Ethiopian TVET-System

Irrigation & Drainage Construction

Level II

Based on, March 2017G.C. Occupational Standard

Module Title: Investigating Sustainable Water Cycle Management

TTLM Code: EIS IDC2 TTLM 0920v2

This module includes the following Learning Guides

LG 46: Check water cycle and System

LG Code: EIS IDC2 M11 LO1-46

LG 47: Advise Sustainable Water Usage

LG Code: EIS IDC2 M11 LO2-47

LG 48: Assess Factors Affecting Water Quality

LG Code: EIS IDC2 M11 LO2-48

Instruction Sheet	Learning Guide #46: Check water cycle and System

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

- Ascertaining continuous cycle of water evaporation and condensation
- Meteorological and hydrological data
- Range of water and drain system
- Methods of capturing, storing and distributing water
- Methods of Community water usage services
- Proper documentation of findings and result

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 –

- Ascertain Continuous cycle of water evaporation and condensation in the area following standard procedures and using approved methods, tools and equipment.
- Collect and check meteorological and hydrological data from respective institutions
- Determine range of water and drain system use to deliver services following standard procedures
- Verify methods of capturing, storing and distributing water with discretion
- Determine community usage of water services using approved methods.
- Document, report and prepare findings and results for utilization in making design model

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the "Information Sheets 1- 6". Try to understand what are being discussed.
4. Accomplish the "Self-checks 1,2,3,4 and 5 " in each information sheets on pages 14, 18, 26, 32, 37 and 46.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).

6. If you earned a satisfactory evaluation proceed to "Operation sheets 1 and 2 on pages 48. Do the LAP Test on page 49". However, if your rating is unsatisfactory, see your teacher for further instructions or go back to the Learning Activity.
7. After You accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result; then proceed to the next LG.

Information Sheet-1	water cycle management system

1.1 Introduction to water cycle

Water is integral to maintaining the quality of our natural and built environment. Protecting our water and natural environments through better water management is crucial in adapting to changing demography, resource use and climatic regimes.

The hydrologic cycle is the central focus of hydrology. The cycle has no beginning or end, and its many processes occur continuously water evaporates from the oceans and the land surface to become part of the atmosphere; water vapor is transported and lifted in the atmosphere until it condenses and precipitates on the land or the oceans; precipitate water may be intercepted by vegetation, become overland flow over the ground surface, infiltrate into the ground, flow through the soil as subsurface flow, and discharge into streams as surface runoff. Much of the intercepted water and surface runoff returns to the atmosphere through evaporation. The infiltrated water may percolate deeper to recharge groundwater, later emerging in springs or seeping into streams to form surface runoff, and finally flowing out to the sea or evaporating into the atmosphere as the hydrologic cycle continues.

Water cycle management relates to all planning, strategy development, operational and tactical decisions to optimize the water cycle to satisfy human or environmental objectives. It is used in different organizations to mean management of a sub-set of the whole water cycle.

Before using the water for irrigation the first step is to check water cycle and system so that adequate water can be obtained. Understanding the water cycle and system help us to identify and collect the water needed. All components of the hydrological cycle should be taken into account when developing water management plans. Each component has a specific role that must be better understood.

The water cycle or hydrologic cycle is a continuous cycle where water evaporates, travels into the air and becomes part of a cloud, falls down to earth as precipitation, and then evaporates again. This repeats again and again in a never-ending cycle. Water keeps moving and changing from a solid to a liquid to a gas, over and over again.

Precipitation creates runoff that travels over the ground surface and helps to fill lakes and rivers. It also percolates or moves downward through openings in the soil to replenish aquifers under the ground. Some places receive more precipitation than others do. These areas are usually close to oceans or large bodies of water that allow more water to evaporate and form clouds. Other areas receive less precipitation. Often these areas are far from water or near mountains. As clouds move up and over mountains, the water vapor condenses to form precipitation and freezes. Snow falls on the peaks.

