SMALL SCALE IRRIGATION DEVELOPMENT LEVEL-I

Model TTLM

Learning Guide #03

Unit of Competence: Support Irrigation water source Identification

Module Title: Supporting Irrigation water source Identification

LG code: AGR SSI1M03 LO1-LO3

TTLM Code: AGR SSI1 TTLM 1218V2

Nominal Duration: 20 Hours

Instruction sheet	Learning Guide -3

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

- Identify potential Irrigation Water sources
- Identify water harvesting Techniques
- Identify catchments areas

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 –

- ✓ Identify potential areas.
- ✓ Identify water contributors.
- ✓ Identify potential water ways.
- ✓ Check soil moisture status & level of ground water.
- ✓ Check appropriate practices to identify ground water area and recharge underground water table.
- ✓ Identify appropriate type and species of trees for afforestation of degraded land.
- ✓ Identify water harvesting techniques.
- ✓ Identify proper site for water harvesting.
- ✓ Choose water harvesting technique.
- ✓ Select shade & lining materials
- ✓ Identify water harvesting principles
- ✓ Introduce surface and ground water hydrology
- ✓ Identify and charactering catchment area for climatic variables.
- ✓ Identify potential irrigation water source for implementation to project stage by community need

Learning Activities

1. Read the specific objectives of this Learning Guide.
2. Read the information written in the "Information Sheets".
3. Accomplish the "Self-check" at the end of each learning outcomes.
4. If you earned a satisfactory evaluation proceed to the next "Information Sheet". However, if your rating is unsatisfactory, see your teacher for further instructions or go back to the Learning Activity.
5. Submit your accomplished Self-check. This will form part of your training portfolio

Information Sheet-1	Identify Potential Irrigation Water Sources

Introduction

Irrigation is defined as the science of artificial application of water to the land or soil. It is used to assist in the growing of agricultural crops, maintenance of landscapes, and re-vegetation of disturbed soils in dry areas and during periods of inadequate rainfall.

1.1 Identifying potential areas

- **Irrigation potential** refers to irrigation as the process by which water is diverted from a river or pumped from a well and used for the purpose of agricultural production.

The definition of irrigation potential is not straightforward and implies a series of assumptions about irrigation techniques, investment capacity, national and regional policies, social, health and environmental aspects, and international relationships, notably regarding the sharing of waters. However, to assess the information on land and water resources at the river basin level, knowledge of physical irrigation potential is necessary. The area which can potentially be irrigated depends on the physical resources 'soil' and 'water', combined with the irrigation water requirements as determined by the cropping patterns and climate. Therefore, physical irrigation potential represents a combination of information on gross irrigation water requirements, area of soils suitable for irrigation and available water resources by basin.

1.2 Identifying water contributors

Sources of irrigation water can be surface water or ground water. Surface water can be withdrawn from rivers, lakes or reservoirs or non-conventional sources like treated wastewater, desalinated water or drainage water or rain water catchment .while the main contributors of ground water may includes :-

1. Spreading Basins:

This method involves surface flooding of water in basins that are excavated in the existing terrain. For effective recharge highly permeable soils are suitable and maintenance of a layer of water over the highly permeable soil is necessary. When direct discharge is practiced the amount of water entering the aquifer depends on three factors—the infiltration rate, the percolation rate, and the capacity for horizontal water movement.

At the surface of aquifer, however, clogging occurs by deposition of particles carried by water in suspension or in solution, by algae growth, colloidal swelling and soil dispersion, microbial activity, etc. Recharge by spreading basins is most effective where there are layer below the land surface and the aquifer and where clear water is available for recharge.

2. Recharge Pits and Shafts:

Conditions that permit surface flooding methods for artificial recharge are relatively rare. Often lenses of low permeability lie between the land surface and water table. In such situation artificial recharge systems such as pits and shafts could be effective in order to access the dewatered aquifer. The rate of recharge has been being found to increase as the side slope of the pits increased.

Unfiltered runoff water leaves a thin film of sediments on the sides and bottom of the pits, which require maintenance in order to sustain the high recharge rates. Shafts may be circular, rectangular or square cross-section and may be back filled by porous materials.

Excavation may be terminating above the water table. Recharge rates in both shafts and pits may decrease with time due to accumulation of fine-grained materials and the plugging effect brought by microbial activity.

3. Ditches:

A ditch is described as a long narrow trench, with its bottom width less than its depth. A ditch system is designed to suit topographic and geological condition that exists at the given site. A layout for a ditch and flooding recharge project could include a series of trenches running down the topographic slope.

The ditches could terminate in a collection ditch designed to carry away the water that does not infiltrate in order to avoid ponding and to reduce the accumulation of fine materials.

4. Recharge Wells:

Recharge or injection wells are used to directly recharge the deep-water bearing strata. Recharge wells could be dug through the material overlaying the aquifer and if the earth materials are unconsolidated, a screen can be placed in the well in zone of injection.

Recharge wells are suitable only in areas where thick impervious layer exists between the surface of the soil and the aquifer to be replenished. They are also advantageous in areas where land is scarce. A relatively high rate of recharge can be attained by this method. Clogging of the well screen or aquifer may lead to excessive buildup of water level in the recharge well.

5. Harvesting in Cistern from Hill Sides:

In this method construction of small drains along contours of hilly area are done so that the runoff in these drains are collected in a cistern, which is located at the bottom of a hill or a mountain. This water is used for irrigation or for drinking purpose and the water is of good quality.

6. Subsurface Dams:

Ground water moves from higher-pressure head to lower one. This will help in semi-arid zone regions especially in upper reaches where the ground water velocity is high. By exploiting more ground water in upper reaches more surface water can be utilized indirectly, thereby reducing inflow into lower reaches of supply. Ground water is stored either in natural aquifer materials in sub-surface dams or in artificial sand storage dam.

7. Farm Ponds:

These are traditional structures in rain water harvesting. Farm ponds are small storage structures collecting and storing runoff waste for drinking as well as irrigation purposes. As per the method of construction and their suitability for different topographic conditions farm ponds are classified into three categories such as excavated farm ponds suited for flat topography, embankment ponds suited for hilly and ragged terrains and excavated cum embankment type ponds.

