# Agricultural TVET College

# Small Scale Irrigation Development
# Level II

## MODEL TTLM

## Learning Guide #14

**Unit of Competence:** Assist in Identifying and Selection of Irrigation Methods

**Module Title:** Assisting in Identifying and Selection of Irrigation Methods

**LG Code:** AGR SSI2 14 0816

**TTLM Code:** AGR SSI2 14M TTLM 1218$V_2$

**Nominal Duration:** 40 Hours

## LEARNING OUTCOMES (LOs):-

**LO#1: Create awareness**

**LO#2: Gather relevant information**

| | | |
|---|---|---|
| **Instruction Sheet # 1** | **Unit** | **Assist in Identifying and Selection of Irrigation Methods** |
| | **Module** | **Assisting in Identifying and Selection of Irrigation Methods** |
| | **LO#1-2** | |

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

- Create awareness
- Gather relevant information

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 –

- Select appropriate irrigation methods
- Collect and collate data on soil type
- Identify crop type based on land use capability of the area.
- Identify water source potential is identified in agreement with water resource utilization policy.
- Determine land gradient of the command area using contour map.

**Learning Activities**

1. **Read the specific objectives of this Learning Guide.**
2. **Read the information written in the "Information Sheet"**
3. **Accomplish the "Self-check".**
4. **If you earned a satisfactory evaluation proceed to the next "Information Sheet". However, if your rating is unsatisfactory, see your facilitator for further instructions or go back to Learning Activity.**

5. **Submit your accomplished Self-check. This will form part of your training portfolio.**
6. **Read and Practice "Operation Sheets".**
7. **If you think you are ready proceed to "Job Sheet".**
8. **Request you facilitator to observe your demonstration of the exercises and give you feedback.**

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| **INFORMATION SHEET # 1** | **Unit** | **Assist in Identifying and Selection of Irrigation Methods** |
| | **Module** | **Assisting in Identifying and Selection of Irrigation Methods** |
| | **LO#1** | **Create awareness** |

### 1.1. Gathering information on indigenous practice irrigation methods

#### 1.1.1: Introduction:

Indigenous knowledge is considered to be a body of knowledge existing within or acquired by local people over a period of time through accumulation of experiences, society-nature relationships, community practices and institutions by passing it down to other generations.

The interface between indigenous knowledge systems and water security is embodied in the traditional knowledge and skills in managing and protection of water sources.

The water knowledge rural societies possess can enable them to develop their capacities to achieve sustainable and equitable development. The utilization of indigenous knowledge in the water security processes is based on the fact that indigenous people have managed the ecological and hydrological environments without damaging them.

Indigenous methods of water resource management and irrigation methods may vary from;

- Canal, pond and well digging to cultivation of low adaptive crops
- The soil-moisture relationships, indigenous irrigation, capability of domesticated plants
- Water resource management methods.

#### 1.1.2: Why need gathering information on indigenous practice?

Nowadays, striving to achieve sustainability by introducing new technologies and ignoring the existing local knowledge is of no use to the people who dominantly depend on traditional practices.

The communities which have long-served traditional management systems are not easily willing to work with the imported (modern) techniques if they have not been involved in the development of those systems, or if their social components are interpreted wrongly or even ignored. In such cases, traditional people prefer to remain observers rather than become involved as real participators. In consequence, modern water systems are used while the services are operational, but the communities return to unimproved sources after the services break down.

Thus, successful management practices of societies should be investigated before introducing new technologies and management styles, because endeavors that ignore the local conditions are unlikely to succeed.

### 1.1.3: Gathering information on indigenous practice

In any irrigation development and assessment information of indigenous practice must be gathered using various survey techniques. These survey techniques should assess and investigate the;

- Traditional knowledge that exists in target areas
- Best practices make them more attractive and valuable for the intended purpose
- Successful management practices of societies
- Adaptability to new technologies and management styles.

### 1.1.4: **Survey techniques to gathering information**

Information can be gathered come from a range of sources. Likewise, there are a variety of techniques to use when gathering primary data. Listed below are some of the most common data collection techniques in irrigation practices.

- Interviews
- Questionnaires and Surveys
- Observations
- Focus Groups
- Ethnographies, Oral History, and Case Studies
- Documents and Records

## 1.2. Comparing chosen method with indigenous method.

To choose an irrigation method, the farmer must know the advantages and disadvantages of the various methods. In addition to the indigenous practices farmers must know which method suits the local conditions best. Unfortunately, in many cases there is no single best solution: all methods have their advantages and disadvantages.

Testing of the various methods - under the prevailing local conditions - provides the best basis for a sound choice of irrigation method. The selection of a suitable irrigation method must be based on the following important critical factors.

i. **Natural conditions:-**The natural conditions such as soil type, slope, climate, water quality and availability, have the following impact on the choice of an irrigation method:

ii. **Type of crop**:- Surface irrigation can be used for all types of crops. Sprinkler and drip irrigation, because of their high capital investment per hectare, are mostly used for high value cash crops, such as vegetables and fruit trees. They are seldom used for the lower value staple crops.

  ☞ Drip irrigation is suited to irrigating individual plants or trees or row crops such as vegetables and sugarcane. It is not suitable for close growing crops (e.g. rice).

iii. **Type of technology**:- The type of technology affects the choice of irrigation method. In general, drip and sprinkler irrigation are technically more complicated methods. The purchase of equipment requires high capital investment per hectare. To maintain the equipment a high level of 'know-how' has to be available,. Also, a regular supply of fuel and spare parts must be maintained which - together with the purchase of equipment - may require foreign currency.

  ☞ Surface irrigation systems - in particular small-scale schemes - usually require less sophisticated equipment for both construction and maintenance (unless pumps are used). The equipment needed is often easier to maintain and less dependent on the availability of foreign currency.

iv. **Previous experience with irrigation**:- The choice of an irrigation method also depends on the irrigation tradition within the region or country. Introducing a previously unknown method may lead to unexpected complications. It is not certain that the farmers will accept the new method. The servicing of the equipment may be problematic and the costs may be high compared to the benefits.

v. **Required labour inputs**:- Surface irrigation often requires a much higher labour input - for construction, operation and maintenance - than sprinkler or drip irrigation (Figure 65). Surface irrigation requires accurate land levelling, regular maintenance and a high level of farmers' organization to operate the system. Sprinkler and drip irrigation require little land levelling; system operation and maintenance are less labour-intensive.

vi. **Costs and benefits**:-Before choosing an irrigation method, an estimate must be made of the costs and benefits of the available options. On the cost side not only the construction and installation, but also the operation and maintenance (per hectare) should be taken into account. These costs should then be compared with the expected benefits (yields). It is obvious that farmers will only be interested in implementing a certain method if they consider this economically attractive. Cost/benefit analysis is, however, beyond the scope of this manual.

## 1.3. Making discussion with target group in a participatory approach.

In irrigated agriculture, a number of discussions with target group in a participatory approach are essential based on various issues. These include:

- Performance of irrigation systems caused by institutional and managerial factors;
- Physical factors (poor design, unsuitable topography, poor drainage, poor soil conditions);
- Economic constraints (smaller landholdings, lack of financial resources and credit, lack of key inputs and marketing outlets); and
- Socio-cultural problems (tenure arrangements such as insecure rights and large landholdings leased to individual farmers, caste-related inequities, gender bias).