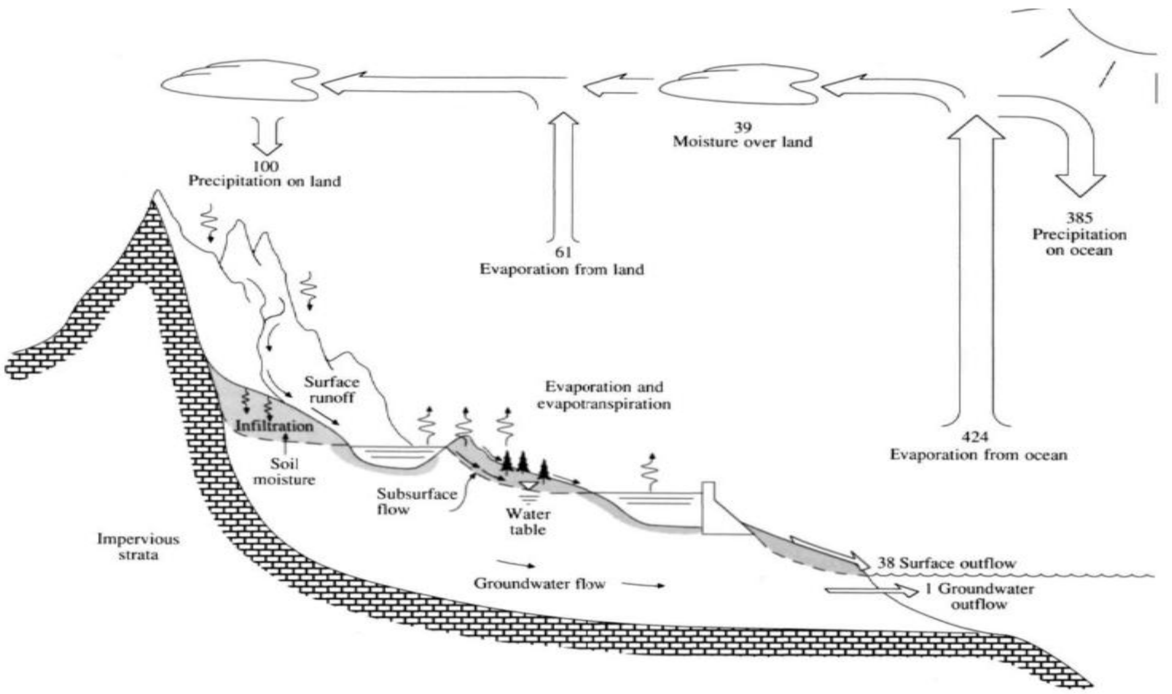


Figure 1: hydrologic cycle

The illustration shows the hydrologic cycle in which water leaves the atmosphere and falls to earth as precipitation where it enters surface waters or percolates into the water table and groundwater and eventually is taken back into the atmosphere by transpiration and evaporation to begin the cycle again.

Water moves through the environment in a pattern known as the hydrologic cycle. Through a process including evaporation, transpiration, condensation, surface waters become clouds, which in turn release their contents as precipitation (rain or snow).

The hydrologic cycle involves the continuous circulation of water in the Earth-Atmosphere system. At its core, the water cycle is the motion of the water from the ground to the atmosphere and back again. Of the many processes involved in the hydrologic cycle, the most important are...