Selection of location of farm ponds depend on several factors such as rainfall, land topography, soil type, texture, permeability, water holding capacity, land-use pattern, etc.

8. Historical Large Well across Streamlet:

If any historical wells are located near the streamlet, then allow the water into the well from streamlet by connecting drains. In this case the historical wells act as a recharge well so that ground water can be improved.

9. Check Dams:

Check dams are small barriers built across the direction of water flow on shallow river and streams for the purpose of rain water harvesting. The small dams retain excess water flow during monsoon rains in a small catchment area behind the structure.

Pressures created in the catchments area send the impounded water into the ground. The major environmental benefit is the replenishment of nearby ground water reserves and wells. The most common case of check dams is to decrease the slope and velocity of a stream to control erosion

Classification

Water well types.

There are two broad classes of drilled-well types, based on the type of aquifer the well is in:

- ♠ Shallow or unconfined wells are completed in the uppermost saturated aquifer at that location (the upper unconfined aquifer).
- ♠ Deep or confined wells are sunk through an impermeable stratum into an aquifer that is sandwiched between two impermeable strata. Obviously, a well-constructed for pumping groundwater can be used passively as a monitoring well and a small diameter well can be pumped, but this distinction by use is common.

Environmental problems

A risk with the placement of water wells is soil salinization. This problem occurs when the water table of the soil begins to drop and salt begins to accumulate as the soil begins to dry out. Another environmental problem that is very prevalent in water well drilling is the potential for methane to seep through.

I. Spring water

- ♠ Is a place where water that has been filtered through soil and rock reappears from underground.
- ♠ Is formed when the pressure in an aquifer causes some of the water to flow out at the surface.

A spring may flow the whole year or only sometimes. This depends on the water getting into the ground all of the time (rain) or only once in a while (snow melting).

A spring often sends water down, along the land. This is how rivers start.

Fig1.2 A natural spring

Types of spring outlets

- *Seepage or filtration spring.* The term seep refers to springs with small flow rates in which the source water has filtered into permeable earth.
- *Fracture springs,* discharge from faults, joints, or fissures in the earth, in which springs have followed a natural course of voids or weaknesses in the bedrock.
- *Tubular springs* are essentially water dissolved and created underground channels, basically cave systems.

Flow

Spring discharge, or resurgence, is determined by the spring's recharge basin. Factors that affect the recharge include the size of the area in which groundwater is captured, the amount of precipitation, the size of capture points, and the size of the spring outlet.

Springs have been used for a variety of human needs including drinking water, powering of mills, and navigation, and more recently some have been used for electricity generation.

1.3 Identifying Potential water ways

Water ways

- Are Systems in which irrigation water is conveyed from source to the required field of irrigation purpose?
- It consists of diversion structures (diverts water from the source to the canal system) such as weirs, barrage, intake structures and canal system (main canal, sub main canal, distribution canal etc) and pump system for pressurized irrigation systems.

Channels

- ✓ Are the irrigation structure or hydraulic structures through which irrigation water flows into required areas.

- ✓ It is defined as opened or closed conduit structure through which water flow. Example, canal (open) and pipe (closed).

In an irrigation scheme, water is taken from a water source, passes through a network of irrigation canals and is delivered to the farmers' fields by using the following field delivery systems

- Breach
- Gated intake
- Siphons
- Spiles
- Pumping

A breach is a temporary opening in the embankment of the field channel, made by a farmer whose field is to be irrigated

- involves no capital cost, but it has disadvantages:
- frequent opening and closing of breaches weakens the embankment;
- opening and closing a breach changes the cross-sectional shape of the field channel;
- there is no discharge control

A gated intake structure is made of wood, masonry or concrete, and is equipped with a gate (like a door to a room)

- It enables the farmer to <u>control the water inflow</u>, but, in comparison with a breach, it is expensive

Fig 1.4 **gated intake**

A siphon is a curved pipe, often made of a plastic such as PVC.

- The pipe or tube is filled with water and laid over the channel bank at every irrigation
- Good water flow control is possible by changing the number of siphons, the diameter of the siphons or both
- Disadvantage is the price of the pipes.
- Also, for efficient operation, the water **level in the field channel needs to be some 10 cm** above the field.

Fig 1.5 siphon tube

A Spile is a short pipe, commonly made of a hard plastic such as PVC, but clay, wooden (Bamboo) pipes are also used.

- The Spile pipes are **<u>buried in the canal embankment</u>** and water flow through this small pipe
- Good water **<u>intake control can be obtained</u>** either
  - by adjusting the water level in the field channel,
  - by use of a water-level regulator, until it is above or below the opening of the Spiles
  - by closing off individual Spiles with a plug or lid
  - by a combination of the two methods
- Disadvantages
  - Can become blocked with mud or plant debris,
  - Pipes can be expensive.

Pumping

- Not advisable method of water intake to field is by pumping
- Justified only if the field to be irrigated is at higher place than the canal
- For efficient operation of the pump, the water depth and discharge in the field channel must be comparatively large than all other methods

Fig 1.7 pumping system

Selection of method

- The water level in the field canal
- Discharge control
- Irrigation Method
- Irrigation schedule
- Field location

1. The water level in the field canal

- When the **<u>water level in the field channel is only slightly higher</u>** (up to 5 cm) than the level of the field (gated intake is good)
  - Breaches used
- If the difference in water level is small to get required volume of water in the field
  - either a large opening through which water is delivered
  - a long time of delivery
- If the difference in water level is small, **<u>siphon will not work</u>**
- If difference in water level is large (say 15 cm) then breach is not recommended, since it will erode canal bank

2. Discharge control

Not only the difference between the water levels between canal and field, but also the **<u>size of the intake opening determines the flow to field</u>**

- The larger the opening, the larger the flow
- Control is almost impossible in breaches

- ♠ Control is good when gated intake
- ♠ Siphons or Spiles - number can be adjusted or different diameters used according to the discharge required

3. Irrigation method

The mode of water intake should match the irrigation method - whether basin, border or furrow

- ➢ Border or basin Irrigation
  - ♠ The water can enter the field at one point.
  - ♠ practiced by using breach or gate intakes,
- ➢ Furrow irrigation
  - ♠ Requires more delivery points, as each furrow should have its own delivery point.
  - ♠ Needs the use of Spiles or siphons.