*Farmer participation*

Participation of farmers is essential from the start. If an irrigation scheme is set up without farmers' participation, they will view it as belonging to the government and feel no responsibility towards it. Farmers may even expect the government to make the repairs and maintain the irrigation system.

The farmers must be asked for their ideas and what their needs are before irrigation is introduced at a site. Furthermore, it is necessary to find out if they are willing and able to be involved in the proposed scheme. The following questions are a guide.

- Do the farmers want irrigation?
- Do they understand the benefits it will offer and the work and costs involved'?
- Are the farmers willing to work as a group to operate and maintain an irrigation system?

| Self-Check 1 | Written Test |
|---|---|

**Name:** _________________________ **Date:** _______________

**Directions:** ***Answer all the questions listed below.***

1. Describe why need gathering information on indigenous practice (5pt)
2. Write down the important critical factors to select irrigation method (8 points)
3. What is *farmer participation*?(2 pt)

***Note:*** **Satisfactory rating – 8 points** **Unsatisfactory – below 8 points**

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| **INFORMATION SHEET # 2** | **Unit** | **Assist in Identifying and Selection of Irrigation Methods** |
| | **Module** | **Assisting in Identifying and Selection of Irrigation Methods** |
| | **LO#2** | **Gather relevant information** |

### 2.1: Collecting and Collating Data on Soil Type

The soil data is collected on several levels: point data, map unit data, spatial data, and interpretative data. Point data describe a pedon profile, is site specific, and should represent what is typical about a particular soil. Map unit data is the information that describes the soil forming factors and includes, where different soil types are found on the landscape, the soils range in characteristics such as color and texture, and how they relate to each other, and topography, climate, vegetation, and geology. The spatial data consists of soil delineations and special features located on georeferenced orthoquadrangle base maps. The interpretative data consists of soil ratings and estimated properties that assist conservationists and land managers in making management decisions.

Soil data is collected in many different ways, and each soil scientist organizes data in a slightly different way. It is most important to collect data that will be useful and meaningful to the end users and to organize it in a way that others can understand. The methods described below are not revolutionary or complex, but have been found to work well for organizing data.

### *A. Point data*

Point data or pedon descriptions are collected ideally from a soil pit. Soil pits are typically sixty to eighty inches (152 to 203 cm) deep, approximately five by six feet (1.5 to 2 m) wide, and large enough to be safe for one or two people to describe the soil profile. Point data can also be described from road cuts, auger holes, erosional cuts, or anywhere a soil profile is exposed. Caution should be used to ensure that the material you describe is naturally-occurring and not disturbed or fill material. The most important piece of information for the point data is the location coordinates. This can be in any format, but must be exact enough for other to locate. Some examples are Township, Range and Section, latitude and longitude, or Universal Transverse Mercator (UTM), and proximity to major roads, rivers, towns, and cities. Data without a location become useless. The point data can be broken down into three categories: physical, chemical, and landscape.

**Physical properties:** are described on site and describe the soil condition at a given time and place. Physical properties consist of texture, depth of horizons, structure, color, stickiness and plasticity, hardness, rock fragments, and depth to root restrictive layers.

**Chemical properties:** can be described on site or later from laboratory analysis. There are

Several tests that can be performed onsite for pH, calcium carbonate percentage, and Effervescence. More complex analyses of electrical conductivity (EC), sodium adsorption rates

(SAR), and gypsum content should be completed in a laboratory. It is also advised to calibrate field measurements against laboratory analysis. This can be completed for pH, particle size, calcium carbonate percentage, and mineralogy. Not all pedon descriptions need laboratory analysis, but it is a good science to sample several representative sites throughout the survey area to calibrate field estimations.

Landscape and climatic properties are described on site. This information will establish the setting for the map unit. These properties include slope, accelerated erosion, landform, flooding potential, elevation, rainfall, air temperature, and soil temperature.

### *B. Map Unit Data*

A map unit is a description of each delineation made on a soil map. It will describe where the unit is located on the landscape, the composition of the soils that are represented by the map unit, the characteristics of each soil present, and other resource information, such as ecological sites and land capability. Map unit data is collected through mapping observations, field notes, and transects. Transects are straight line traverses across soil delineations that are perpendicular to the drainages of the landscape and consist of ten evenly spaced holes/point data. For small delineations the spacing could be in feet and for large delineations in tenths of a mile. The information collected from transects is used to calculate the composition of the map unit including minor components and the range in characteristics for each soil. Field notes are used by soil scientists to record daily observations while mapping. The field notes are then incorporated into the map unit descriptions. Field notes can consist of observations for the range in characteristics, minor components (soils not named in the map unit), vegetation, erosion properties, and other unique properties of the map unit such as desert pavement, crust, and cracks. Again, all notes and transects need to have specific locations and coordinates.

This can easily be done by tracking notes and transects on both aerial photos/field sheets and topographic maps. This way each field sheet (permanent record of soil delineations) will have the documentation collected recorded on the back and each document will belong to a specific field sheet.

### *C. Spatial Data*

Spatial data is the information that is included on the maps including data layers and special features. Soil maps, at a minimum, should have the soil delineations and enough background features so that the user of the maps can quickly locate the areas of interest. Black and white rectified photography is commonly used for field sheets. Field sheets are the permanent hard copy record of the spatial data, which includes soil delineations, documentation, special features, acres mapped, and dates of completion. Special features can be any land or water features which are too small in extent to be easily expressed on soil maps, but are important to land management. Examples of special features could include springs, levees, major roads, stream, gravel pits, and severe erosional areas. The field sheets can be digitized either during or after a soil survey is completed.

***D. Interpretative Data***

Interpretative data can be collected from people who manage the land. An example would be crop yield information and range production. Other interpretative data are the result of estimates based on point data, such as available water content or erosion factors. The following is a list of some interpretative data: available water content, saturated hydraulic conductivity, K factor, T factor, Wind Erosion Groups, shrink-swell potential, and hydrologic group. Another set of interpretative data uses point data to rate soils for specific uses. A rating system from good to severe lets users know of potential limitations associated with a specific use. This set of data is reported in tables and includes: recreational development, building site development, sanitary facilities, construction materials, water management, soil and water features.

Before documentation begins, a filing system needs to be in place. Again this is unique to the soil scientist, but must be systematic, hopefully simple, and understandable to anyone dealing with the soil survey project. The following are simplified steps that occur in a progressive soil survey.

1. Collect all related resources including: topography maps, geology maps, historical mapping, precipitation and temperature information, stream flows, and, most important, good quality aerial photography.
2. Become familiar with the Memorandum of Understanding, the soil survey area, and begin mapping.
3. Create map units and add to the developmental legend.
4. Collect documentation.
    - ✓ Log completed transects, field notes, and pedon descriptions on a spreadsheet format by map unit number and date and on field sheets or topographic maps.
    - ✓ Place documentation in map unit folder; summarize range of characteristics.
    - ✓ Establish type location.
    - ✓ Complete database input sheets.
    - ✓ Input data.

- ✓ Generate map unit descriptions and tables.
- ✓ Build descriptive legend of developmental map units, tables and soil maps. Test map unit
- ✓ By soil staff and other resource specialists.

5. Map units must be approved by quality control and assurance staff before being added to the approved legend.
6. Repeat. The above steps are a continual process until mapping is completed. Remember to keep the descriptive legend and soil maps updated.

