TVET CERTIFICATE V in FORESTRY

EROSION CONTROL IN FOREST

FOREC401

Apply Erosion Control Methods

Competence

Credits: 4

Learning hours: 120

Sector: Agriculture and food processing

Sub-sector: Forestry

Module Note Issue date: August, 2020

Purpose statement

Erosion is among different threats to decrease agricultural production. This module will develop skills and knowledge required to the learner of level 4 to control soil erosion. At the end of this module the learner will be able to identify erosion types, control measures, and establish stabilizers on soil erosion control structures, tools and equipment to be used under minimum supervision.

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LEARNING UNIT 1– IDENTIFY SOIL EROSION

Soil erosion is a natural process that removes soil from one location to another. It becomes a problem when human activity causes it to occur much faster than under natural conditions. There are two main categories of soil erosion based on their causal agent. The first one is normal or geologic erosion; It occurs under natural conditions without the intervention of man and it is a very slow process. The second one is Accelerated soil erosion. This is the most serious types of loss generally caused by an intervention of any agencies like man & animals and it is a rapid process

LO 1.1– Soil erosion types and its forms.

Content/Topic 1: Soil texture and structure

1. Soil texture

Soil texture is the proportion of the three sizes of soil particles that are present with the fineness or thickness of a soil. Based on their size, these particles are called sand, silt, or clay.

i. Sand: It is the largest of the mineral particles. Sand particles create large pore spaces that improve aeration. Water flows through the large pore spaces quickly. Soils with a high percentage of sand are generally well-drained. Sandy soils lack the ability to hold nutrients and are not fertile. Sandy soils also feel gritty to the touch.

ii. Silt: It is a mid-size soil particle. It has good water-holding ability and good fertility characteristics. Silt feels like flour when dry and smooth like velvet when moist.

iii. Clay: It is the smallest size soil particle. Clay has the ability to hold both nutrients and water that can be used by plants. It creates very small pore spaces, resulting in poor aeration and poor water drainage. Clay forms hard clumps when dry and is sticky when wet.

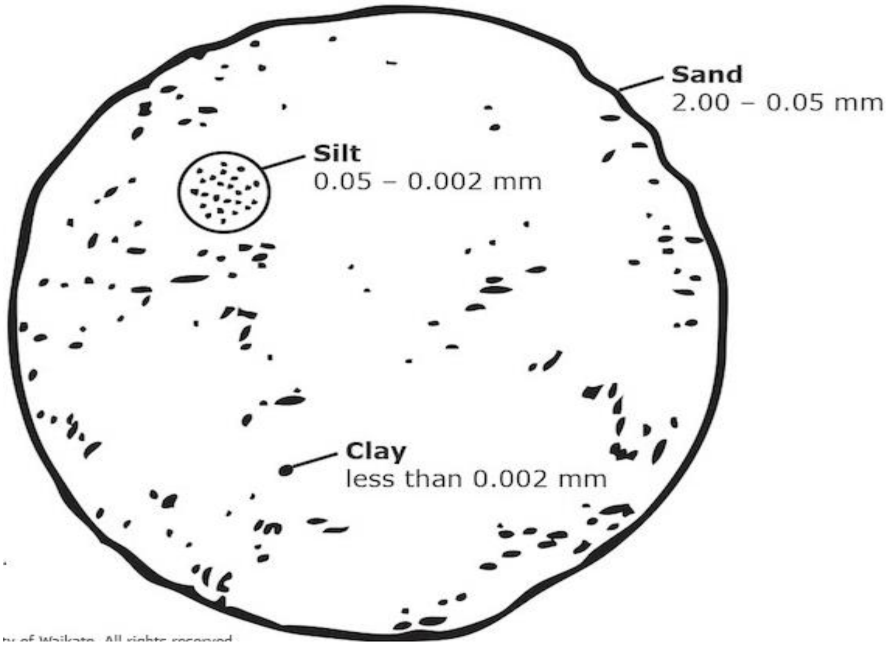


Figure 1: Relative size of Sand, slit and clay particles

The following table shows Characteristics of soil particles; Sand, Silt, and Clay

Characteristics	**Sand**	**Silt**	**Clay**
Looseness	Good	Fair	Poor
Air Space	Good	Fair to Good	Poor
Drainage	Good	Fair to Good	Poor
Tendency to Form Clods	Poor	Fair	Good
Ease of Working	Good	Fair to Good	Poor
Moisture-Holding Ability	Poor	Fair to Good	Good
Fertility	Good	Fair to Good	Fair to Good

Soil texture may be determined in one of two ways. The percentages of sand, silt, and clay may be tested in the lab. Once tested, the textural class of the soil can be determined by referring to the textural triangle (a device used to differentiate the several classes of soil). Soils with different amounts of sand, silt, and clay are given different names. For instance, a soil containing 40 percent sand, 20 percent clay, and 40 percent silt is called loam soil.

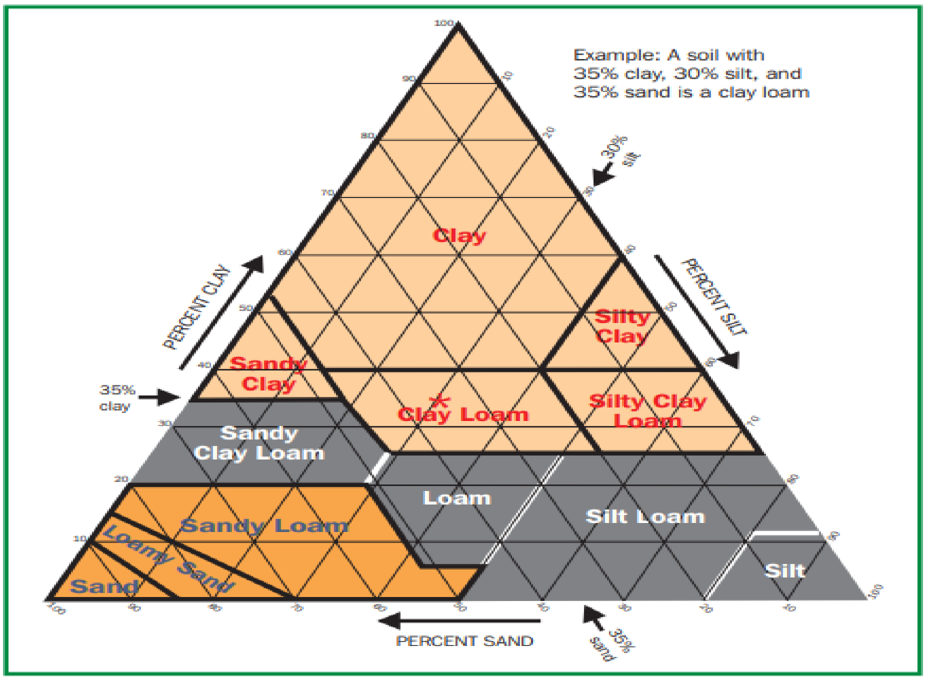


Figure 2: The textural triangle can be used to differentiate the several classes of soil

Soil characteristics related to texture

The texture of a soil is important because it determines soil characteristics that affect plant growth. A few of these characteristics are water-holding capacity, permeability, and soil workability.

i. Water-holding capacity: It is the ability of a soil to retain water. Most plants require a steady supply of water, and it is obtained from the soil. While plants need water, they also need air in the root zone.

ii. Permeability or Soil workability: It is the ease with which soil may be tilled and the timing of the work. It is ease with which air and water may pass through the soil. However, Soils with a larger percentage of sand are easier to work than soils with a larger percentage of clay.

2. Soil Structure

Sand, silt, clay, and organic matter particles in a soil combine with one another to form larger particles of various shapes and sizes and are often referred to as **aggregates**, or **clusters**. Soil structure is the arrangement of the soil particles into aggregates of various sizes and shapes. Aggregates that occur naturally in the soil are referred to as **peds**, while clumps of soil caused by tillage are called **clods**.

Soil structural categories

There are eight primary types of soil structure, including blocky, columnar, crumb, granular, massive, platy, prismatic, and single grain.

i. Blocky: The units are block-like. They consist of six or more flat or slightly rounded surfaces.

ii. Columnar: The units are similar to prisms and are bounded by flat or slightly rounded vertical faces. The tops of columns are very distinct and normally rounded.

iii. Crumb: The aggregates are small, porous, and weakly held together.

iv. Granular: The units are approximately spherical or polyhedral. The aggregates are small, non-porous, and held together strongly.

v. Massive: There is no apparent structure. Soil particles cling together in large uniform masses.

vi. Platy: The units are flat and plate-like. They are generally oriented horizontally. Plates overlap, usually causing slow permeability.

vii. Prismatic: The individual units are bounded by flat to rounded vertical faces. Units are distinctly longer vertically. The tops of the prisms are somewhat indistinct and normally flat.

viii. Single grain: There is no apparent structure. Soil particles exist as individuals and do not form aggregates.