4. Irrigation schedule

Two factors for considering the schedule

a)What is the **<u>duration and frequency of water supply</u>** to the field

- ♠ If duration of water delivery to the field is short, gated intake preferred
- ♠ Breaches requires some time to open, frequent opening will degrade the bund
- ♠ Siphon requires time to get started
- ♠ Spile can be used for furrows if time is short

b)<u> How many fields are supplied</u> or are there two or more field to be supplied from one intake

- ♠ If more than one uses, breach cannot control delivery for equal discharge
- ♠ Levels of field is not equal, hence gated supply not useful
- ♠ To ensure equal water intake, siphons or spiles are recommended because the total discharge is determined by the number and diameter of tubes

5. Field location

- ➢ If the field to be irrigated is situated in the upper part of a channel, then the use of a breach should be avoided, because
  - ♠ breaches can seriously damage the shape of a channel
  - ♠ affect the delivery of water to farmers downstream
- ➢ When a large opening is needed, a gated intake is much more practical (at head end)

1.4. Checking soil moisture status and level of ground water

Introduction

Soil moisture is the water that is above the water table extending down from the ground surface is the soil zone or root zone which is defined as being the depth of over burden that is penetrated by the root of vegetation.

Groundwater has an important role in the environment: it replenishes streams, rivers, and wetlands and helps to support wildlife habitat; it is used as primary source of drinking water and also in agricultural and industrial activities. Around the world, groundwater resources are under increasing pressure caused by the intensification of human activities and other factors such as climate changes. Reductions in groundwater stores have implications for the water cycle because groundwater supplies the base flow in many rivers and it supports Evapotranspiration in high water table regions. Reductions in groundwater storage also have major implications for water quality because the salinity of the extracted water frequently increases as the volume of the reservoir decreases. Groundwater resources need to be carefully protected because in many regions, withdrawal rates exceed recharge rates. Once modified or contaminated, groundwater can be very costly and difficult to restore.

In fact the purposes of groundwater monitoring are:

1. collecting, processing and analysing the data as a baseline for assessment of the current state, anticipating changes and forecasting trends in groundwater quantity and quality due to natural processes and human impacts in time and space;
2. Providing information for improvements in the planning, policy and management of groundwater resources.

Groundwater monitoring is a continuous, methodologically and technically standardized process involving in situ, satellite and airborne observations and laboratoryanalysis of quality variables. In fact a groundwater monitoring programme includes both groundwater quantity (e.g. groundwater level and recharge rates) and quality monitoring (analysis of selected physical and chemical variables) networks.Groundwater monitoring programmes operate at the international, national, regional and local scales:at local scales, groundwater monitoring activitiesoften include a great density of monitoring wells, multilevel groundwater sampling of the unsaturated and saturated zones, high sampling frequency, and analysis of variables chosen; numerical models used on regional scales are valuable to fill in spatial and temporal gaps in in situ monitoring, although their reliability is more uncertain when high quality input data are not available. Satellite observations are now playing an increasingly important role in global groundwater resources assessment and groundwater storage change, but only at lower spatial and temporal resolutions.

All these information types, used synergistically, can yield a consistent picture of the current state of global groundwater resources, so that in the future it will be possible to provide more accurate prediction of variations in groundwater availability.

1. Definitions and units of measurement

Several critical variables must be considered under the heading "groundwater": groundwater level, groundwater recharge and discharge, well groundwater level and water quality.

Of these, monitoring groundwater levels usually takes priority because it is a direct indicator of groundwater supply and withdrawal rates.

- ***Groundwater level (m):***defined as the depth or elevation aboveor below sea level at which the surface of ground water stands. The level of the water table, the upper surface or top of the saturated portion of the soil or bedrock layer that indicates the uppermost extent of groundwater. It can be expressed as a height above a datum, such as sea level, or a depth from the surface.
- ***Groundwater recharges(m/s):*** process that occurs naturally where permeable soil or rock allows water to readily seep into the aquifer. This takes place intermittently during and immediately following periods of rain and snowmelt, which are the principal sources for replenishment of moisture in the soil water system. This depends on the rate and duration of rainfall, the subsequent conditions at the upper land surface boundary, the antecedent soil moisture conditions, the water table depth and the soil type. Monitoring of groundwater recharge allows for estimation of its temporal variability and areal distribution.
- ***Groundwater discharge (m/s):*** process in which groundwater that enters the terrain in recharge areas leaves the aquifer at discharge points. When the water table intersects the land surface there is a discharge zone. Discharge points typically occur as seepage into wetlands, lakes and streams. Monitoring of natural groundwater discharge (springs, bank seepage and base flow) provides data needed for calculation of groundwater balance and storage.
- ***Well head level (m):*** The elevation of a well top above sea level. A well is an opening in the surface of the earth for the purpose of removing fresh water. Wells represent keyholes to aquifers, which allow groundwater level variations, pressure and quality measurements to be made and thus furnish information from which the health of the

aquifer system can be judged. Monitoring wells are located outside of the impact of pollution sources and influence of groundwater abstraction sites on groundwater system. Monitoring wells serve to observe one aquifer only. Well design should permit separate measurement and testing of individual aquifers.

- ***Water quality*** *is* the composition of constituents dissolved or contained within the water in the functioning of natural processes and human activities. Chemical composition is the most invoked factor in characterizing water quality. Biological, physical, and radiological factors are also considered when discussing water quality.

2. Existing measurements methods and standards

In situ measurements

When holes are drilled they provide unique in-situ data on groundwater resources and the initial test pumping provides key baseline reference information on groundwater quantity and quality.