The above steps are the process of a progressive soil survey. Before the process begins, you must know who and what information the end users will need, as specified in the Memorandum of Understanding. As a soil scientist begins to map, a legend begins to develop. A legend is simply a list of map units that includes soil names, phases, and slopes. In the early days of mapping a new survey area, the legend may exist only as numbers with generalized soil names or properties. As more and more time is spent mapping and data is collected, the legend evolves. Each piece of documentation is recorded on a spreadsheet by both map unit and date. It is sometimes helpful to color code documentation by year. Then, each piece of documentation is placed in a folder that represents that map unit; this is where the range in characteristics are built. A summary sheet for each soil collects the individual range in characteristics accumulated from the documentation for each map unit. When sufficient documentation has been collected, a type location is selected. A type location or typical pedonis the site data that best represents the soil for a particular map unit. The typical pedon will have the most typical characteristics of the named soil. The map unit can be written using the typical pedon and incorporating all of the data collected. The map unit description represents all areas where the unit occurs and is unique for the soil survey area. Information may vary due to the land managers' and conservationists' need for the soil survey.

The following information is generally included in a soil map unit description: Setting - landform, slope range, elevation, mean annual precipitation, mean annual air and soil temperature, and frost-free period; Composition - including minor components; Typical Profile with location and coordinates - detailed description of each soil by horizon; Soil Properties and Qualities - classification, parent material, depth class, drainage class, permeability, available water capacity, runoff class, shrink-swell potential, seasonal water table depth, hydrologic group, land capability, ecological site, present vegetation, land resource unit, and major land resource area. The soil survey area is best represented if all the data collected is processed and included in the map unit descriptions.

### 2.2: Identifying Crop Type Based On Land Use Capability of the Area

***Agricultural land classes***

**Class A, Crop land** - Land that is suitable for current and potential crops with limitations to production which range from none to moderate levels.

**Class B, Limited crop land -** Land that is marginal for current and potential crops due to severe limitations; and suitable for pastures. Engineering and/or agronomic improvements may be required before the land is considered suitable for cropping.

**Class C, Pasture land -** Land that is suitable only for improved or native pastures due to limitations which preclude continuous cultivation for crop production; but some areas may tolerate a short period of ground disturbance for pasture establishment.

**Class D, Non-agricultural land -** Land not suitable for agricultural uses due to extreme limitations. This may be undisturbed land with significant habitat, conservation and/or catchment values or land that may be unsuitable because of very steep slopes, shallow soils, rocky outcrop or poor drainage.

Crop Type identification

Factors related to the crop that impacts on the decision of which irrigation system to use are the following:

- Crop lifespan and seasonality
- Irrigation frequency
- Application area
- Peak crop water requirement

**A. Crop Lifespan and Seasonality**

Irrigation system that are used for annual, seasonal crops such as vegetables must be of such a type that it can be installed and removed annually in order to allow the normal cultivation and harvesting practices. Typically this includes movable systems and static systems such as sprinklers, which can be moved, and drippers, which can be rolled up and stored.

Long term crops such as sub-tropical fruit require a permanent system that allows for irrigation throughout the year, including during harvesting. The long lifespan and high income potential of an orchard also necessitates a permanent system.

**B. Irrigation Frequency**

The frequency at which crops requires to be irrigated impacts on the choice of irrigation system. For crops such as sub-tropical fruit that require frequent and regular irrigation, permanent irrigation systems are most suitable.

Tree yield and quality are extremely sensitive to water stress. Water availability is critical especially during flowering and fruit set, which is the time with the highest peak water demand. Generally speaking, trees require regular irrigation at least two or three times a week, because they have shallow root systems with an average depth of only about 300mm. This limits the plant available water. The physiological processes of trees, and therefore their production, are very quickly influenced by water stress.

Certain irrigation systems, such as moveable sprinklers, are also extremely labour intensive and time-consuming. Movable systems are suitable for crops that are less sensitive to water stress.

**C. Application Area**

Certain crop plants can be wetted completely during irrigation, while cultural practices of other crops, such as mangoes, prohibit wetting of leaves and fruit. Diseases such as black spot spread and develop more rapidly under wet conditions. A decision on the irrigation system to use must take into account the parts of the plant that can be wetted.

Certain plants, such as field crops, are also planted very closely together, while orchard crops are planted further apart. It would therefore make sense to apply water to an entire field of crops by using overhead systems, while it would not make sense using such a system for sub-tropical fruit because irrigation is only required on the root-zone of each tree.

### D. Peak Crop Water Requirement

The peak water requirement for sub-tropical fruit is in the summer months, when transpiration is high. The peak water requirement is expressed as mm/day and is the minimum application rate the irrigation system must have. The peak water requirement for sub-tropical fruit is usually between 4mm/day and 6mm/day.

Peak irrigation requirements differ between production areas, with cooler, moist areas having a lower peak requirement than warmer and drier areas. The peak irrigation requirement for a specific area is determined from historical E-pan data and crop factors, or computer models such as SAPWAT. The irrigation designer determines the peak irrigation requirement for the specific production area before the irrigation design is done. An irrigation system must at least be able to supply the peak irrigation requirement.

***Example:***

Daily Application Rate

An irrigation system has an application rate of 3mm/h.

Crop is irrigated for 4 hours every second day, being 3 days a week.

The daily application rate is calculated as follows:

Application per Cycle: 3mm/h x 4h = 12mm

Application per Week: 12mm per day x 3 days per week = 36mm per week

Daily Application Rate: 36mm per week / 7 days = 5.1mm per day

This irrigation system can satisfy a peak water requirement of 5mm a day, assuming that the soil can hold 15mm of water for Friday, Saturday and Sunday.

All the types of irrigation systems have application rates high enough to satisfy the crop water requirements of sub-tropical fruit. The design of the specific irrigation system will determine if the system as a whole can satisfy the peak irrigation requirement.

The most commonly used irrigation systems for sub-tropical fruit production are permanent micro-jet and drip irrigation systems. Both systems satisfy the criteria for the crop type by:

- Being a permanent system that can irrigate a block at any time and that can be scheduled according to the requirements of the crop and water holding capacity of the soil
- Irrigating under the tree, wetting only the root-zone

### 1.3 Identifying water source potential

One of the first questions any grower must answer when considering an irrigation system is: *What will be the water source?* Growers can't do much irrigating without an adequate supply of good quality water.

There are actually four water supply questions: How much will you need? What sources can you use for supply? How much water can that source provide? What is the quality of the water from your planned source?

The sources of water that are practicable for public and domestic purposes are classified as:

- ✓ rainwater
- ✓ surface water such as lakes, rivers and ponds
- ✓ groundwater from springs, wells and boreholes

**Rainwater**: Rainwater can be used for domestic purposes in areas where there are no alternative sources of water such as springs, rivers and lakes, or where these sources of water are contaminated. The term **rainwater harvesting** is sometimes used. It simply means collecting, or harvesting, rainwater as it runs off from hard surfaces such as rooftops and storing it in a tank or cistern.

The main advantage of rainwater is that it is free. It is fairly reliable though obviously dependent on the amount of rain that falls. It does not usually require pumps or pipes and is available at the doorstep. Using rainwater can reduce the burden on women and children who typically are the water carriers in Ethiopia and walk long distances to fetch inadequate supplies.