- evaporation
- transpiration
- condensation
- precipitation
- runoff

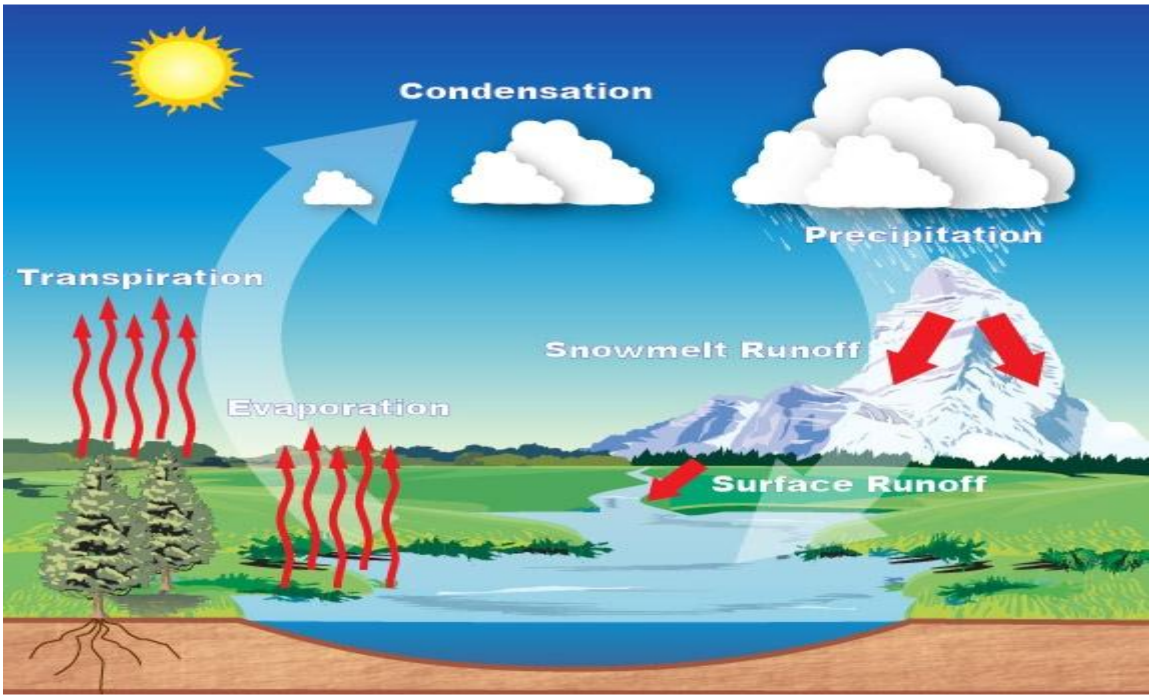


Figure 2: Hydrologic cycle

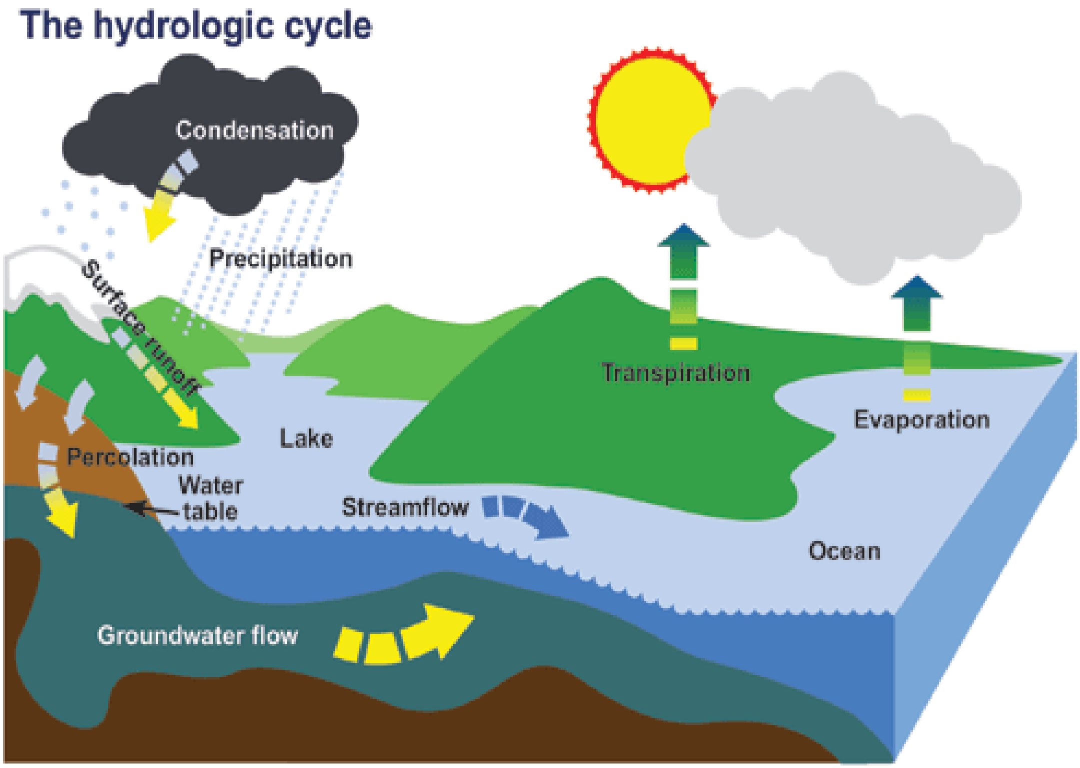


Figure 3: Hydrologic cycle

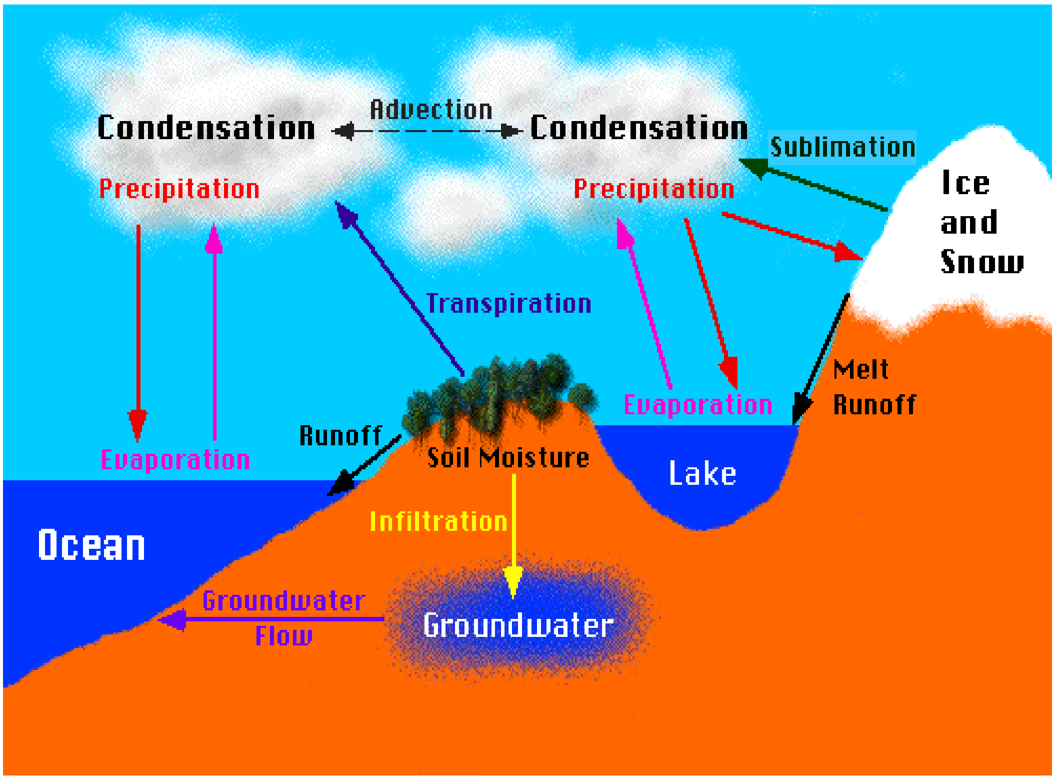


Figure 4: Hydrological cycles

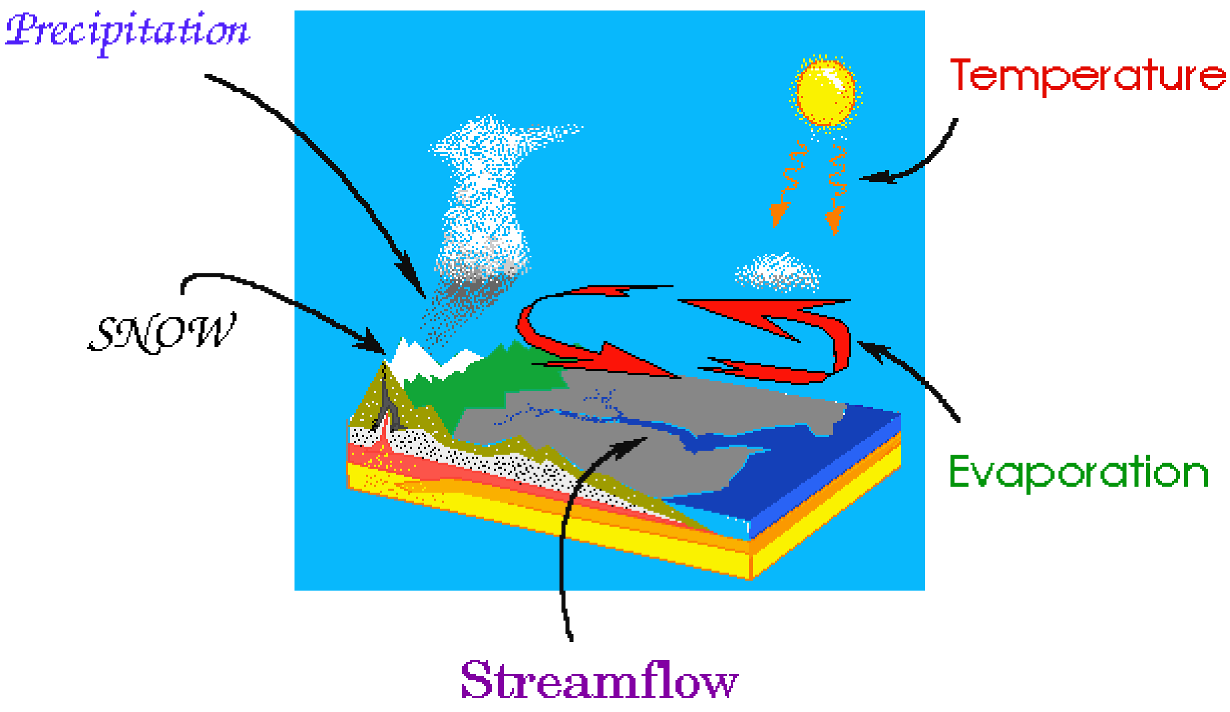


Figure 5: Hydrological cycles

A. Evaporation

Evaporation is the change of state in a substance from a liquid to a gas. In meteorology, the substance we are concerned about the most is water. For evaporation to take place, energy is required. The energy can come from any source: the sun, the atmosphere, the earth, or objects on the earth such as humans. Everyone has experienced evaporation personally. When our body heats up due to the air, temperature or/and through exercise, the body sweats, secreting water onto the skin.

The purpose is to cause the body to use its heat to evaporate the liquid, thereby removing heat and cooling the body. It is the same effect that can be seen when you step out of a shower or swimming pool. The coolness you feel is from the removing of bodily heat to evaporate the water on your skin.

Daily the result of evaporation and precipitation is measured within the still well, by means of a high quality evaporation micrometer with a measuring range of 100 mm and an accuracy of 0.02 mm. This accuracy can be obtained because the still well prevents rippling of the water surface.

The amount of evaporation is a function of temperature, humidity, wind and other ambient conditions. In order to relate the evaporation to wind current or expected conditions, the maximum and minimum temperature as well as the amount of air passed are recorded with the evaporation. For a more exact use of the evaporation pan it is recommended to use an additional wind path meter.