To determine groundwater elevation above mean sea level, use the following equation:

$$\mathbf{E_W = E - D}$$

Where:

$\mathbf{E_W}$ = Elevation of water above mean sea level (m) or local datum

E = Elevation above sea level or local datum at point of measurement (m)

D = Depth to water (m)

GROUNDWATER BALANCE EQUATION [C. P. Kumar, National Institute of Hydrology]

The estimation of the groundwater balance of a region requires quantification of all individual inflows to or outflows from a groundwater system and change in groundwater storage over a given time period. The basic concept of water balance is:

Change in storage of the system= Input to - outflow from
(Over a period of time) the system the system

Considering the various inflow and outflow components in a given study area, the groundwater balance equation can be written as:

$$\mathbf{Rr + Rc + Ri + Rt + Si + Ig = Et + Tp + Se + Og + S}$$

Where:

Rr = recharge from rainfall;

Rc = recharge from canal seepage;

Ri = recharge from field irrigation;

Rt = recharge from tanks;

Si = influent seepage from rivers;

Ig = inflow from other basins;

Et = Evapotranspiration from groundwater

Tp = draft from groundwater

Se = effluent seepage to rivers;

Og = outflow to other basins;

S = change in groundwater storage [C. P. Kumar, National Institute of Hydrology].

Preferably, all elements of the groundwater balance equation should be computed using independent methods. However, it is not always possible to compute all individual components of the groundwater balance equation separately. Sometimes, depending on the problem, some components can be lumped, and account only for their net value in the equation.

Tools of measurement

Different techniques can be used to measure the groundwater level within the piezometer or well, including:

- ***Plopper,*** where a concave metal casting attached to the graduated tape makes a plopping noise when it hits the groundwater surface.
- ***Electrical sounder,*** where the insulated wires for a pair of electrodes are incorporated into a graduated flat tape. A circuit is completed when the electrodes come into contact with the groundwater surface, which activates a light and/or buzzer
- ***Wetted-tape****,* where a weighted tape that is rubbed with colored chalk is lowered down the piezometer until it is submerged. The water level is indicated by where the chalk has been removed.
- ***Bubble tube***, where a length of plastic tubing marked with depth increments is lowered down the piezometer. Contact with the standing water is distinguished by blowing into the tube and listening for the sound of bubbles.
- ***Automatic water level recorders***, similar to that used in surface water bodies such as pressure transducers, or capacitance probes.

1.5. Checking appropriate practices to identify ground water area and recharge underground water table.

Water table, which is the top most part of groundwater, may be located near or even at land surface and not fixed meaning it fluctuate seasonally.

Two zones can be distinguished in which water occurs in the ground:

a) The unsaturated zone/ Zone of aeration b) The saturated zone

Unsaturated Zone**:** This is also known as zone of aeration or vadose zone. In this zone the soil pores are only partially saturated with water. The space between the land surface and the water table marks the extent of this zone. Further, the zone of aeration has three sub zones: soil water zone, capillary fringe and intermediate zone. The zone below soil water zone (capillary fringe and intermediate zone) are called vadose zone.

The soil water zone lies close to the ground surface in the major root band of the vegetation from which the water is lost to the atmosphere by Evapotranspiration. Capillary fringe on the other hand hold water by capillary action. This zone extends from the water table upwards to the limit of the capillary rise. The intermediate zone lies between the soil water zone and the capillary fringe.

Saturated Zone: Groundwater is the water which occurs in the saturated zone. All earth materials, from soils to rocks have pore spaces although these pores are completely saturated with water below the groundwater table or phreatic surface (GWT).

The vertical distance from the ground surface to the water table varies from place to place - it may be a few feet, or several hundred feet. Generally, the water table is deeper beneath hills and shallower beneath valleys. It is hardly ever flat! In any one place the water table usually rises with increased recharge from precipitation and declines in response to seasonally dry weather, drought, or excessive pumping of ground water. If however the water table is hundreds of feet down, it may take years for the infiltrating water to reach the saturated zone and there will be no seasonal change in water table levels. If ground water is "confined" by overlying impermeable rock formations, the well water levels represent a pressure level and not a water table level.

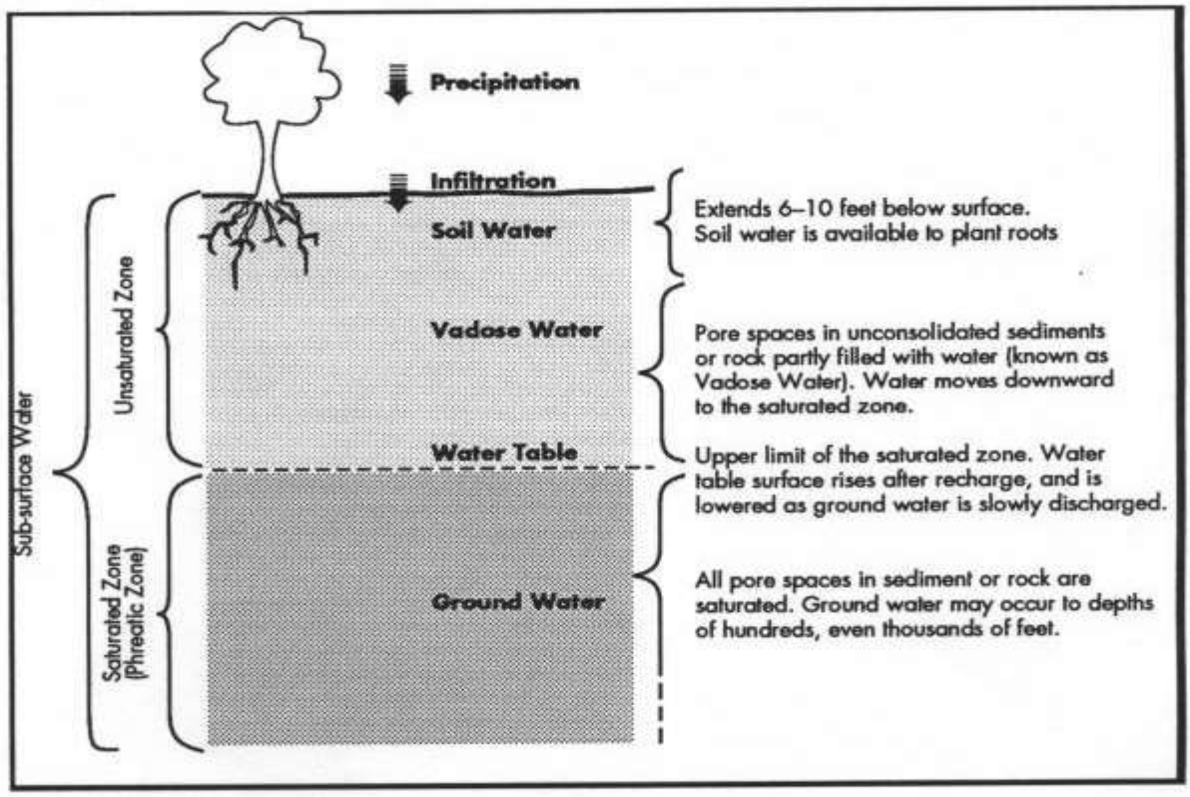

Fig: 1.8: Subsurface water and its contributors

The spaces between soil or sediment particles and cracks in solid rock are called ***voids or pores***. Each sediment and rock type has differences in porosity, (the amount of water a rock formation can hold).