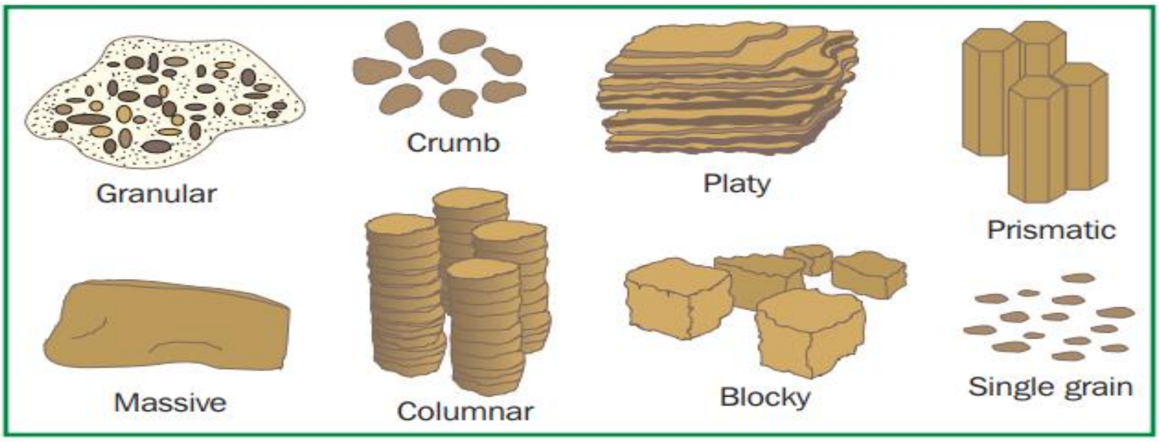


Figure 3: The eight different categories of soil structure

Content/Topic 2: Types of erosion

Based on the various agents that bring about soil erosion, there are two types of soil erosion in nature and these types are **water erosion** and **wind erosion**

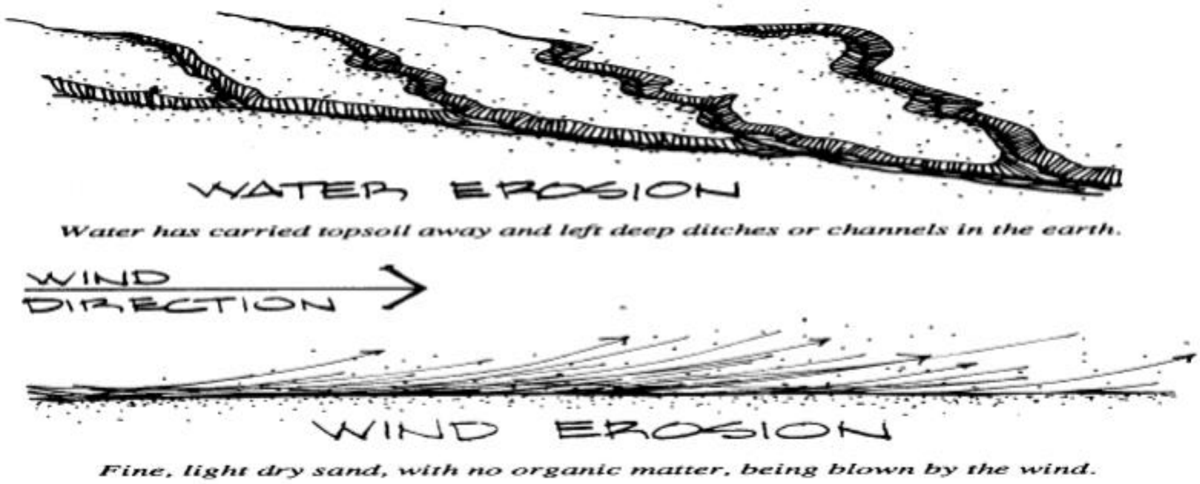


Figure 4: Illustration of water and wind erosion

1. Water erosion

It is caused by the action of rain water, which removes the soil by falling as rain drops as well as by its surface slope action

a. Phases of water erosion

1. Detachment: Individual grains separated from soil mass/matrix

2. Transportation: Detached grains transported over land surface land surface

3. Deposition: Soil grains deposited in new sites

b. Types of Water Erosion

1. splash: Is the first stage of the **erosion** process. It occurs when raindrops hit bare soil. The explosive impact breaks up soil aggregates so that individual soil particles are splashed onto the soil surface

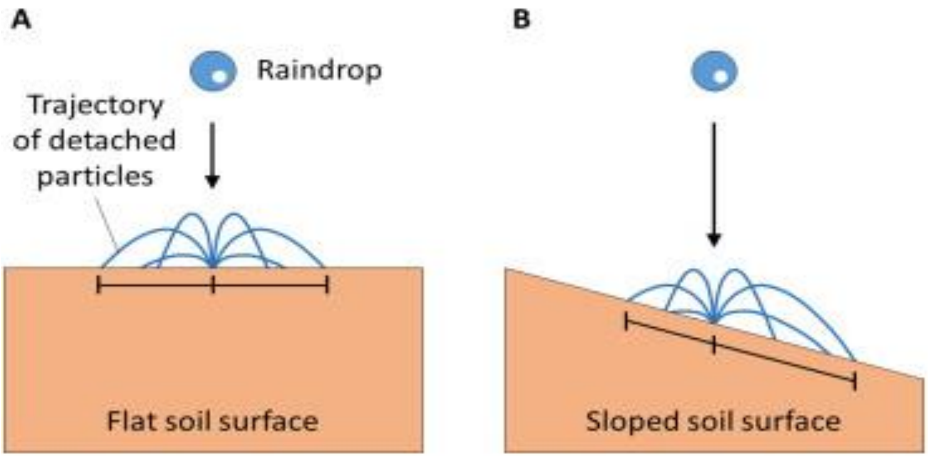


Figure 5: Splash erosion

2. **Sheet or interrill:** Removal of thin layer of soil over an entire soil surface caused by water flowing across soil surface. The soil removed in small but uniform amounts from all over and therefore, does not leave a mark behind.

Figure 6: Sheet erosion

3. **Rill Erosion:** occurs during/after rain or when snow melts, & involves concentration of flowing water into small channels

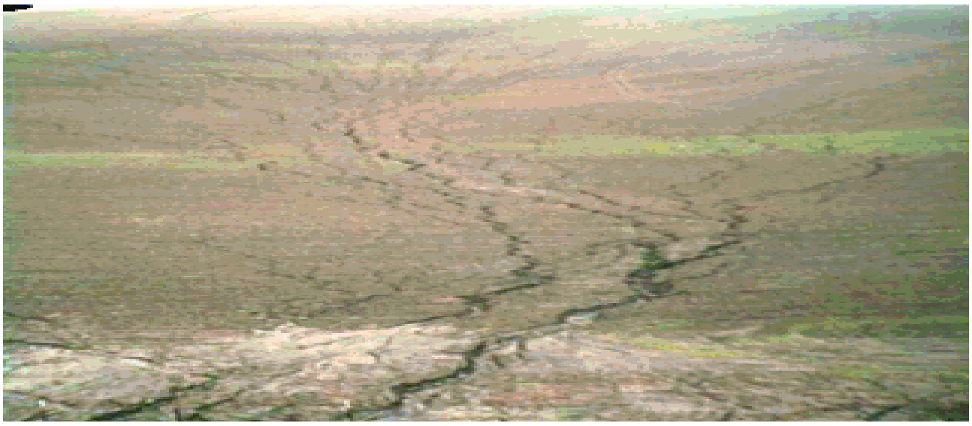


Figure 7: Rill Erosion

4. **Gully Erosion:** in areas steeper slopes, flow of water from rills concentrated, forming deep channels. Several rills converge towards the steep slopes & join to form board channels of water called gullies.

Figure 8: Gully erosion

5. **Landslide Erosion:**

A **landslide** is any geologic process in which gravity **causes** rock, soil, artificial fill or a combination of the three to move down a slope. Several things can trigger **landslides**, including the slow weathering of rocks as well as soil erosion, earthquakes and volcanic activity. A landslide occurs when part of a natural slope is unable to support its own weight.

Figure 9: Landslide

6. **Bank erosion:** Is the wearing away of the **banks** of a stream or river.

This is distinguished from **erosion** of the bed of the watercourse, which is referred to as scour. The roots of trees growing by a stream are undercut by such **erosion**. As the roots bind the soil tightly, they form abutments which jut out over the water.

Figure 10: Bank erosion

7. **Flooding Erosion:** A **flood occurs** when water floods land that's normally dry, which can **happen in** a multitude of ways. Excessive rain, a ruptured dam or earthwork, rapid melting of snow or ice, or even an unfortunately placed work dam can beat a river, spreading over the adjacent land, called a floodplain.

Figure 11: Flooding Erosion

Deforestation plays several roles in the **flooding** because trees prevent sediment runoff and forests hold and use more water than farms or grasslands. Some rainwater stays on the leaves, and it may evaporate directly **to** the air (the more water used in the watershed, the less remains **to** run off).