Fig1: Rainwater is collected from the roof

**Surface water:** Surface water supplies are taken from rivers, lakes or ponds. Surface water can provide a consistent and manageable source of water. However, it is subject to greater risk of contamination than groundwater and therefore usually requires treatment. Contamination is most likely to be with microbiological pathogens from human and animal excreta. There is also the possibility of accidental or deliberate pollution by industries or the agricultural community.

Fig2: Surface water source

**Groundwater:** Groundwater is water found beneath the ground surface held in the spaces within porous soil and rock. Groundwater can be obtained from springs, boreholes or wells. A borehole is a particular type of well with a narrow shaft. Usually a drilling rig is needed to drill (bore) the hole into the rock. The depth that water is taken from and the types of rock it has passed through are important factors that affect the quality of the groundwater. Groundwater, particularly from deep sources, may provide water of good microbiological quality. This is because bacteria, protozoa, viruses and helminthes are filtered from the water as it passes through the layers of soil and rock into the groundwater. Groundwater sources are therefore preferable to surface water sources. However, groundwater can contain chemical contaminants, such as arsenic, fluorides and nitrates.

**Springs**

Permeable rocks have tiny spaces between the solid rock particles that allow water and other fluids to pass through and be held within the rock structure. Impermeable rocks do not have these spaces and water cannot pass through them. A spring occurs at the point where the boundary between a **permeable layer** of underground rock and an **impermeable layer** reaches the ground surface.

Rainwater percolates (trickles down) through the soil into permeable layers of subsoil or underground rock. The downward **percolation** will be stopped if this layer sits on top of an impermeable layer and the water can go no further. Depending on the slope of the layers, the water will run along the top of the impermeable layer to a point where it reaches the surface and emerges as a spring (see Figure3). A spring may vary in volume and contamination levels according to the amount of rainfall.

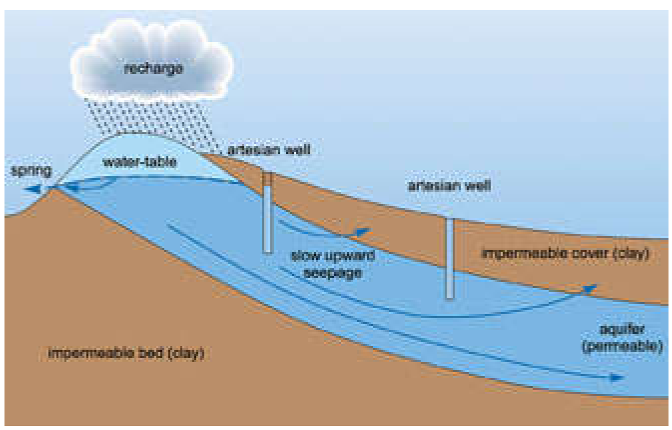



Fig2: Recharging process and source of ground water

## 1.4 Determining land gradient of the command area using contour map

**Contour line:** A line drawn on a map representing an imaginary line on the ground along which all points are at the same elevation.

- ✓ Characteristics of contour lines indicate a vertical distance above or below a datum plane.
- ✓ The vertical distance between adjacent contour lines is known as the contour interval, and the amount of the contour interval is given in the marginal information.
- ✓ Starting as sea level, the zero contours, and each contour line represents an elevation above sea level.
- ✓ On most maps the contour lines indicate the nature of the slope.

***TYPES OF CONTOUR LINES***

a. **Index Contour Line.** Starting at zero elevation, every fifth contour line is drawn with a heavier line. These are known as index contours. Along each index contour the line is broken and its elevation is given.

b. **Intermediate Contour Line.** The contour lines falling between index contours are called intermediate contours. They are drawn with a finer line than the index contours and do not have elevations given.

c. **Supplementary Contour Line.** A third type of contour line that is not often used is the supplementary contour line. This line is depicted as a dashed line and is used to indicate a minimal change in elevation or terrain between two intermediate contour lines. Using the contour lines on a map, the elevation of any point may be determined by:

   - ✓ Finding the contour lines on a map from the marginal information, and noting both the amount and the unit of measure.
   - ✓ Finding the numbered contour line nearest the point for which the elevation is being sought.
   - ✓ Determining the direction of the slope from the numbered contour lines index contour to the desired point.
   - ✓ Counting the number of contour lines that must be crossed to go from the numbered index contour line to the desired point and noting the direction up or down. The number of lines crossed, multiplied by the contour interval is the distance above or below the starting value.
   - ✓ If the desired point is on a contour line, its elevation is that of the contour line.
   - ✓ For estimating elevation of a point between contours, most military needs are satisfied by estimating elevation to an accuracy of one half the contour interval.

- ✓ To estimate the elevation to the top of an unmarked hill, add half the contour interval to the elevation of the higher contour line around the hill.
- ✓ To estimate the elevation of the bottom at a depression, subtract half the contour interval from the value of the lowest contour line around the depression.

***RELIEF FEATURES***

**Slopes:** The spacing of the contour lines indicates the nature of the slopes.

**Uniform steep slope:** Contour lines evenly spaced and close together indicate a uniform steep slope. The closer the contour lines are to each other the steeper the slope.

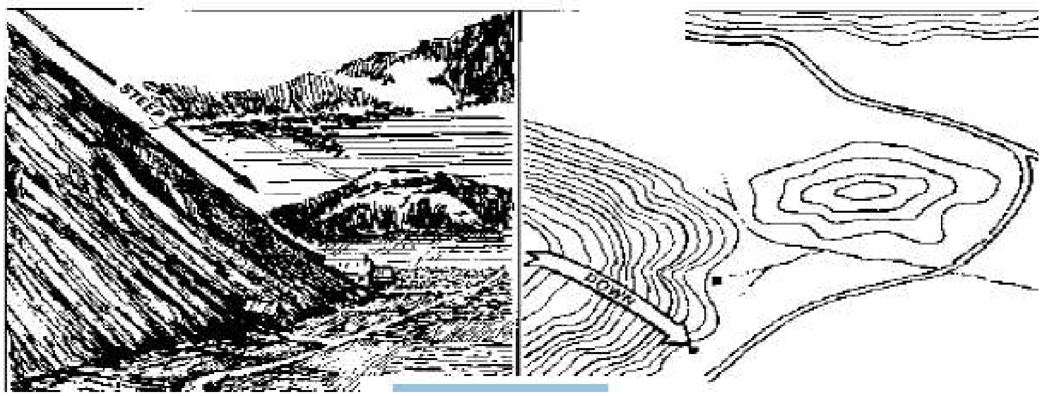



Figure_3: Steep slope

**Uniform gentle slopes:** Contour lines evenly spaced and wide apart indicate a uniform gentle slope.

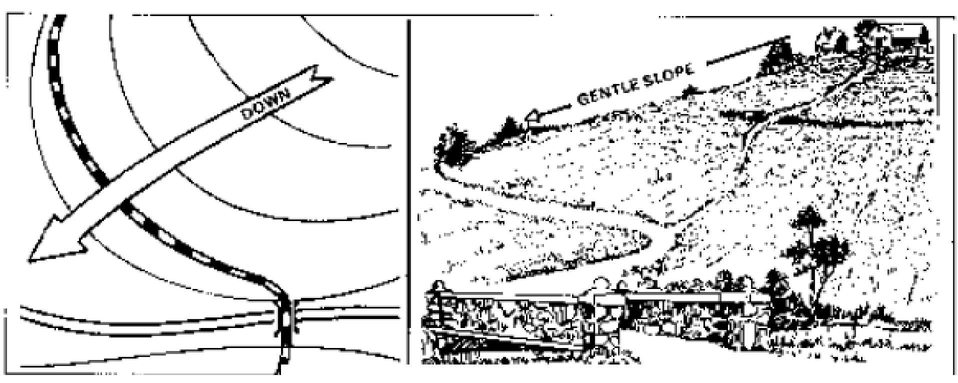



Figure_4: Gentle slope

**Convex slope:** Contour lines widely spaced at the top and closely spaced at the bottom. An observer at the top of a convex slope cannot observe most of the slope, or the terrain at the bottom. The further up the slope, the easier it is to climb.