Porosity is expressed as the ratio of pore space to solid material per unit volume. For example, saturated sand may have 30% pore space to 70% solid material, while fractured granite may have 1% pore space to 99% solid rock. The sand is therefore more porous than the fractured granite.

Imagine a cubic foot of granite and a cubic foot of sand with porosity of 1% and 30%. Now add water to each. The granite will "fill up" first because there is less pore space. If it were a real aquifer, the water table level in the granite would rise faster. Similarly, because there is less storage than in the sand, the fractured granite water table would decline more rapidly in response to pumping or drought. Ground water is always on the move, although usually very slowly. The discharge (or outflow) of water from aquifers occurs as part of the natural movement of water in the hydrologic system. Water table levels in aquifers therefore represent the combined effects of rates of recharge and rates of discharge. If pumping of aquifers takes place in excess of recharge then resource use will eventually not be sustainable. Careful monitoring of water levels in wells can show how water table levels change, and well data, with water levels and dates of the measurement are very important for ground water management. For any well data however it is very important to know exactly which rock formations the well penetrates.

There can be more than one aquifer beneath the surface! Water table information, in addition to other information about geology, precipitation and pumping rates are of great value when assessing ground water potential.

Ground water can be recharged by using two methods these are:

By natural method: these methods includes

- Rainfall filtrates into the underground.
- Snow melt filtrates into the underground.
- Stream flow that soaks into the ground and in underlying aquifer.

By artificial method: these methods includes

- Recharge ponds
- Injection wells
- Storm water/drain
- Irrigation
- Surface run off

1.6 Identifying appropriate type and species of trees for afforestation of degraded Land.

Afforestation is planting of trees in areas that have not previously held by forests or is the planting of trees in deforested areas.

Itis the restocking of existing forests and woodlands which have been depleted, an effect of deforestation.

Before afforestation After afforestation

Figure: 1. 9. *Areas before and after afforestation*

Trees may be planted:

- To provide timber and wood pulp;
- To provide firewood in countries where this is an energy source;

- ♠ To bind soil together and prevent soil erosion and to act as windbreaks.

A sustainable and well-planned afforestation project helps improve soil conservation**,** management andwater quality**.** Afforestation projects undertaken without a complete understanding of the surroundings can cause additional environmental damages. For instance, fast-growing trees commonly used in timber plantations consume huge amounts of water, hence depleting water resources around the area. There are also concerns about irreversible changes in the soil caused by exotic species. For example, pine trees are known to turn the soil acidic. The water from the soil eventually trickles down to local streams and water bodies, which, in turn, causes harm to both the water and land ecosystems. In areas of highly degraded land, afforestation is the main solution to retard soil erosion and it also enhances or improve soil water holding capacity or intake rate of the soil.

Self-Check 1	**Written Test**

Name: ___________________________ Date: ________________

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

1. Define irrigation and its advantages (3point)
2. Write the contributors of water for irrigation (2point)
3. Write the purpose of ground water monitoring (2point)
4. Write definition and measurement unit for the following variables of groundwater”: groundwater level, groundwater recharge and discharge, well head level and water quality. (5point)
5. Write the artificial methods used for recharging ground water (4point)
6. Discuss different techniques used to measure underground water level. (4point)
7. What is water table and saturated zone as well as unsaturated zone? (3point)
8. What is afforestation and its purposes (3point)

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

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

Operational Sheet – 1	**Practical-1**

Direction: Identify surface and ground water sources for irrigation.

Procedure:

1. Identify surface water sources, like river, lake, pond, reservoir etc.
2. Identify ground water sources, like well water and spring water.
3. Determine the amount of water that gets from surface and ground water sources.
4. Determine the quality of water that satisfy crop water requirement.

Lap Test	**Practical Demonstration**

Name: ____________________ Date: _____________

Time started:________________ Time finished:________

Instructions:

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

- Identify ground water sources, like well water and spring water.
- Measure the source of water discharge

Request you teacher if there is problem

Information Sheet-2	Identifying Water harvesting Techniques

Introduction

Water harvesting is a technique used for concentration, collection and storage and use rainfall via runoff for various purposes such as domestic, livestock and agricultural use.

It is collected from various hard surfaces such as rooftops and or other manmade above ground hard surfaces

It is a system which consists of:-

- catchment area (the surface on which runoff is generated)
- command area (the area where runoff is utilized)
- runoff transfer infrastructure (channels, gullies, hard surfaces)
- Diversion method and storage structures.
- Silt trap/sediment pond(in case of ex-situ)

2.1 Identifying Water Harvesting Techniques

In most cases the water harvesting techniques fall under three basic categories whose main characteristics are summarized as follows:

1. Micro catchments rainwater harvesting: sometimes referred to as "Within-Field Catchment System" .It is runoff collected close to the crop growing area and used to replenish soil moisture.

Main characteristics:

- overland flow harvested from short catchment length
- catchment length usually between 1 and 30 meters
- runoff stored in soil profile
- ratio catchment: cultivated area usually 1:1 to 3:1
- Normally no provision for overflow since it handles small flows.
- plant growth is even

Typical Examples:

- Negarism Micro catchments (for trees)
- Contour Bunds (for trees)
- Contour Ridges (for crops)
- Semi-Circular Bunds (for range and fodder)

2. Macro-catchment rainwater harvesting: also known as external catchment systems, handle large runoff flows diverted from some source such as a road, home compound, pasture or hillside.