2. Wind erosion

Wind erosion is the process of detachment, transportation and deposition of soil particles by the action of wind. It occurs in all parts of the world and is a cause of serious soil deterioration. Soil erosion by wind is common in dry regions where soil is chiefly sandy & vegetation is very poor or even absent. Wind erosion also triggered by the destruction of natural vegetation cover of land

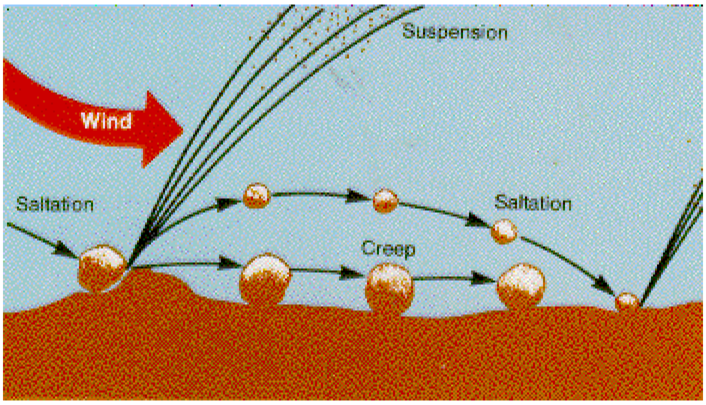


Figure 12: Wind erosion

1. Suspension:

Saltation occurs when very fine dirt and dust particles are lifted into the wind. They can be thrown into the air through impact with other particles or by the wind itself. This process involves fine dirt and dust that are less than 0.1mm in diameter. Wind is able to carry these particles over very long distance. It is probably the most common form of wind action and also the easiest to recognize

2. Saltation:

In a saltation process, the particles involved are between 0.1mm to 0.5mm. The wind is able to lift them up briefly but drops them in very short interval. This results in a hop and bounce motion over the surface. Some times as the particles fall, they bounce back up and continue the routine.

3. Soil creep:

Creping or surface creep is when soil particles larger than 0.5 mm in diameter are dragged over the surface of the land because they are too heavy for the wind to lift up. As the particles roll and move along the surface, they knock into other.

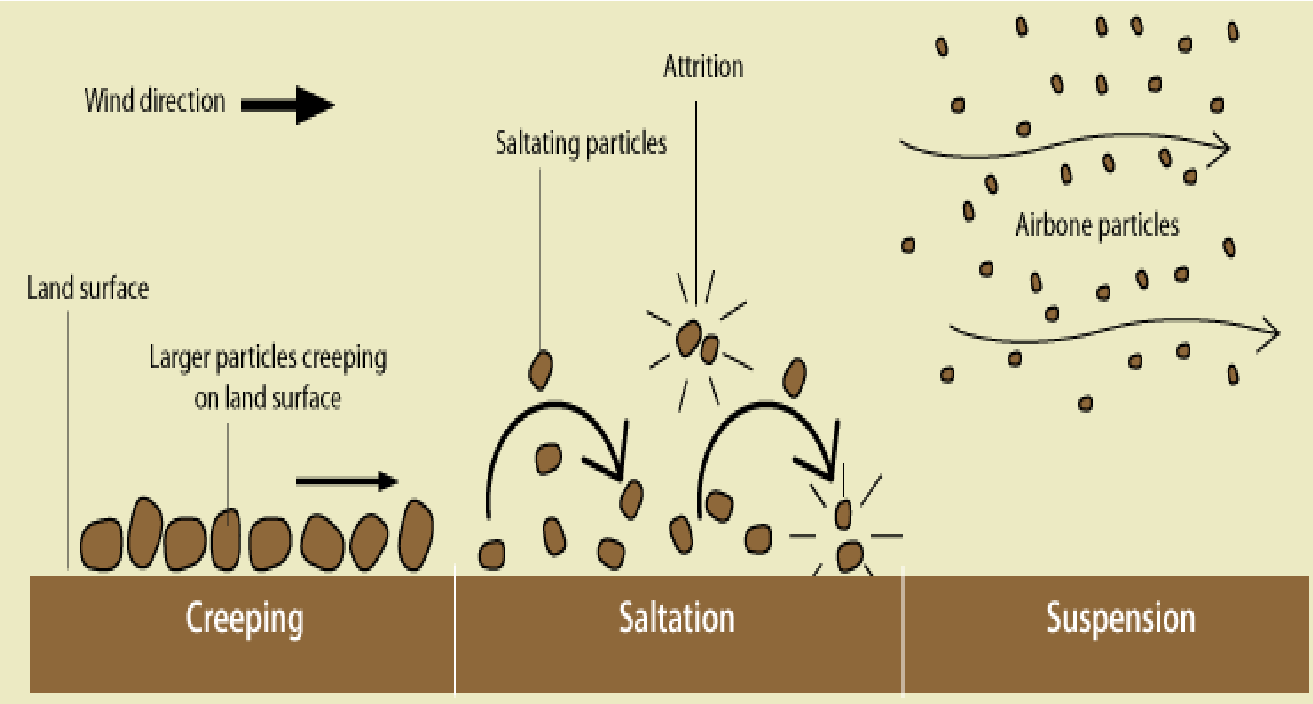


Figure 13: Wind erosion occurs in three processes known as creeping, saltation and suspension

Wind erosion It is a common phenomenon occurring mostly in flat, bare areas; dry, sandy soils; or anywhere the soil is loose, dry, and finely granulated. Wind erosion damages land and natural vegetation by removing soil from one place and depositing it in another. It causes soil loss, dryness and deterioration of soil structure, **nutrient and productivity losses** and **air pollution**.

Topic 3: Types of erosion found in Rwanda

In Rwanda like in other countries in the world there are two types of erosion based on agents that bring about soil erosion which are wind and water. Four types of soil erosion that are commonly found in Rwanda are; **Sheet erosion, Rill erosion, Gully erosion and Splash erosion**

LO 1.2 – Identification of erosion causes

Soil erosion is one form of soil degradation along with soil compaction, low organic matter, loss of soil structure, poor internal drainage, salinization, and soil acidity problems. These other forms of soil degradation, serious in themselves, usually contribute to accelerated soil erosion. The are two main causes of erosion. The first one is **Natural causes** include Rainfall, Wind and tectonic movement(earthquake). The second one is **Artificial causes** or human activities include deforestation, overgrazing and cropping practices Poor land management. In addition, Factors influencing soil erosion, slope and vegetation cover soil nature (soil texture and structure).

Content/Topic 1: Natural causes

1. Rainfall

Rainfall and Runoff The greater the intensity and duration of a rainstorm, the higher the erosion potential. The impact of raindrops on the soil surface can break down soil aggregates and disperse the aggregate material. Lighter aggregate materials such as very fine sand, silt, clay and organic matter are easily removed by the raindrop splash and runoff water. Soil movement by rainfall (raindrop splash) is usually greatest and most noticeable during short-duration, high-intensity thunderstorms. Surface water runoff occurs whenever there is excess water on a slope that cannot be absorbed into the soil. Reduced infiltration due to soil compaction, crusting or freezing increases the surface runoff and soil erosion. Runoff from agricultural land is greatest when compared with other land areas

2. Wind

Wind erosion is the detachment and transportation of soil particles by wind when the airstream passing over a surface generates sufficient lift and drag to overcome the forces of gravity, friction and cohesion.

Once a particle has been removed from the surface, it may be transported in suspension, by saltation or by surface creep. Loss of topsoil by wind erosion over a relatively short time period can significantly decrease soil fertility and crop yield. The rate and magnitude of soil erosion by wind is controlled by the following factors:

- ✓ Soil Erodibility
- ✓ Soil Surface Roughness
- ✓ Climate (wind patterns, precipitation, frost action)
- ✓ Unsheltered Distance
- ✓ Vegetative Cover
- ✓ Topography (exposure, elevation, terrain roughness, localised funnelling of wind)
- ✓ Cultural practices (cultivation, vegetation depletion).

3. Tectonic movement(earthquake)

It is mechanical movement of the earth’s crust caused by forces that act in the crust and, primarily, mantle.

Tectonic movements result in the deformation of the rocks making up the crust and are usually ass ociated with a change in the chemical composition, phase state (mineral composition), and internal structure of the rocks subjected to deformation.

Content/Topic 2: Artificial causes/ Human activities:

1. Deforestation

Deforestation is the clearing of trees, transforming a wooded area into cleared land. Trees prevent **soil erosion** and play a pivotal role in the water cycle by absorbing water in the ground and returning water vapor back to the atmosphere. If trees are removed, the area can become much warmer and drier, which may result in **desertification**, which is a transformation of once fertile land into desert.

Trees and plants act as a natural barrier to slow water as it runs off the land. Roots bind the soil and prevent it from washing away. The absence of vegetation causes the topsoil to erode more quickly.

Figure 14: Deforestation as source of erosion

However, Deforestation causes soil erosion. Because the roots of trees hold soil tightly and prevent the soil from erosion. If we cut trees the roots leave the soil and so that the soil will erode. When forest is cut down, nothing is there to protect the soil. Once the forests are cut down, the erosive effects are much worse than on flat land. Erosion and rainfall in such places can cause huge mudslides. This can cause serious land degradation. Loss of trees and other vegetation may cause soil erosion

2. Overgrazing

Overgrazing typically increases **soil erosion**. Reduction in **soil** depth, **soil** organic matter and **soil** fertility impair the land's future natural and agricultural productivity.

Figure 15: Influence of overgrazing on soil erosion

Continued overgrazing reduces inputs of soil organic matter because less plant biomass is available as litter, which in turn reduces soil organic matter, nutrients, and biotic activity. This leads to deteriorated soil structure, which increases the potential for erosion and reduces water-holding capacity of soil.

3. Cropping practices and poor land management

Farming is probably the most significant activity that accelerates **soil erosion** because of the amount of land that is farmed and how much **farming** practices disturb the ground. Farmers remove native vegetation and then plow the land to plant new seeds.