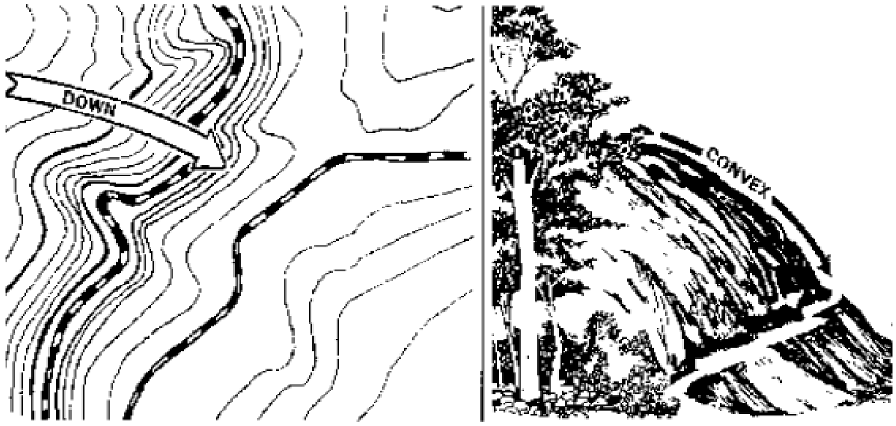



Figure_5: Convex slope

**Concave slope.** Contour lines are closely spaced at top and widely spaced at bottom. An observer at the top of the concave slope can observe the entire slope and the terrain at the bottom. The further up the slope, the more difficult it is to climb.

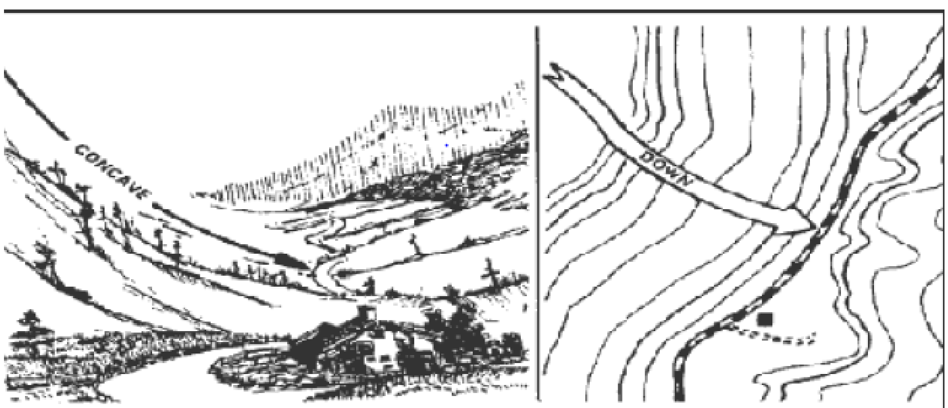



Figure_6: Concave slope

### *TERRAIN FEATURES*

**Hill:** A point or small area of high ground. Contour lines will represent the hill by being a closed loop within a small area on the map. When you are located on a hilltop the ground slopes down in all directions.

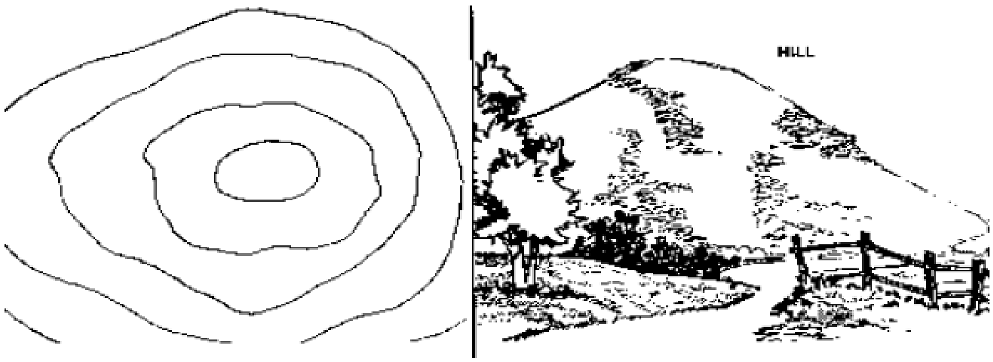
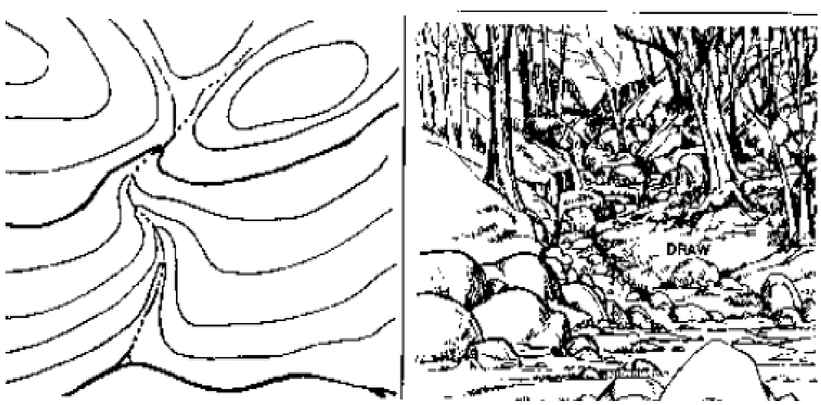
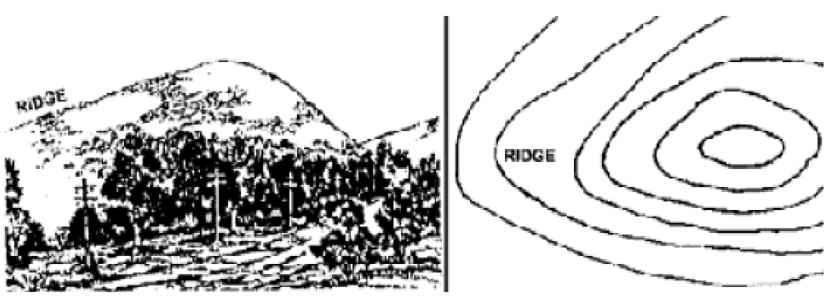



Figure_7: Slope terrain

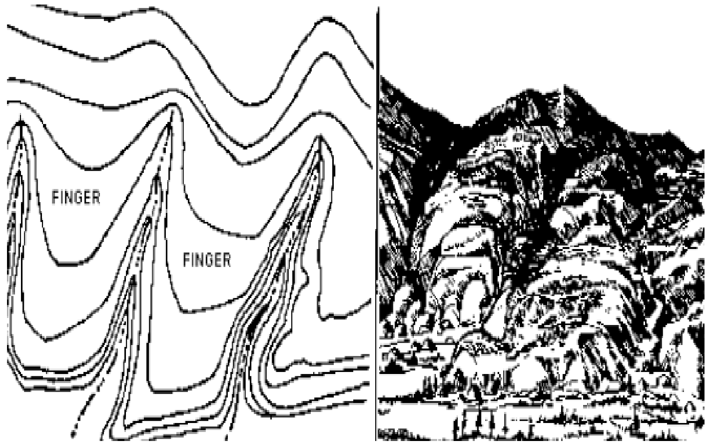
**Draw:** A less developed stream course in which there is essentially no level ground, and therefore, little or no maneuver room within its confines. The ground slopes upward on each side and towards the head of the draw. Draws occur frequently along the sides of ridges. Contours indicating a draw are **V** shaped, with the point of the "**V**" toward the head of the draw.