Long Slope Catchment Technique

Main Characteristics:

- overland flow or rill flow harvested
- runoff stored in soil profile
- catchment usually 30 - 200 meters in length
- ratio catchment: cultivated area usually 2:1 to 10:1
- provision for overflow of excess water
- uneven plant growth unless land leveled

Typical Examples:

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

3 .Floodwater farming (floodwater harvesting): often referred to as "Water Spreading" and sometimes "Spate Irrigation"

Main Characteristics:

- turbulent channel flow harvested either (a) by diversion or (b) by spreading within channel bed/valley floor
- runoff stored in soil profile
- catchment long (may be several kilometers)
- ratio catchment: cultivated area above 10:1
- provision for overflow of excess water

Typical Examples:

- Permeable Rock Dams (for crops)
- Water Spreading Bunds (for crops)

2.2 Identify proper site for water harvesting

The site which is used for water harvesting must be satisfying the following points. These are:

- The area must collect sufficient runoff water.
- The runoff water collected from the area should be easily diverted to the storage tank.
- The area should be located sufficiently away from pollution sources.
- The area must generate as little sediment as possible.

2.3 Choosing Water Harvesting Techniques

The water harvesting techniques must be identifying for one specific area based on *applicability* and *adaptability* for that area it may be micro, macro or flood water harvesting techniques.

2.4 Selecting Shade and lining materials

The main advantage of using shades and lining materials for water harvesting structures is

- ✓ To reduce evaporation and seepage loss respectively.

Seepage losses

- ♠ Appropriate and low cost lining materials should be used in order to reduce the water losses through seepage.
- ♠ The following materials are mostly used for lining water tanks.
  - ➢ Red clay
  - ➢ Termite mound.
  - ➢ Cement mortar
  - ➢ Concrete
  - ➢ Stone or brick with cement mortar
  - ➢ Polyphone sheet (plastic lining) - the thickness should not be less than 0.5 mm.

Evaporation losses

- ♠ Reducing evaporation is an important way to increase the supply of water.
- ♠ Therefore, the following measures should be taken:
  - ➢ The storage tank should be covered with appropriate roofing materials that inhibit vaporization.
  - ➢ Surface area of the storage tank should be minimizing to reduce the cost of tank roofing.

2.5 Identifying Water Harvesting Principles

Both large and small scale water harvesting techniques follow the same principles to create the most effective ways of capturing water. The principles described here come from the University of Arizona Water Harvesting course taught by James Riley and from the textbook used in the class, written by Tucsonan Brad Lancaster.

Start with observing the site

Start with careful observations of where the water flows, how the water flows, and what is already working on the site. This will save large amounts of time and effort when installing harvesting techniques.

Start at the top

Allow gravity to assist in water harvesting. Begin by working on the highest area of the site. (This may be the roof of a house.) By doing this, the water is controlled before it can gain speed and volume.

Keep it simple

Install techniques that can be done by hand, and can be easily fixed if damaged. Installing numerous small harvesting techniques rather than one big project allows for better infiltration of the water.

Slower is better

Try to slow the flow of water as much as possible and spread it across the site, rather than allowing the water to run off the site.

The more the better

In locations where abundant water can flow, plan an overflow route. The overflow water should be harvested, rather than directed off the site. A series of check dams and basins is an effective way to manage overflow.

Green is good

Try to maximize the ground cover by adding plants to the site. Plant roots loosen the soil and allow easier infiltration of water into the soil.

Use multi-functional techniques

This is the most advanced principle, but it can have the most impact to a site. Turn berm and check dams into walking paths and bridges. Select plants that can provide shade and cool your home, or even provide food.

Always critique the site

As with the careful observation of the site prior installation, it is always important to observe the site even after the initial harvesting techniques are placed on the site. Keep track of what the water is doing and how the site can be improved.

With a little time and effort, any site can be transformed into a sustainable oasis using these eight principles. It is important to remember that rainwater harvesting on a site is never finished and can always be improved.

2.6 Introducing surface and ground water hydrology

Hydrology is defined as the science that deals with the depletion and replenishment of our water resources. It deals with surface as wells as ground waters, as far as their occurrence, circulation, distribution, chemical and physical properties, reactions to environment and living beings etc. are concerned. Most of the earth's water sources ,such as ,rivers ,lakes ,oceans and underground sources ,gets their supplies from the rains, while the rain water in self, is the evaporation from the sources .water is lost to the atmosphere as vapor from the earth,which is then precipitated back in the form of rain,snow,hail,dew,sleet or frost etc. This evaporation and precipitation continues for ever and thereby, a balance is maintained between the two .this process is known as *hydrological cycle*.

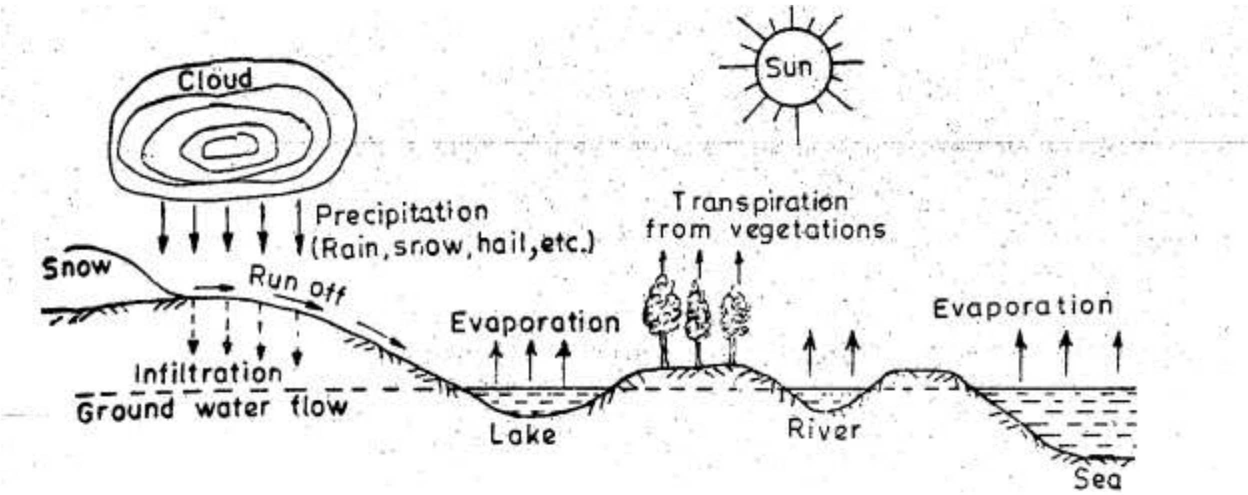

Fig 2.1: **hydrological cycle**

Surface water is the water occurs on the ground surface from rains, rivers, ponds, lakes etc. that is used for domestic and irrigation purposes. It is the main source of water and it also recharges the underground water through seepage, percolation etc.