Figure 16: Soil erosion from poor cropping practices

Because most crops grow only in spring and summer, the land lies fallow during the winter. Of course, winter is also the stormy season in many locations, so wind and rain are available to wash soil away. Tractor tires make deep grooves, which are natural pathways for water. Fine soil is blown away by wind.

Content /Topic 3: Factors influencing soil erosion

Both natural and human caused factors **affect** the amount of **erosion** a stream may experience. Natural factors include the **gradient** (or steepness) of the streambed since that **affects** the speed of the flow of water. Rainfall and snowmelt **affect** the amount of water in a stream as well as the speed of the flow. However, the main factors influencing soil erosion are slope and vegetation cover soil nature (soil texture and structure)

1. Slope

As the **slope** increases, the type of **erosion** changes, shaping the ground into different shapes and thereby increasing the surface area - and hence the number of pores that can absorb water, at least in the initial phase.

Figure 17: Soil erosion influenced by steep slope

The steeper the slope, the more soil is carried away by running water. The erosion of soil caused by running water depends on the slope of the land and the amount of rainfall. Erosion by wind and water carries away broken particles of rocks and soil until the mountain become level lands or plains.

Slope angle and length affects runoff generated when rain falls to the surface. The amount of water on a particular hill slope segment is dependent on what falls from precipitation and what runs into it from an upslope hill slope segment.

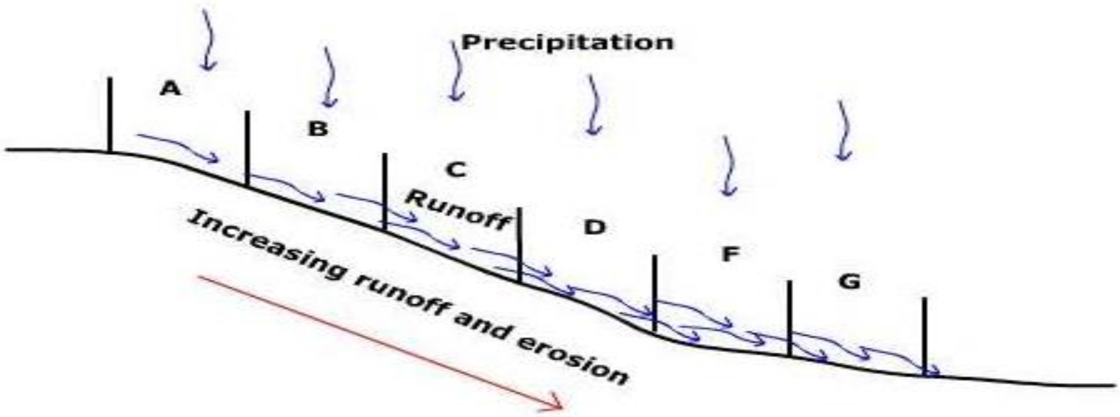


Figure 18: Hill slope position, runoff & erosion

As water runs down slope, the water that has accumulated in segment **A** runs off adding to what falls into segment **B** by precipitation. The water in **B** runs into **C**, and **C** into **D**, and so on. The amount of water increases in the down slope direction as water is contributed of water from upslope segments.

2. **Vegetation cover**

Vegetation type has also been demonstrated to be an important factor that impacts runoff and sediment yields on a slope. A covering of vegetation on the soil surface increases the soil surface roughness and acts as successive barriers that impede surface runoff and increase the infiltration time.

Figure 19: Erosion influenced by plants with short roots

The potential for soil erosion increases if the soil has no or very little vegetative cover of plants and/or crop residues. Plant and residue cover protects the soil from raindrop impact and splash, tends to slow down the movement of runoff water and allows excess surface water to infiltrate.

LO 1.3 – Identification of erosion effects

The effects of soil erosion go beyond the loss of fertile land. It has led to increased pollution and sedimentation in streams and rivers, clogging these waterways and causing declines in fish and other species. And degraded lands are also often less able to hold onto water, which can worsen flooding.

Content/Topic 1: Soil loss

The effects of soil erosion go beyond the loss of fertile land loss of soil structure, nutrient degradation, and soil salinity.

Figure 20: Soil loss form erosion

It results in the progressive down-slope movement of soil, causing severe soil loss on upper slope positions and accumulation in lower-slope positions. This form of erosion is a major delivery mechanism for water erosion. Tillage action moves soil to convergent areas of a field where surface water runoff concentrates

C0ontent/Topic 2: Water sedimentation

Sedimentation occurs when eroded material that is being transported by water, settles out of the water column onto the surface, as the water flow slows. The sediments that form a waterway's bed, banks and floodplain have been transported from higher in the catchment and deposited there by the flow of water.

Figure 21: Erosion and sedimentation

The sediments that form a waterway's bed, banks and valley have been transported from higher in the catchment and deposited there by the flow of water.

Content /Topic 3: Fertility decrease

Soil fertility decline occurs when the quantities of nutrients removed from the soil in harvested products exceed the quantities of nutrients being applied.

Figure 22: Loss of soil fertility from soil erosion

Loosing topsoil to erosion contributes to a loss of inherent soil fertility levels of some essential soil elements. Some of them are nitrogen, phosphorus, potassium, and thus to a decline in potential crop yield. The addition of manure and fertilizer can supply needed crop nutrients and help offset some loss of essential fertility caused by soil erosion. In addition, preventing soil erosion means preserving inherent soil fertility and minimizing fertilizer and management inputs.

Content /Topic 4: Flora and fauna

Biodiversity loss is the extinction of species (plant or animal) worldwide, and also the local reduction or loss of species in a certain habitat.

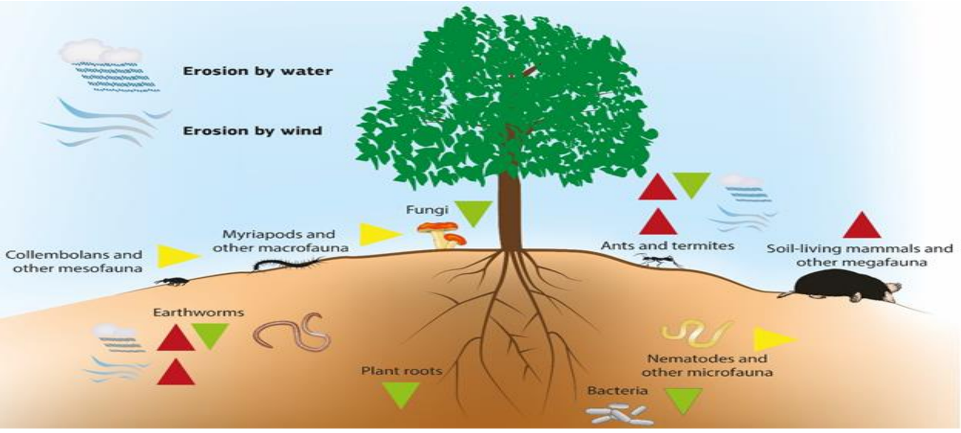


Figure 23: Loss of fauna and flora by erosion

Soil erosion can lead to the soil running off into waterways, which increases the sedimentation of the water, and makes aquatic ecosystems inhospitable for those organisms that require clearer waters for their habitat.

The relationship between soil erosion and biodiversity is extremely complicated. Erosion is widely recognized as one of the main threats to soil. Given this, soil loss surely has an impact on the organisms populating this ecosystem. At the same time, the massive variety of species living in the soil influences both its aggregate stability and water infiltration through their moving and feeding activities. Large-scale assessments of both soil erosion and biodiversity distribution are currently available.

Content /Topic 5: Economic effect

Soil erosion is not only an environmental issue; it also causes huge losses to the economy. Therefore, different economic activities can be destroyed by erosion. Some of them are land degradation, forest cover loss, infrastructure loss, water pollution, etc.

Content /Topic 6: Low production and productivity

Erosion can decrease rooting depth, soil fertility, organic matter in the soil and plant-available water reserves (Lal, 1987). Accelerated erosion affects productivity both directly and indirectly. Directly, the erosion induced reduction in crop yields is attributed to loss of rooting depth, degradation of soil structure, decrease in plant-available water reserves, reduction in organic matter, and nutrient imbalance.

Figure 24: Low production from erosion

Depending on soil properties and the degree of degradation, adverse effects of erosion on crop yields can be mostly compensated for by additional inputs of macronutrients (N, P, K) and macronutrients plus organic matter, by supplemental applications of some micronutrients, and by irrigation.

LEARNING UNIT 2– SELECT TOOLS AND EQUIPMENT

LO 2.1 – Identify tools and equipment

Content/Topic 1: Types of tools and equipment

1. Damping level

Dumpy level is commonly used leveling instrument to locate the points in same horizontal plane. It is also called as automatic level or builder's level. Elevations of different points and distance between the points of same elevation can be determined by dumpy level.

Figure 25: Main parts of Damp level

Components of Dumpy Level

Dumpy level consists the different parts or components most of them are; Telescope, Bubble tubes, Compass, Vertical spindle, Tribrach screws, Foot screws, Leveling head, Tripod

Benefits of Dumpy Level Surveying

- ✓ Dumpy level is easy to use.
- ✓ Adjustments can be made as per the requirement on any type of ground.
- ✓ Level readings are very accurate in case of dumpy level.
- ✓ Optical power is high for dumpy level.
- ✓ Price of dumpy level is cheap when compared to other instruments.