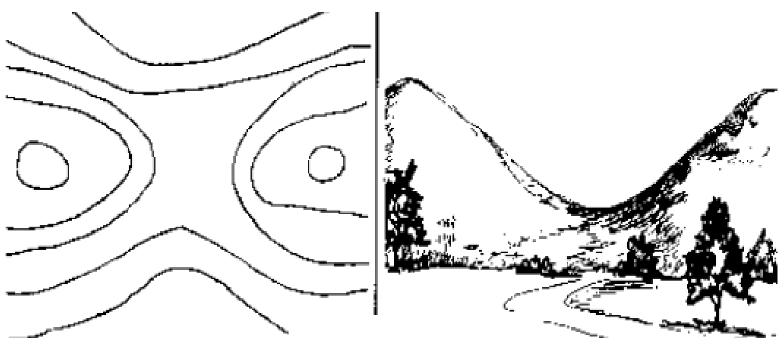

**Ridge:** A line of high ground, with normally minor variations along its crest. The ridge is not simply a line of hills. All points of the ridge crest are appreciably higher than the ground around it.



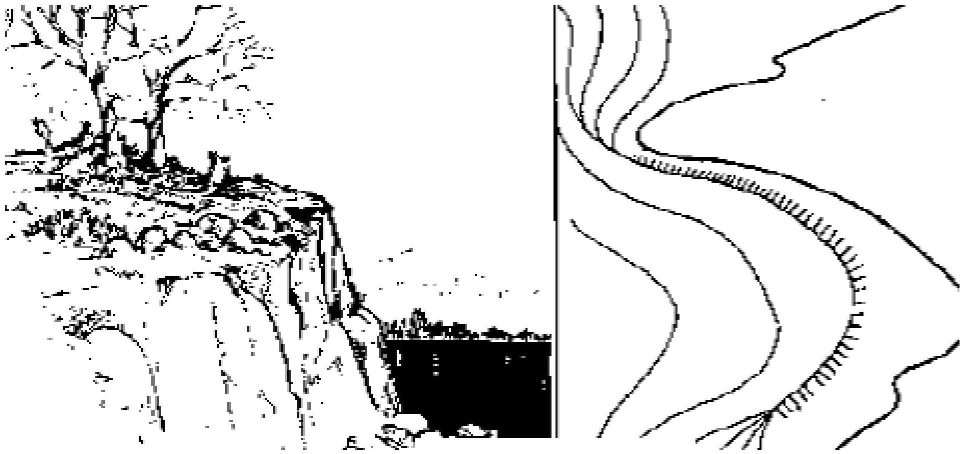
**Finger:** A usually short continuously sloping line of higher ground, normally jutting out from the side of a ridge. A finger is often formed by two cutting draws down the side of a ridge.



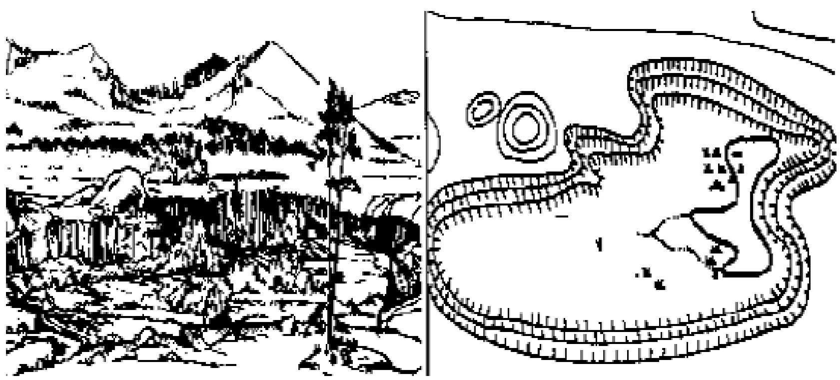

**Saddle:** A dip or low point along the crest of a ridge. A saddle is not necessarily the lower ground between two hilltops. A saddle is simply a dip or break along an otherwise level ridge crest.



**Cliff:** A vertical or near vertical slope. When a slope is so steep that it cannot be shown by the contour interval, it is shown by ticked "carrying" contours. The tick marks always point toward lower level of elevation.



**Depression:** A low point or sinkhole surrounded on all sides by higher ground. Tick marks are used in conjunction with contours to show the lower elevation of a depression. One additional contour with tick marks will be used for each depth equal to the contour interval of the map.



***Estimating Slope***

Slope is used by the operations section in several different ways: to estimate the amount of time it takes to construct a fire line; to determine whether or not a dozer, engine, or hand crew can work in a specific area; to calculate pump pressure needed to reach a location; and to calculate fire behavior characteristics, such as rate of spread.

On incidents, slope is the degree of inclination or steepness and it is usually expressed in percent. A one percent slope indicates a rise or drop of one unit over a distance of 100 horizontal units. For example, a one percent slope rise would indicate a one foot rise over a 100 foot horizontal distance. Slope can be calculated using a topographic map or it can be determined in the field with a clinometers.

To calculate slope using a topographic map, you will need to determine the following:

- ❖ Vertical Distance (also referred to as Rise) – This is the difference in elevation between two points; it is calculated by subtracting the elevation of one point from the elevation of the other point.
- ❖ Horizontal Distance (also referred to as Run) – This is the distance from one point to the other and is calculated by measuring distance with a ruler and applying the map scale.

For example, if the map scale is 1:24,000 and the distance between the two points when measured with a ruler is ½ inch, the horizontal distance would be 12,000 inches or 1,000 feet.

***Slope can then be calculated using the slope formula:***

$$\frac{\text{Vertical Distance}}{\text{Horizontal Distance}} \times 100 = \%\ Slope$$

Another way to write the slope formula is:

$$Rise \big/ Run \times 100 = \%\ Slope$$

*Example on how to calculate percentage of slope using contour map*

**A**. Slope may be expressed in several ways, but all depend upon the comparison of vertical distance (VD) to horizontal distance (HD) (Figure a). Before we can determine the percentage of a slope, we must know the VD of the slope. The VD is determined by subtracting the lowest point of the slope from the highest point. Use the contour lines to determine the highest and lowest point of the slope (Figure b).