Ground water is the underground water that occurs in the saturated zone of variable thickness and depth, below the earth's surface. Cracks and pores in the existing rocks and unconsolidated crystal layers, make up a large underground reservoir, where part of the precipitation is stored.

The ground water is utilized through wells and tube wells. Various lifting devices, such as those animals, manual, wind, diesel or electric power can be used for lifting water from wells. The use of open wells is a traditional method of tapping ground water in areas where ground water table is high. The use of tube wells, however, is a subsequent development in the techniques of tapping ground water, and certainly requires diesel or electric power.

The rainfall that percolates below the ground surface passes through the voids of the rocks and joins the water table. These voids are generally inter-connected, permitting the movement of the ground water. But in some rocks, they may be isolated and this preventing the movement of water between the interstices. The mode of occurrence of ground water therefore, depends largely upon the type of formation, and hence depends upon the geology of the area.

The possibility of occurrence of ground water mainly depends on upon two geological factors i.e. the porosity of the rocks and the permeability of the rocks.

The porosity of a rock, which is the major geological criteria for occurrence of ground water, is a quantitative measurement of the interstices or voids present in the rock. It is generally defined as the percentage of the voids present in a given volume of aggregate.

Porosity=Total volume of voids in the aggregate (Vv)

Total volume of the aggregate (V)

It is generally denoted by the letter n.

Therefore **n**=**<u>Vv</u>***100(percent)

V

Porosity, in fact, depends upon the shape, packing and degree of sorting of the component grains in a given material. Uniform and well sorted grains give rise to higher porosity; whereas, heterogeneous grains with irregular arrangement decrease the porosity.

The porosity of rocks and unconsolidated materials may vary considerably. It may be less than 50%.but generally; it does not exceed 40% except in very poorly compacted materials. In general, a porosity greater than 20% is considered to be large and below 5% as small and between 5 to 20% as medium.

Table 2.1 Porosity values of a few rock formations

S.no	***Type of rock formation***	***Porosity***
1.	Granite, Quartzite	1.5%
2.	Slate, shale	4%
3.	Limestone	5 to 10%
4.	Sandstone	10 to 15 %
5.	Sand and gravel	20 to 30%
6.	Only gravel	25%
7.	Only sand	35%
8.	Clay and soil	45%

The permeability rockis defined as the ability of rock or unconsolidated sediment, to transmit or pass water through itself. The permeability is measured in terms of coefficient of permeability. Various methods including constant head permeameter and variable head permeameter are used to measure permeability.

Self-Check 2	Written Test

Name: ___________________________ Date: ________________

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

1. Define water harvesting and what its system consists of (4points)
2. Write water harvesting techniques (4point)
3. What are the points used for identifying proper water harvesting site (3point)
4. Why lining and shading of water harvesting structures are needed for (5point)
5. What are the points in which hydrologic cycle consists of (4point)

Note: Satisfactory rating - 10points and above Unsatisfactory – below 19 points

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

Operational Sheet – 2	Practical-2

Direction: Construction or preparation of storage tanks for storing water by using different water harvesting techniques.

Procedure:

1. Calculate the amount of runoff harvesting from the catchment area.
2. Construction of diversion channel.
3. Construction of silt trap/sediment pond.
4. Finally, construction of storage tanks.

Information Sheet-3	Identify catchment areas

Introduction

Catchment area

- Is defined as the land area that contributes runoff to a given *Hydro Edge*.
- Is a natural or man-made unit draining runoff water to a common point?

3.1 Identifying and characterizing catchment areas for climatic variables

Selection of catchment and cultivation area

- Selection of the catchment area is based on:-
  - The catchment area must collect sufficient runoff water should have low infiltration
  - The runoff water collected from the catchment area should be easily diverted to the tank.
  - The catchment area should be located sufficiently away from pollution sources
  - The catchment must generate as little sediment as possible.
- Selection of the cropping area is also based on its infiltration characteristics, water storing capacity and its nutrients. **Cropping areas** should have:
  - high infiltration
  - low runoff
  - high water storing capacity
  - good plant nutrition

General Soil requirements in the catchment areas and the cropping areas

Catchment area:

a. Macro catchments systems

- clayey / loamy soil with some clay and silt, sodic soils and rock surfaces
- compact structure
- shallow soils (<1m)

b. Micro catchment systems

- Medium texture, deep soil, crust-forming capability

Earth works

- Stable soil types not subject to piping

- No soils which crack on drying high proportion of montmorillonite clay
- No erodible soils (sandy soils, silty-sandy soils or soils with very poor structure)

Cropping areas

- medium texture /infiltration/
- good structure (high organic matter)
- 1.0- 2.5 m deep
- Nutrient-rich, low salinity.

Catchment areas are in general two types. These are surface and roof catchment area.

A. Surface catchment area

Water must be collecting from surface catchment it may be bare land, forest, cultivated area etc.