Drawbacks of Dumpy Level Surveying

- ✓ It is limited to only horizontal angle measurement.
- ✓ The angles obtained by dumpy are not accurate.

2. **Theodolite**

A surveying and precision instrument for measuring angles in the horizontal and vertical planes. It is a very important instrument in plane surveying.

Figure 26: Parts of theodolite

Use of theodolite;

- ✓ Mapping applications and in the construction industry
- ✓ Measurement of Horizontal and vertical angle
- ✓ Measurement of magnetic bearing of lines
- ✓ Locating points on line
- ✓ Prolonging survey lines
- ✓ Determining difference in elevation
- ✓ Setting out curves
- ✓ Mining works etc.

3. **Clinometers**

Clinometer is an instrument used for measuring angles of slope elevation, or depression of an object with respect to gravity's direction. One way to measure slope angle with reference to the earth's ground plane, is to use an accelerometer.

Figure 27: Suunto clinometer

It is used to find the angle for calculating tree heights. It is also used to determine obstacles at an Atmosphere Study Site. The calculations work by applying the principles based on the properties of right triangles. You construct and use the clinometer by following the directions and using the formula below. The clinometer also lends itself for additional hands-on teaching exercises of trigonometric principles.

4. Measuring Tape

Measuring tapes are important tools in many industries and professions. However, despite being a common tool in workplaces and workshops, the measuring tape is often a confusing and difficult tool to use. Using a measuring tape requires a combination of numeracy skills and practical knowledge of the tool, which develops from experience. Older learners are often uncomfortable admitting their lack of experience and difficulty using the measuring tape

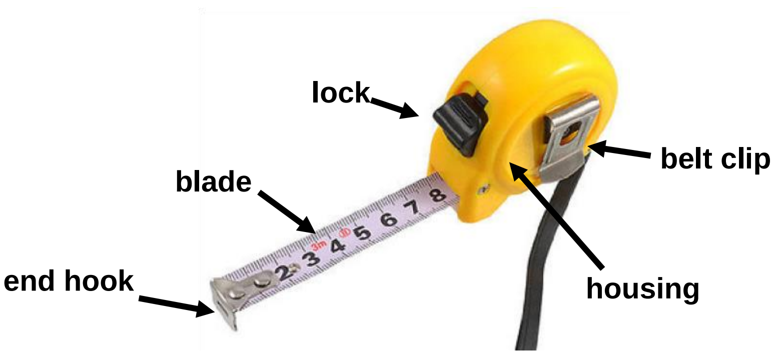


Figure 28: Parts of a measuring tape

Identify parts of the measuring tape If the majority of learners are unfamiliar with measuring tapes it may be worthwhile discussing the specific names of the component parts. Main parts of tape measure are; end hook, belt clip, housing, blade and lock.

5. **Survey pegs** or **survey** stakes are **used** during land surveys to mark points and boundaries on a landscape or construction site. They are **used** by builders, contractors, landscapers, gardeners etc.

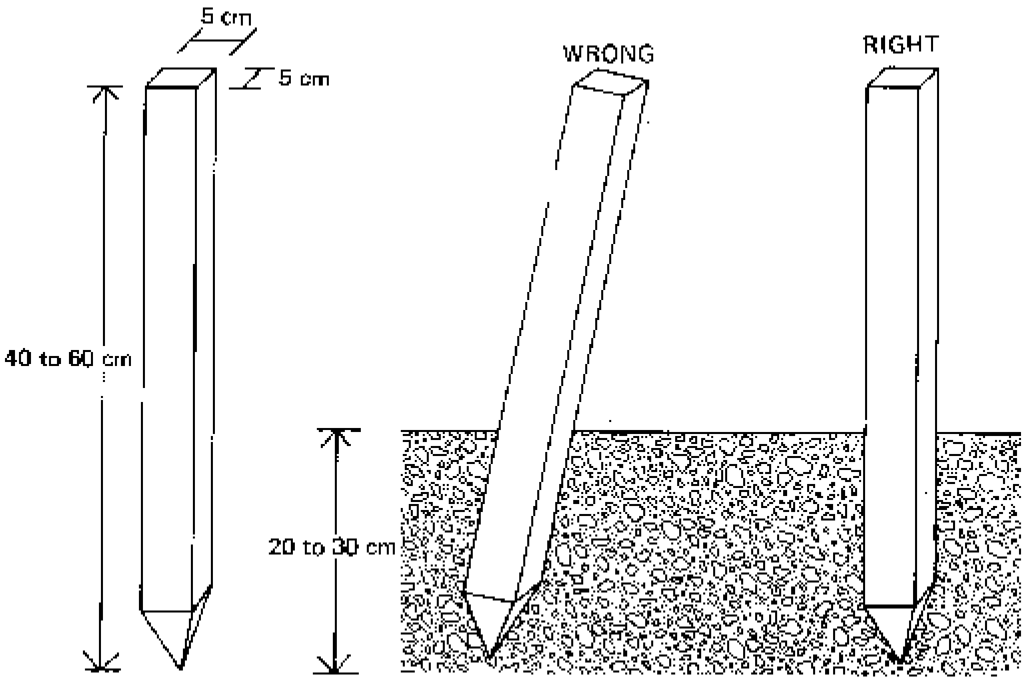


Figure 29: Surveying stakes used in site measurement

6. Rods

Rod is a surveying instrument used for marking the position of stations, and for sightings of those stations, as well as for ranging straight lines.

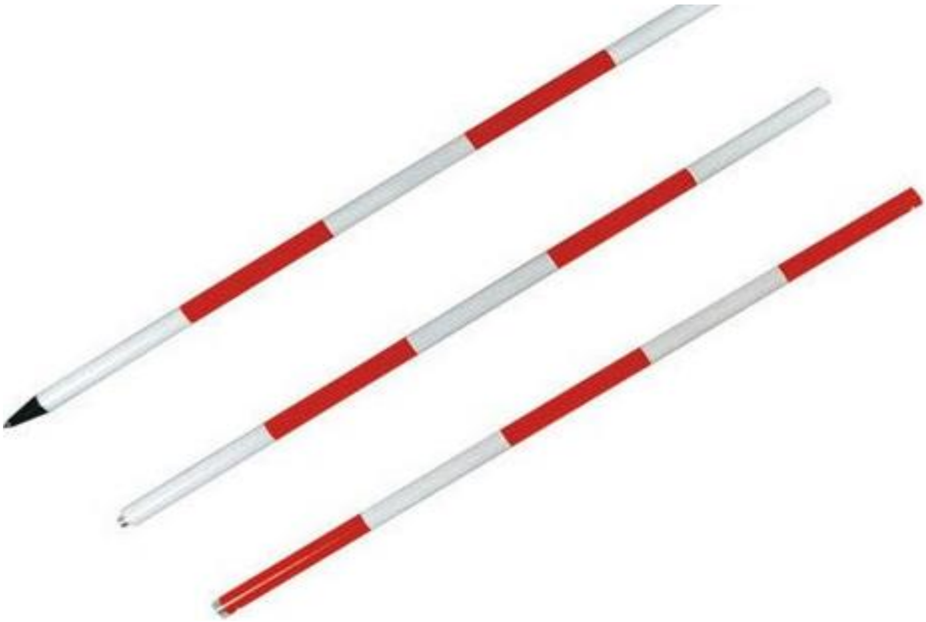


Figure 30: Surveying rods

7. N-Frame level

The N-frame level is used to set out contour lines and slopes on the field.

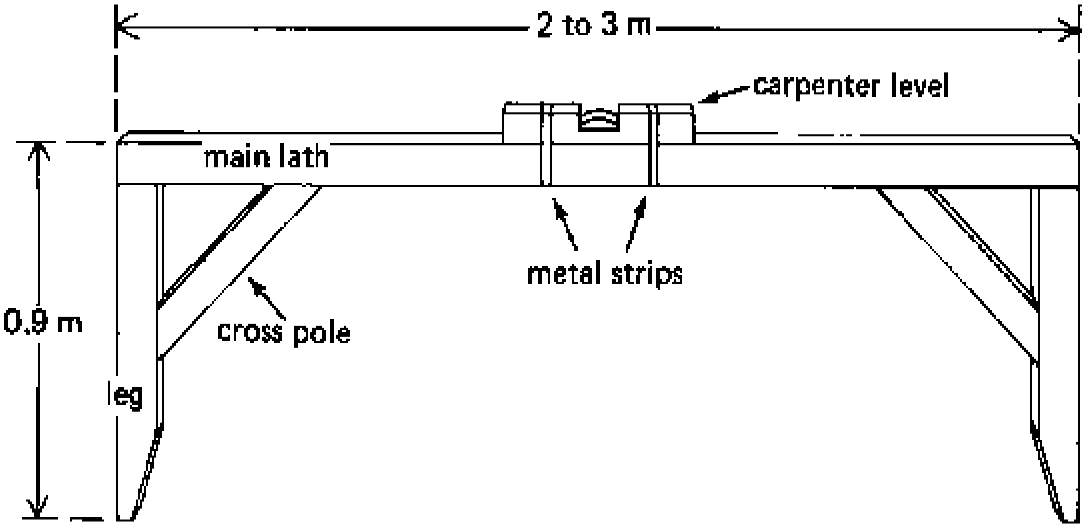


Figure 31: N-Frame level

8. A level

A **level** is an optical instrument used to establish or verify points in the same horizontal plane in a process known as levelling, and is used in conjunction with a levelling staff to establish the relative heights levels of objects or marks. It is widely used in surveying and construction to measure height differences and to transfer, measure, and set heights of known objects or marks. For ordinary levelling, level surfaces at different elevations can be considered to be parallel. Level lining is an important factor when planning for storm water drainage is knowing the rise or fall of the allotment that you are preparing for. This will allow to calculate the heights or depths of drains and excavations to enable the flow of storm water to the legal drainage outlets.