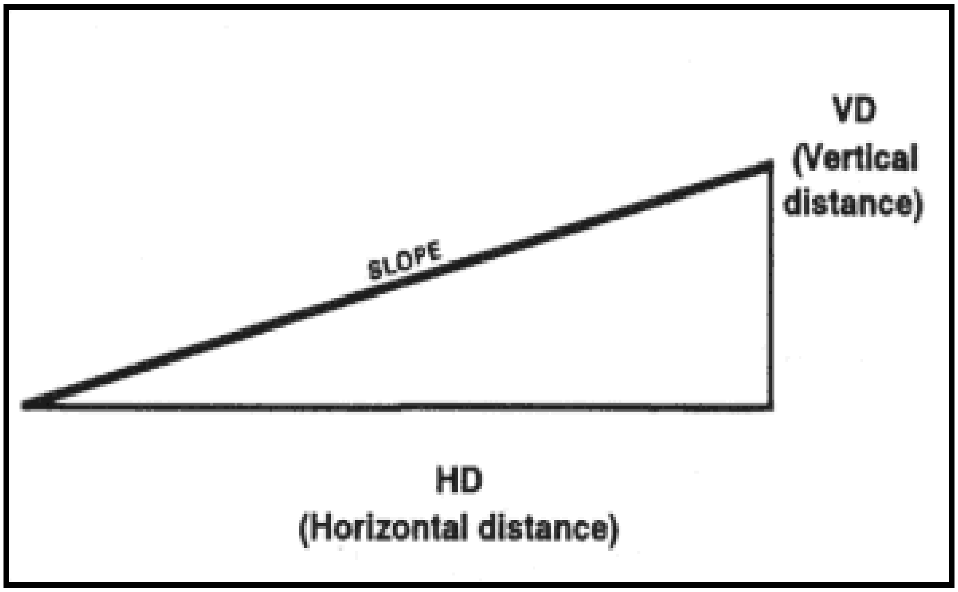



**Figure a. Slope diagram.**

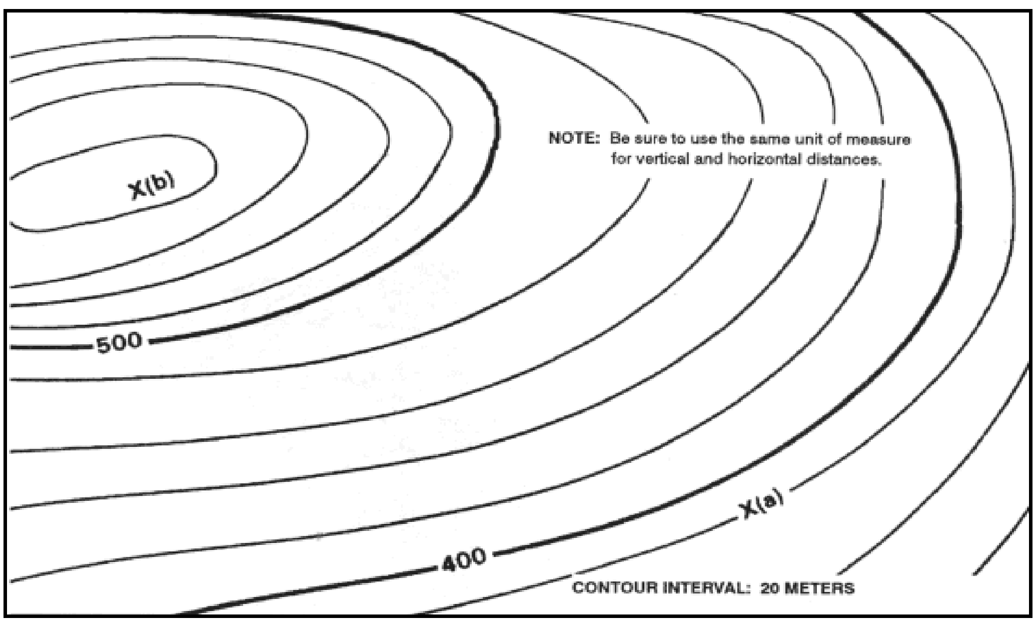



**Figure b. Contour line around a slope.**

**B**. To determine the percentage of the slope between points (a) and (b) in Figure b, determine the elevation of point (b) (590 meters). Then determine the elevation of point (a) (380 meters). Determine the vertical distance between the two points by subtracting the elevation of point (a) from the elevation of point .The difference (210 meters) is the VD between points (a) and (b).

Then measure the HD between the two points on the map in Figure c. After the horizontal distance has been determined, compute the percentage of the slope by using the formula shown in Figure d.

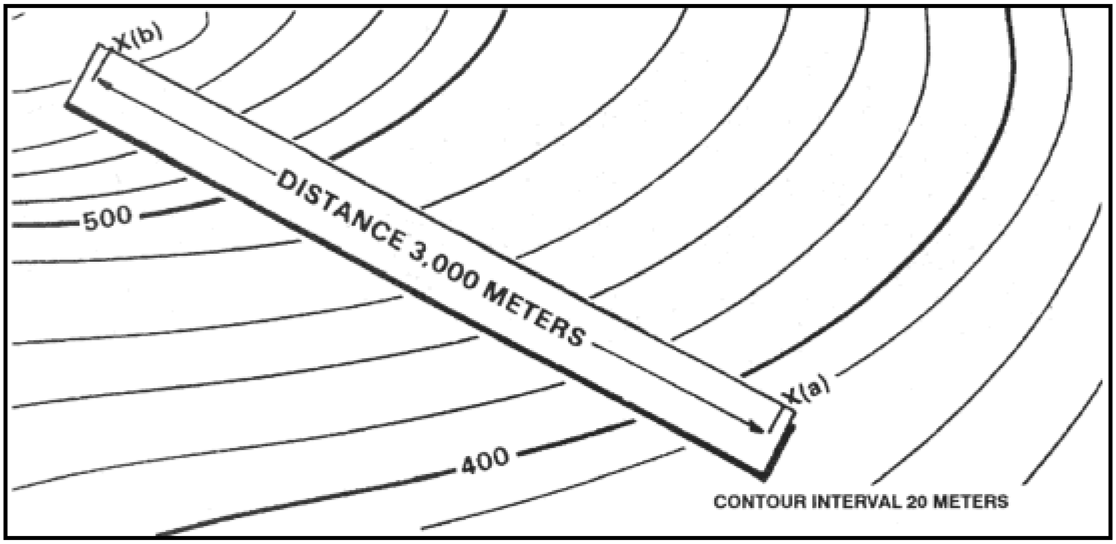



Figure c. Measuring horizontal distance.