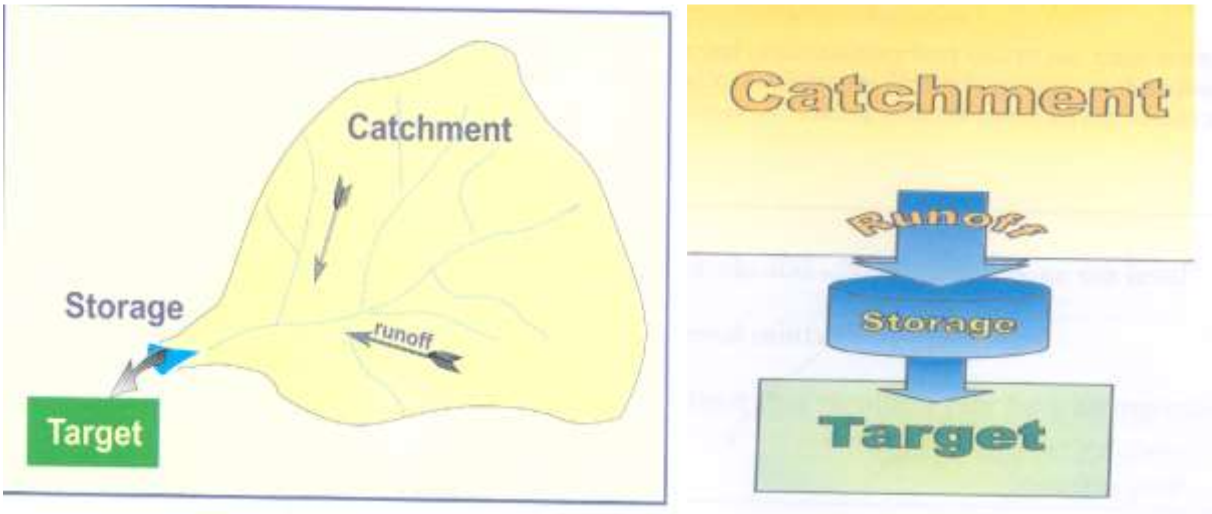

Fig. 3.1 **Principle of surface catchment area**

Estimation of run-off from surface catchments

$$Q = CIA/360$$

Where Q= run off discharge rate (m^3/s)

C = run-off coefficient

I= rain fall intensity (mm/hr)

A= catchment area (ha)

Table 3.1. Runoff coefficient values for use with the rational formula.

		loam	Clay and silt loam	Tight clay
Wood Land	**Flat (<5% slope)**	**0.10**	**0.30**	**0.40**
	Rolling (5-10% slope)	**0.25**	**0.35**	**0.50**
	Hilly (10-30% slope)	**0.30**	**0.50**	**0.60**
Pasture	**Flat (<5% slope)**	**0.10**	**0.3**	**0.40**
	Rolling (5-10% slope)	**0.16**	**0.36**	**0.55**
	Hilly (10-30% slope)	**0.22**	**0.42**	**0.60**
Cultivated	**Flat (<5% slope)**	**0.30**	**0.50**	**0.60**
	Rolling (5-10% slope)	**0.4**	**0.60**	**0.70**
	Hilly (10-30% slope)	**0.52**	**0.72**	**0.82**
Urban areas		**30% 0f area impervious**	**50% 0f area impervious**	**70% 0f area impervious**
	Flat (<5% slope)	**0.40**	**0.55**	**0.65**
	Rolling (5-10% slope)	**0.50**	**0.65**	**0.80**

B. Roof catchment area

Roof water harvesting systems gather rainwater caught on the roof of a house or other areas using gutters and down-pipes (made of local wood, bamboo, galvanized iron or PVC) and lead it to one or more storage containers ranging from simple pots to large tanks.

Rainwater can be collected from most forms of roof. Tiled or sheeted roofs, of corrugated mild steel, are preferable being the easiest to use and give the cleanest water. Asbestos sheeting or lead-painted surfaces should be avoided if possible due to health problems.

Estimation of run-off from roof catchments

$$Q = A\,(C \times p)$$

Where A = roof area required (m^2)

Q = Run –off amounts that is harvested (m^3 or liter)

C = run-off coefficient

p = annual precipitation (mm)

Table 3.2 Roof catchments run-off coefficients

Roof catchments	Run-off coefficient
Sheet metal	0.9
Cement tile	0.7
Clay tile	0.4

3.2 Identifying potential Irrigation water source for implementing project stage by community need

In most needs assessment surveys, a need means something that specially relates to a particular group or community. It is not usually a universal need, such as the need for food or affection .but it is more than individual need, asin I need a new couch for the living room or I really need a vacation .those may truly be needs, but they are not generally the types of needs that are assessed in needs assessment surveys.

We have taken some time to talk about community needs, since knowing them is fundamental for good community development for irrigation project work. But despite their importance, needs are just part of picture .the other part, at least as basic, is community assets the skills,interest,capacities and other resources that can be found in any community. Those assets ought to be identified, just as thoroughly as needs.

In general, however, needs assessment surveys have some common characteristics?

- They have a pre-set list of questions to be answered
- They have a pre-determined sample of the number and types of people to answer these questions in advance
- They are done by personal interviews,phone or by written response(e.g. a mail-in survey)
- The results of the survey are tabulated, summarized, distributed, discussed and Last but not least used.

Eventually, for any project designer or implementer, before coming to construct any irrigation project, it is better to discuss or aware the community their need by making deep

Assessment methods of discussion to identify the potential irrigation water sources and its final implementation of the project stage.

Self-Check 3	Written Test

Name: ___________________________ Date: ________________

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

1. Define catchment area (3point)
2. Write the factors in which a selection of catchment area is based on (4point)
3. Write the formulas of run-off from surface catchments and from roof catchments (5point)

Note: Satisfactory rating - 6 points and above Unsatisfactory - below 6 points

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

Operational Sheet – 1	Practical-1 Estimate run-off from surface catchment

Direction: Estimate Run-off Discharge rate of surface catchment

Procedure:

1. Determine the area of the catchment

2. Determine the rain fall intensity of the area

3. Determine the run-off coefficient of the area depending on the area coverage and soil type of the area (wood land, pasture land, cultivated land and urban areas)

4. Finally, determine the run-off discharge rate of the area

Operational Sheet – 2	Practical-2 Estimate run-off from roof catchments

Direction: Estimate Run-off amount that can be harvested from Roof catchment

Procedure:

1. Determine the roof catchment area

2. Determine the annual precipitation of the area

3. Determine the run-off coefficient of the roof depending on the roof material (sheet metal, cement tile and clay tile)

4. Finally, determine the run-off amount that can be harvested from the roof catchment

Lap Test	**Practical Demonstration**

Name: ______________________ Date: ______________

Time started:_________________ Time finished:_________

Instructions:

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

- ➢ Calculate rain fall intensity of the area Measure the source of water discharge
- ➢ Calculate run-off discharge rate of the area
- ➢ Calculate the volume of water

Request you teacher if there is problem

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