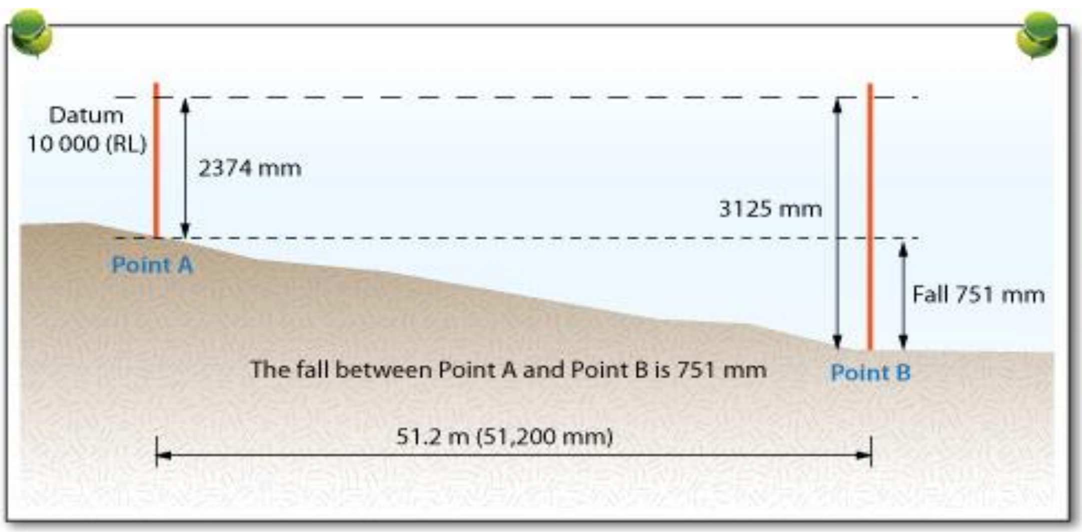


Figure 32: Measuring elevation between two different points

Content/Topic 2: Classification of tools and equipment

Erosion control tools and equipment are classified into two categories. These categories are optic and mechanical

1. Optical tools/ Equipment

An optical instrument (or "optic" for short) is a device that either processes light waves (or photons) to enhance an image for viewing, or to analyze and determine their characteristic properties. Different lenses refract light in different ways and form images useful for a variety of purposes. Like mirrors, lenses can be convex or concave. A convex lens is curved outward; a concave lens is curved inward.

Figure 33: Optical tools/ camera, theodolite, telescope and compass

The main **surveying** instruments in use around the world are the theodolite, measuring tape, total station, GPS level, rod, Compasses and Clinometer. Most instruments screw onto a tripod when in use. Tape measures are often **used** for measurement of smaller distances.

2. Mechanical tools and equipment

Mechanical tools and equipment used in erosion control and slope measurement are like

An **inclinometer** used for measuring angles of slope (or tilt), elevation, or depression, N-flame, Rods, pegs, Military model and Compass with inclinometer, etc.

Figure 34: Mechanical tools (Blériot Monoplane Inclinometer, Military model and Compass with inclinometer)

Content /Topic3: Estimation of tools and equipment

Estimation is the process of predicting tools and equipment used to assess and control soil erosion. Tools and equipments are estimated based on **erosion factors** like; climatic, hydrological, topographic, soil, geological and vegetation conditions, as well as the economic and technical and the socioeconomic conditions of the human society. causes of erosion, amount of damage, location

LO 2.2 – Check tools and equipment

Content/Topic 1: Adjustments

Adjustment is a small alteration or movement made to achieve a desired fit, appearance, or result. By taking an example of theodolites adjustments, they are made to establish fixed relationship between the instrument's fundamental lines. The fundamental lines or axis of a transit theodolite include the following:

- Vertical axis
- Axis of plate levels
- Axis of telescope
- Line of collimation
- Horizontal axis
- Axis of altitude bubble and the Vernier should read zero.

These adjustments once made last for a long time. These are important for accuracy of observations taken from the instrument. The permanent adjustments in case of transit theodolite are:

Horizontal axis adjustment: The horizontal axis must be perpendicular to the vertical axis.

Vertical circle index adjustment: The vertical circle must read zero when the line of collimation is horizontal.

Figure 35: Adjustments of theodolite

Adjustment of altitude level: The axis of altitude level must be parallel to the line of collimation.

Collimation adjustment: The line of collimation or line of sight should coincide with axis of the telescope. The line of sight should also be perpendicular to the horizontal axis at its intersection with the vertical axis. Also, the optical axis, the axis of the objective slide, and the line of sight should coincide.

Adjustment of horizontal plate levels: The axis of plate levels must be perpendicular to the vertical axis.

Content/Topic 2: Fixation

The initial setting operation includes fixing the theodolite on a tripod, along with approximate levelling and centering over the station mark. For setting up the instrument, the tripod is placed over the station with its legs widely spread so that the center of the tripod head lies above the station point and its head approximately level (by eye estimation). The instrument is then fixed with the tripod by screwing through the trivet.

Figure 36: Fixation of theodolite

The height of the instrument should be such that observer can see through telescope conveniently. After this, a plumb bob is suspended from the bottom of the instrument and it should approximately align with the station mark.

Content /Topic3: Oiling

Oiling is an action of putting oil on something, especially a machine, usually to make it work more easily without sticking

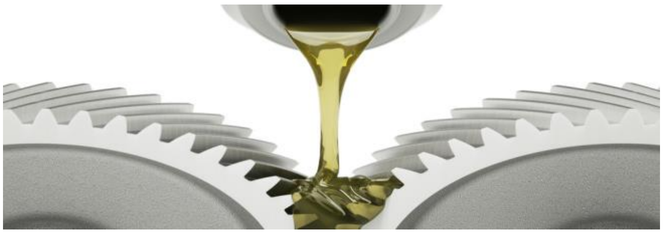


Figure 37: Oiling of machine

Oiling has different advantages including;

- ✓ Long-term protection of equipment
- ✓ Increased mechanical reliability
- ✓ Accurate lubrication
- ✓ Reduced maintenance costs
- ✓ Increased profitability
- ✓ The right lubricant volume per point

LO 2.3 – Use and maintain tools and equipment

An effective use of tools and equipments involves the following procedures:

- ✓ Positioning
- ✓ Measurements
- ✓ Recording data
- ✓ Cleaning and maintenance after using

Content/Topic 1: Positioning

The basic idea is to position the instrument so that its line of sight is collinear with the desired centerline. Tool or equipment like theodolite is typically mounted on a rugged steel stand, set up so it is level and pointed north, with the altitude and azimuth scales reading zero degrees. A balloon is released in front of the theodolite, and its position is precisely tracked, usually once a minute. Positioning of theodolite has an advantage of indicating the orientation of the telescope, and are used to relate the first point sighted through the telescope to subsequent sightings of other points from the same theodolite position.

Content/Topic 2: Measurements

There are four fundamental ways to measure erosion: change in weight, change in surface elevation, change in channel cross section and sediment collection from erosion plots and watersheds.

Reasons for erosion measurements are:

- ✓ To determine the environmental impact of erosion and conservation practices,
- ✓ Scientific erosion research
- ✓ Development and evaluation of erosion control technology
- ✓ Development of erosion prediction technology and
- ✓ Allocation of conservation resources and development of conservation regulations, policies and programs.

Content/Topic 3: Recording data

The general purpose of data recording is to set in writing and assure the preservation of the data collected eroded site or location. In erosion, quantitative data (number of death, tones of soil transported, hectares of forest destroyed, etc) and qualitative data (extent at which a given site is eroded; low, medium or high) should be collected. There are two types of erosion data recording technics

1. An electronic record is information recorded by a computer that is produced or received as soft copy. Examples of electronic records include: e-mail messages, word- processed documents, electronic spreadsheets, digital images and databases.

2. A manual record a bookkeeping system where records are maintained by hand, without using a computer system. Instead, transactions are written in journals, from which the information is manually rolled up into a set of financial statements.

Content /Topic3: Cleaning and maintenance after using

Cleaning is the process of removing unwanted substances, such as dirt, infectious agents, and other impurities, from an object or environment. Cleaning occurs in many different contexts, and uses many different methods. maintenance involves functional checks, servicing, repairing or replacing of necessary devices, equipment and machinery.

Genera and routine care of survey equipment consists of;

- ✓ Keeping equipment as clean and dry as possible
- ✓ Always inspect equipment for cracks or dents
- ✓ Clean equipment as frequently as possible
- ✓ Cover your equipment when it is being left for long periods of time

LEARNING UNIT 3 – APPLY EROSION CONTROL METHODS

Erosion control measures that are natural or organic based are efforts to protect the earth's surface through materials that come from the earth.