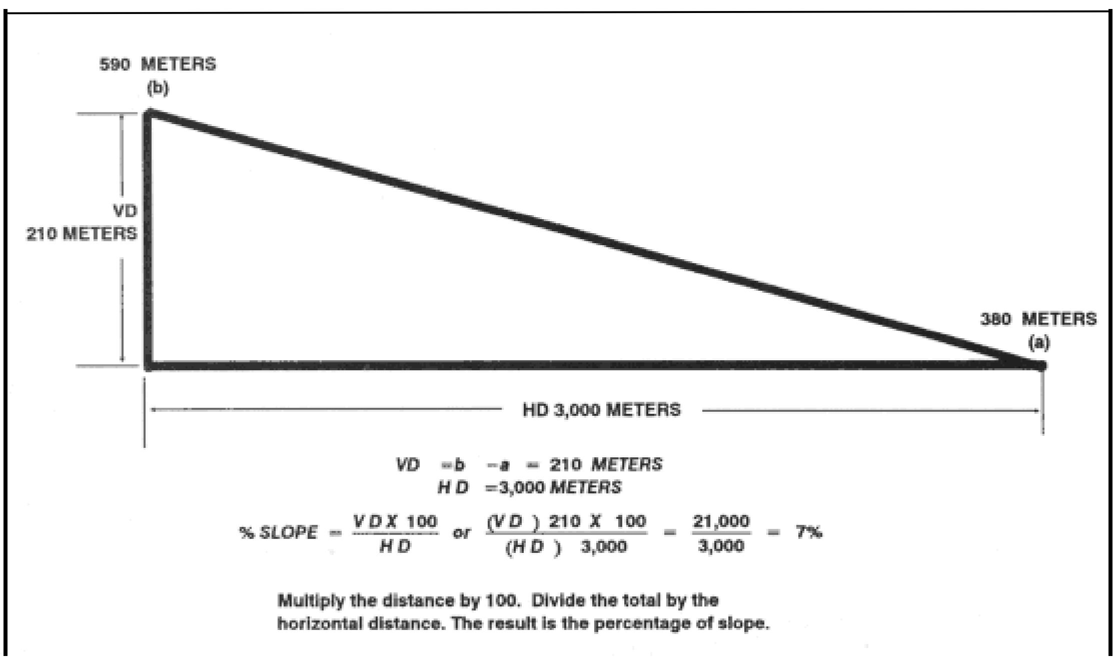



Figure d. Percentage of slope in meters.

**C**. The slope angle can also be expressed in degrees. To do this, determine the VD and HD of the slope. Multiply the VD by 57.3 and then divide the total by the HD (Figure e). This method determines the approximate degree of slope and is reasonably accurate for slope angles less than 20º.

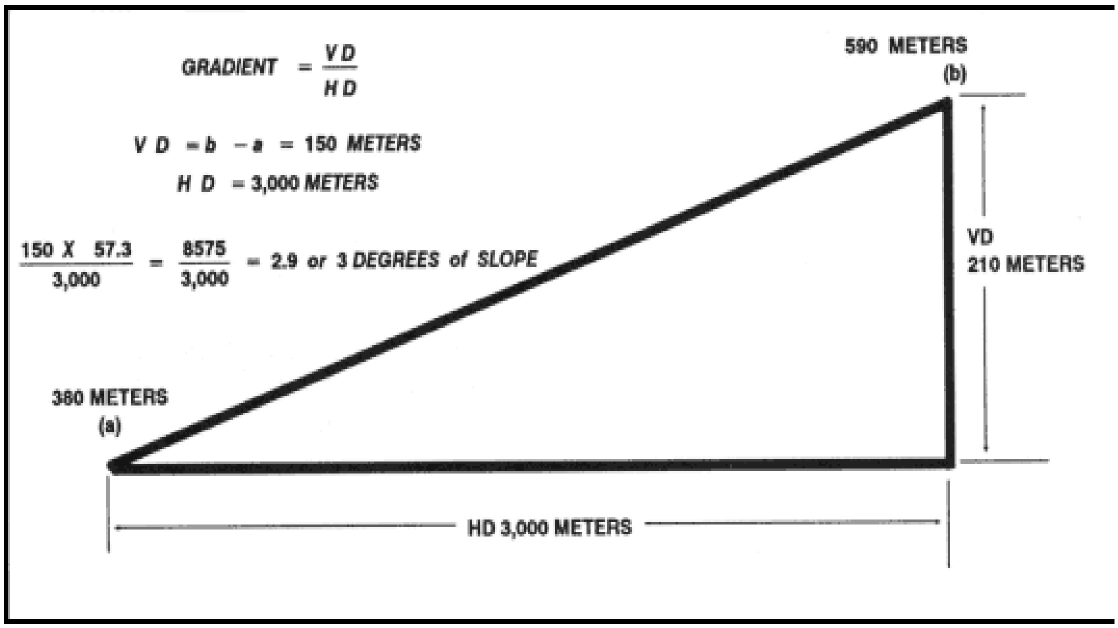



Figure e. Degree of slope.

**D**. The slope angle can also be expressed as a gradient. The relationship of horizontal and vertical distance is expressed as a fraction with a numerator of one (Figure f).

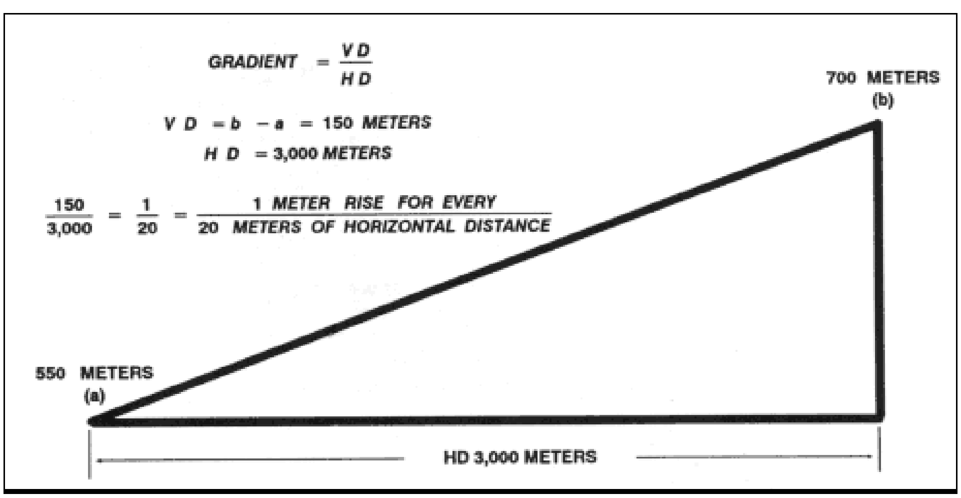



Figure f. Gradient.

| Self check 2 | Written test |
|---|---|

**Name: ________________________ Date: ______________**

Directions: Answer the questions listed below.

1. Write the way of collected soil data on several levels? (5pts)
2. List and explain agricultural land class classification categories? (5pts)
3. Write the factor related to the crop impact on the decision of which irrigation system is to use? (5pts)
4. List and explain water source potential for using irrigation systems? (5pts)
5. Write and explain types of contour lines? (5pts)
6. Write the advantage of reading topographic map? (5pts)

**Note: Satisfactory Rating**; 30 and above **UN satisfactory rating:** below 30

**You can ask your teacher for the copy of the correct answer**

| Operation Sheet 1 | Read topographic map |
|---|---|

**Materials, Tools and equipments used**:-

- ✓ Paper ($A_4$,$A_3$)
- ✓ Ruler
- ✓ Pencil
- ✓ Topographic map
- ✓ Drawing materials
- ✓ GPS

**Objective:** To understand how to read topographic map and identify the features of top map.

**Procedure: -** The following procedures should be taken into account to Carrying out how to read a topographic map.

- ✓ Understand the contour lines
- ✓ Know the land features represented on topo map
- ✓ Learn what the colors represents
- ✓ Know the scale of the map
- ✓ Find true northing

| LAP Test | Practical Demonstration |
|---|---|

Name: _____________________________ Date: ________________

Time started: ________________________ Time finished: ________________

***Instructions:***

You are required to perform any of the following

1. Identify different features of topo maps

2. Report work out come to the teacher

3. Request your teacher for evaluation