phase (consolidation), the solids continue to densify due to desiccation as residual water vapour escapes through the fabric (volume reduction can be as high as

65 per cent). The Geotube can be cut open and the solids recovered and hauled off for disposal. The bags can be buried in an impermeable lined landfill.

- One of the great advantages of Geotubes compared to traditional drying beds is the fact that once inside the Geotube, sludge will not get any wetter, even in periods of heavy rainfall. Geotubes can be laid out on existing drying beds and, because of their geometrics, much greater volumes per square metre can be placed on the bed, resulting in labour savings through fewer sludge removal events.

Problems

- Blowouts due to poor seem sealing.
- Erosion occurring when two geo-tubes are butted together.

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 soil conservation measurements? (3 pts)
2 Write soil physical conservation measurement ? (5 pts)
3 List down common soil conservation practices for cultivated land)? (5 pts)

Note: **Satisfactory rating – 9 points** **Unsatisfactory - below 9points**

Answer Sheet

Score = ___________
Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

1____

2.____

3.____

Operation Sheet 1	Conduct erosion and sediment control activities

Objectives: To conduct erosion and sediment control activities with different types of erosion and sediment control practices practically.

Procedures:

- Prepare checklist to note and report breaches (violations) of erosion and sediment control legislations
- Walk around the area of land; try to find out breaches (violations) of erosion and sediment control legislations
- As you walk around the area of land, try to outline and locate major breaches (violations) of erosion and sediment control legislations
- Prepare plan to identify major areas of erosion and to select suitable conservation measures following sequences in planning soil conservation
- Consider the essential steps to be followed in developing and implementing an ESCP
- Sketch the design, layout and construction of relevant groups and individual soil conservation measures on a piece of paper
- Make simple construction or prepare model representing each erosion and sediment control measures with clear identification of components
- As you perform construction activities, you are required to do all activities on the field using appropriate equipments
- Identify relevant issues connected with the design, lay out and construction of each erosion and sediment control measures

- Discuss and consult relevant and appropriate people about erosion and sediment control measures
- Report and present your result outcome

LAP Test	Practical Demonstration

Name: ______________________________ Date: ________________

Time started: ________________________ Time finished: ________________

Instructions:

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

   1.1. Request your trainer to arrange for you to conduct erosion and sediment control activities. Make sure you Conduct erosion and sediment control activities following the essential steps to be followed in developing and implementing an ESCP. Submit and illustrate your outputs to your trainer for evaluation

   1.2. Request a set of tools and equipment, then perform the following tasks in front of your trainer –

   - Identify erosion and sediment control structures/ measures/ practices
   - Identify components and functions each elements of erosion and sediment control structures/ measures/ practices
   - Carry out routine work with control measures and structures
   - Undertake activities in accordance with legislation/ community expectation and project specifications
   - Communicate ideas and information
   - Collect, analyze and organize information
   - Plan and organize erosion and sediment control activities on development sites
   - Work with others and in teams
   - Use line level for soil conservation following Operational procedures
     - ✓ Check the accuracy of spirit level
     - ✓ Measure the percentage slope
     - ✓ Mark out contour lines
     - ✓ Mark the VI

- ✓ Mark graded lines

- Conduct erosion and sediment control activities on development sites
- apply mathematical ideas and techniques to measurement and timing
- Solve technical and organizational problems while conducting erosion and sediment control activities on development sites

2. Request your trainer for evaluation and feedback