LO 3.1 – Identification of erosion control methods

Erosion control involves two methods, agronomic/biological and mechanical/physical control methods

Content/Topic 1: Agronomic/biological control methods

In this, erosion is controlled through crops or vegetation - that is by nature's way of doing things. It means that cultivation should be done in suitable way by adopting measures, which shall minimize erosion. Improper cultivation leads to severe soil erosion. A permanent vegetative cover is the best protection for soil. Studies indicated that bare ground allows four times more soil erosion compared to permanent plant covered ground. Therefore, vegetation plays an important role in controlling soil erosion and can be used as effective erosion control measure. In this method we try to plant such species, which are capable of holding soil strongly and can survive in very adverse soil condition. The main principle of biological control is to prevent high velocity of water and conserve water within the soil. In biological control following method can be adopted.

Content/Topic 2: Mechanical/physical methods

Mechanical practices are engineering measures used to control soil erosion from sloping land surface. The purpose of constructing the mechanical structures is to increase the time of stay of runoff water to increase the infiltration time for the water and to break the land slope, thus reducing the velocity of the runoff water.

Mechanical soil conservation strategies are important management practices for crop production. These strategies use methodologies that include the use of bunds, terraces, waterways / drainage channels, and other structures, for example vegetative barriers, or stone / rock lines. Mechanical practices of soil conservation include various engineering techniques and structures which are adopted to supplement the biological methods when the latter alone not sufficiently effective. These practices aim at the following objectives:

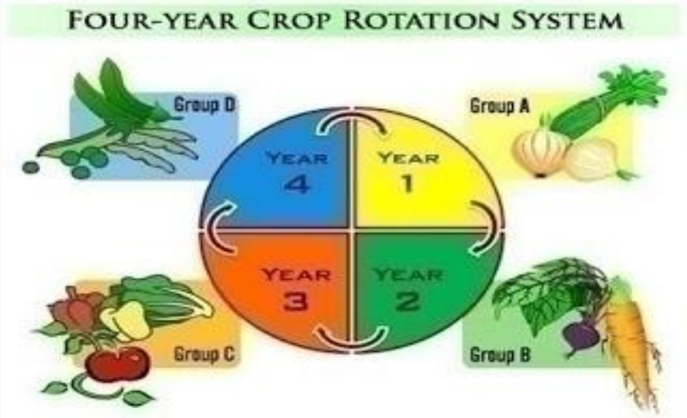
- To reduce the velocity of runoff water and to retain it for long period so as to allow maximum water to be absorbed and held in soil.
- To advice a long slope into several small parts so as to reduce the velocity of runoff water to the minimum
- Protection against erosion by wind and water

LO 3.2 – Application of agronomic/biological control methods

Content/Topic: Agronomic methods

1. Crop rotation principles

It may be defined as a more or less regular succession of different crops being grown on the same piece of land.



Rotation of crop reduces erosion and increases the fertility of soil by different crops being grown on the same patch of land so as to enable intake of plant food from different layers of soil. In addition, crop rotation increases crop yield and net profit while it reduces use of chemicals as well as water pollution. For example, leguminous crops like pulses are grown alternately with wheat, barley or mustard. Fig. 3.3 shows typical layout for crop rotation system.

2. Buffer strip (strip cropping, grasses) principles

It is the practice of growing alternate strips of row crops and inter-tilled crops in the same field. In this, the crops are grown in strips at right angles to the slope of land. Erosion is largely limited to row - crop strips and soil removed from these is trapped in the next strip, which is generally planted with a leguminous or grass crop.

Figure 38: Strip cropping (buffer strip cropping and contour strip cropping)

Strip cropping reduces soil erosion due to both water and wind erosions, and water borne contamination. Strip cropping is generally of three types, namely, contour strip cropping, field strip cropping and buffer strip cropping.

3. Contour cultivation practices

Contouring refers to applying all tillage practices, such as, ploughing, planting, cultivation & harvesting on the contour i.e. across the slope rather than up and downhill. In regions of low rainfall, this helps in conservation of moisture and in humid areas reduces erosion by reducing surface runoff.

Figure 39: Contour farming

The furrows between the ridges developed by contour tillage operations catch and hold the water, thereby, checking the high water velocity, which erodes soil and causes sheet, rill or gully erosion. On steep slopes or under conditions of high rainfall intensity and soil Erodibility, contour farming alone will increase gullying because row breaks may release stored water. Under such conditions they are supplemented by strip cropping.

4. Agroforestry practices (Wind breaks, Cover crops establishment (appropriate species))

Cover crops are grown as a conservation measure either during off-season or for ground protection under trees. These also add organic matter to soil. All these provide good cover from erosion control point of view and at the same time furnish hay or fodder and serve as soil building crops.

Figure 40: Agroforestry practices with cover crops establishment

These cover crops are also grown under trees to protect the soil from the impact of water drops falling from the canopy particularly important for tall trees like rubber where height of fall is more

5. Afforestation/reforestation

Reforestation refers to planting trees on land that was previously forest whereas **afforestation** refers to planting trees on patches of land which were not previously covered in forest.

Figure 41: Afforestation/ reforestation

Afforestation prevents soil erosion because trees grow very large, very strong roots that take hold in soil and prevent it from washing away

6. Mulching practices

Mulching is the covering of the soil with crop residues such as straw, maize, stalks etc. These cover protects the soil from the rain drop impact and reduces the velocity of runoff and wind. It is also useful as an alternative to cover crop in dry areas where a cover crop should compete for moisture with the main crop.

Figure 42: Mulching practices

7. Conservation tillage practices

Conservation tillage is any method of soil cultivation that leaves previous crops residue on field before and after planting the next crop. It decreases soil erosion, runoff, water pollution, CO_2 emission and also fossil fuel.

Figure 43: Conservation tillage

Conservation tillage methods include **no-till**, **strip-till**, **ridge-till** and **mulch-till**. **No-till** involves planting crops directly into residue that has been not at all, whereas in strip-till narrow strips are tilled and the rest of the field left untilled (strip-till). In Ridge-till row crops are planted directly on permanent ridges of 10-15 cm by clearing previous year's crop residues form ridge tops only. **Mulch-till** is any other reduced tillage system that leaves at least one third of the soil surface covered with crop residue.

LO 3.3 – Application of mechanical/physical control methods

Content/Topic 1: Water harvesting structures (ditches, channels)

Landscape management is a means to protect natural resources from the adverse impacts. In particular, the adequate management of ditches could improve crop quality. Ditch networks have been primarily designed for waterlogging control and erosion prevention.

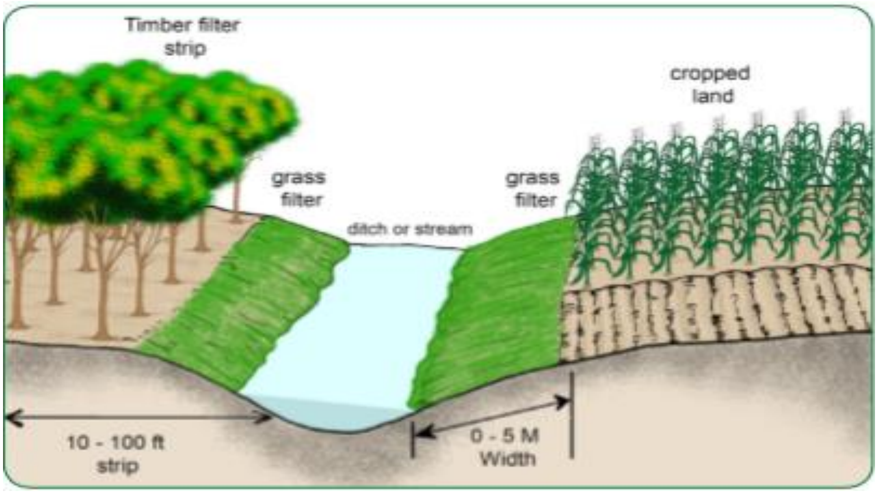


Figure 44: Ditch/ channel

Ditches and channels are classified as:

i. Minor Channels (Roadside Ditches): Minor channels collect sheet flow from the highway pavement or right-of-way and convey that flow to collection points in larger channels or pipes.

ii. Major Channels (Drainage Channels): Major channels collect drainage from minor channels, pipe systems, and offsite areas, and convey that flow to an adequate discharge point on- or offsite.

iii. Natural Channels: Natural channels are formed through geomorphologic activity, including erosion and sedimentation.

Content/Topic 2: Gabions

A row of stepped back gabions, stone filled cages, line a mountain road protecting the embankment from erosion and protecting the road.

Figure 45: Gabions for protecting road destruction

Gabions are used:

- To slow the speed of concentrated run-off
- In conditions where water velocity is so high that it causes gully formation.
- On steeper slopes to stabilize the area especially where the slope drops to a road or any other structure.
- To protect earth embankments in steep areas from slipping over.
- To protect farms, buildings, roads, railways and other structures constructed on the edges of a slope.
- To help in recovering eroded areas by filling in already formed gullies.
- To prevent gullies from forming in areas where they may be prevalent.

Advantages of using gabions

- They are easy to handle and construct.
- Once constructed, they are permanent
- They are permeable to water thus allow water to pass through them.
- Gabions have other advantages which are; flexibility, durability, strength and landscaping

Content /Topic 3: Stones bund

The **stone bunds** form a barrier that slows down water runoff, allowing rainwater to seep into the soil and spread more evenly over the land. This slowing down of water runoff helps with building-up a layer of fine soil and manure particles, rich in nutrients.

Figure 46: Stone bunds for erosion control in a cultivated land

Advantage of stones bund

- ✓ A minimum amount of labor on upkeep erosion control is required
- ✓ Stone bunds need to be usually implemented by the community, with development projects supporting the technical, material and logistics aspects
- ✓ Economic success requires optimal spacing of stone bunds based on the type of construction, materials transport cost, and how labor is organized.
- ✓ Soil and water conservation
- ✓ Increase local resilience to climate change

Content /Topic 4: Vegetated waterway

Grassed waterways are broad, shallow and typically saucer-shaped channels designed to move surface water across farmland without causing soil erosion. The vegetative cover in the **waterway** slows the water flow and protects the channel surface from the eroding forces of runoff water.

Figure 47: Vegetated waterway

Purpose of Grassed Waterways

Grassed waterways are used as outlets to prevent rill and gully formation. The vegetative cover slows the water flow, minimizing channel surface erosion. When properly constructed, grassed waterways can safely transport large water flows to the down slope. These waterways can also be used as outlets for water released from contoured and terraced systems and from diverted channels. This best management practice can reduce sedimentation of nearby water bodies and pollutants in runoff. The vegetation improves the soil aeration and water quality (impacting the aquatic habitat) due to its nutrient removal (nitrogen, phosphorus, herbicides and pesticides) through plant uptake and sorption by soil. The waterways can also provide a wildlife habitat.

Content /Topic 5: Wattle construction

Erosion Control Wattles are one of the most frequently used filtration and stabilization products around drains, construction sites, and streams. Below are a few of the most common questions we hear customers asking when it comes to the wattles. Construction activities, such as grading and filling, drastically reduce soil quality on construction sites. Left unprotected, sites will be further degraded by erosion and begin to adversely affect the surrounding environment.

Figure 48: Erosion control in cultivated land using wattle construction

Difference between a wattle and a log

While similar in the shape and design, there are a couple of differences between the erosion control wattle and the erosion control log.

- ✓ Erosion control wattles are typically smaller in diameter.
- ✓ Erosion control wattles are less densely packs than logs.
- ✓ Wattles are commonly used for filtration.

How are they installed?

Typical installation for a wattle involves a process of digging a small trench and staking the wattles into position. However, depending on your location, installation methods/requirements may vary.

- ✓ Dig a small trench where the wattles need to placed.
- ✓ Place the wattles into the trench and backfill the area.
- ✓ Stake the wattles every 4 ft. (1 ft.= 30,48 cm) on center.

LEARNING UNIT 4 – MAINTAIN EROSION CONTROL STRUCTURES

Erosion control structures are used to manage surface runoff and soil loss. Water and sediment control basins, diversion terraces, and grassed waterways are the most common upland erosion control measures that can be implemented, depending on the size of the watershed and type of erosion (i.e., sheet, rill or gully erosion).

LO 4.1– Identification types of damages on structure

There are three types of erosion structure damage which are silting, sedimentation and lands slide weeds

Content/Topic 1: Silting

The deposition or accumulation of silt that is suspended throughout a body of standing water or in some considerable portion of it; especially the choking, filling, or covering with stream-deposited silt behind a dam or other place of retarded flow, or in a reservoir. It refers both to the increased concentration of suspended sediments and to the increased accumulation (temporary or permanent) of fine sediments on bottoms where they are undesirable. Siltation is most often caused by soil erosion or sediment spill.

Figure 49:Siltation of a waterway

Typically, soil degradation by intensive or inadequate agricultural practices, leading to soil erosion. The result will be an increased amount of silt and clay in the water bodies that drain the area. Another important cause of siltation is the sewage that are discharged from households or business establishments with no septic tanks or wastewater treatment facilities to bodies of water.

Content/Topic 2: Sedimentation

Sedimentation is a natural process in which rock is formed from small pieces of sand, stone, etc. that have been left by water, ice, or wind. Sedimentation occurs when eroded material that is being transported by water, settles out of the water column onto the surface, as the water flow slows.

Effects of erosion and sedimentation:

- ✓ Loss of fertile top soil
- ✓ Flooding from clogged ditches, culverts, and storm sewers
- ✓ Damaged plant and animal life
- ✓ Closed ponds, lakes, and reservoirs
- ✓ Damaged aquatic and other habitats
- ✓ Decreased recreational value and use
- ✓ Structural damage to buildings and roads

Figure 50: Erosion and sedimentation

Causes of sedimentation

- ✓ Mining activities
- ✓ Forest harvesting activities
- ✓ Agriculture activities (fertilizers application)
- ✓ Wind
- ✓ Urbanization

Content/Topic 3: Lands slide

A landslide is defined as the movement of a mass of rock, debris, or earth down a slope. Landslides are a type of "mass wasting," which denotes any down-slope movement of soil and rock under the direct influence of gravity.

Landslides can be initiated by rainfall, snowmelt, changes in water level, stream erosion, changes in ground water, earthquakes, volcanic activity, disturbance by human activities, or any combination of these factors. Earthquake shaking and other factors can also induce landslides underwater.

Landslides are mainly caused by gravity acting on weakened rocks and soil that make up a sloping area of land. Both natural and human-related activities can increase the risk for landslides. Water from heavy rainfall is a frequent trigger for landslides

Figure 51: Landslide

Causes of Landslides

i. Natural causes of Landslides:

Earthquakes: Seismic activities have always been a main cause of landslides throughout the world. Any time plate tectonics move the soil that covers them moves with it. When earthquakes occur on areas with steep slopes, many times the soil slips causing landslides. Furthermore, ashen debris flows caused by earthquakes can also trigger mass movement of soil.

Heavy Rainfall: When sloped areas become completely saturated by heavy rainfall many times landslides can occur. Without the aid of mechanical root support the soil simply runs off when it contains too much water.

ii. Human causes of Landslides:

Clear Cutting: Method of timber harvesting which completely removes all old growth timber from the area. This method is hazardous because it destroys the existing mechanical root structure in the area.

Mining: Mining operations that use blasting techniques often cause other areas that are at the risk of sliding to slide due to vibrations under the soil.

LO 4.2– Identification of maintenance techniques

There are different techniques of maintaining anti-erosion infrastructure include; Desisting, Weeding and clearing.

Content/Topic 1: Desisting

Desisting include measures used to mitigate destruction of anti-erosive infrastructures. The following measures can be used:

- Place a layer of large rocks against the earth around both ends of the culvert pipe to keep the soil from being exposed.
- Plant vegetation along the bank, the roots of the vegetation will help keep the soil in place.
- Place a layer of material on top of the soil along the bank in the area prone to erosion.

Content/Topic 2: Weeding

Weeding is the process to remove out the weeds. Weeds are unwanted plants which grown along the useful crops. Weeding is required for anti-erosive ditches to increase water flow and prevent flooding and erosion.

Content/Topic 3: Clearing

Surface cover is a major factor to control erosion because it reduces the impact of raindrops falling on bare soils and wind removing soil particles. It also reduces the speed of water flowing over the land. Runoff and erosion before and after clearing depending on the type of weeds grow on anti-erosive ditch. However, clearing of anti-erosive ditches and other erosion control infrastructure improves the water flow movement even though clearing vegetation removes the protection of plants and roots needed to lock soil in place.

LO 4.1– Rehabilitation of soil erosion control structures

The effects of soil erosion go beyond the loss of fertile land. It has led to increased pollution and sedimentation in streams and rivers, clogging these waterways and causing declines in fish and other species. And degraded lands are also often less able to hold onto water, which can worsen flooding.

Content/Topic 1: Identification the level of damages

Levels of soil erosion control structures damage are identified and categorized based on different factors including; Amount of material transported by erosion, Topography of the site, Speed of water and Flooding rate

Content/Topic 2: Repairing practices/techniques

Maintenance of diversion channels

Deposits of silt in the channel should always be removed and thrown to the underlying land. This is to make sure that water flows freely all the time. Any large plants, trees or bushes should be cleared from the embankment trench or channel. The roots of trees may cause cracking and breaking of the embankment.

Maintenance of anti-erosive ditches

- ✓ Ensuring the embankments remain horizontal.
- ✓ Reinforce and repair any part of the structure which has become weak by compacting.
- ✓ Filling in the gullies or gaps with earth and compacting well.
- ✓ Vegetation or the grass cover should be protected to remain adequate.
- ✓ If trees prevent the growth of grass under cover, they should be cut.

Maintenance of filter strips

- ✓ Frequent inspection especially after heavy rains to remove accumulated sediments.
- ✓ Minimize the development of erosion channels by repairing them or planting more grass.
- ✓ Plant more grass or reseed bare patches.
- ✓ Mow or remove vegetation regularly to leave a height of 15 cm.
- ✓ Test the soil periodically to ensure healthy growth of grass or vegetation.
- ✓ Control or remove unwanted trees, bush or noxious weeds.
- ✓ Fence off livestock from the strips to maximize the filtering potential.
- ✓ Discourage use of machinery such as mowers through the strips.
- ✓ Filter strips should be used with good agricultural practices such as pasture management, proper nutrients and pest management to enhance effectiveness.

Maintenance of gabions

- ✓ Should be inspected regularly after each heavy storm
- ✓ Monitoring and removing any regrowth of invasive species on the gabions
- ✓ Should be repaired in case the storms cause any damage

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