Stilling well with micrometer

Figure 6. Evaporation pan

B. Transpiration

Transpiration is the evaporation of water from plants through stomata. Stomata are small openings found on the underside of leaves that are connected to vascular plant tissues. In most plants, transpiration is a passive process largely controlled by the humidity of the atmosphere and the moisture content of the soil. Of the transpired water passing through a plant only 1% is used in the growth process of the plant. The remaining 99% is passed into the atmosphere.

C. Condensation

Condensation is the process whereby water vapor in the atmosphere is changed into a liquid state. In the atmosphere condensation may appear as clouds or dew. Condensation is the process whereby water appears on the side of an un-insulated cold drink can or bottle.

Condensation is not a matter of one particular temperature but of a difference between two temperatures; the air temperature and the dew point temperature. At its basic meaning, the dew point is the temperature where dew can form. Actually, it is the temperature that, if the air is cool to that level, the air becomes saturated. Any additional cooling causes water vapor to condense. Foggy conditions often occur when air temperature and dew point are equal.
Condensation is the opposite of evaporation. Since water vapor has a higher energy level than that of liquid water, when condensation occurs, the excess energy in the form of heat energy is released.

D. Precipitation

Precipitation is the result when the tiny condensation particles grow too large, through collision and coalesce, for the rising air to support, and thus fall to the earth. Precipitation can be in the form of rain, hail, snow or sleet. Precipitation is the primary way we receive fresh water in earth. On average, the world receives about 38½" (980 mm) each year over both the oceans and land masses.

E. Runoff

Runoff occurs when there is excessive precipitation and the ground is saturated (cannot absorb anymore water). Rivers and lakes are results of runoff. There is some evaporation from runoff into the atmosphere but for the most part water in rivers and lakes return to the oceans. If runoff water flows into the lakes only(with no outlet for water to flow out of the lakes), then evaporation is the only means for water to return to the atmosphere. With evaporation only pure water evaporated, and therefore any contaminates and salts are left behind. The result is the lake becomes salty. Evaporation of this runoff into the atmosphere begins the hydrologic cycle over again. Some of the water percolates into the soil and into the ground water only to be drawn into plants again for transpiration to take place.

F. Infiltration rate

The infiltration rate is the velocity or speed at which water enters into the soil. It is usually measured by the depth (in mm) of the water layer that can enter the soil in one hour. An infiltration rate of 15 mm/hour means that a water layer of 15 mm on the soil surface will take one hour to infiltrate.

In dry soil, water infiltrates rapidly. This is called the initial infiltration rate. As more water replaces the air in the pores, the water from the soil surface infiltrates more slowly and eventually reaches a steady rate. This is called the basic infiltration rate. The infiltration rate depends on soil texture (the size of the soil particles) and soil structure (the arrangement of the soil particles. The most common method to measure the infiltration rate is by a field test using a cylinder or ring Infiltrometer.

Table 1. Basic infiltration rates for various soil types

Soil type	Basic infiltration rate (mm/hour)
Sand	less than 30
sandy loam	20 – 30
Loam	10 – 20
clay loam	5 – 10
Clay	1 – 5

Note: The infiltration curve should be determined for normal soil moisture conditions before rain fall happen i.e. usually when the top soil is dry.

1.2 Geographical Information Systems (GIS)

A Geographical Information System (GIS) is a system for capturing, storing, analyzing and managing data and associated attributes, which are spatially referenced. Generally the tools and equipments used are Meters, GPS (Global positioning System) and compass.

Geographical Information System (GIS) is a technology that provides the means to collect and use geographic data to assist in the development of Agriculture. A digital map is generally of much greater value than the same map printed on a paper as the digital version can be combined with other sources of data for analyzing information with a graphical presentation. The GIS software makes it possible to synthesize large amounts of different data, combining different layers of information to manage and retrieve the data in a more useful manner. GIS provides a powerful means for agricultural scientists to better service to the farmers and farming community in answering their query and helping in a better decision making to implement planning activities for the development of agriculture.

1.3 Definition of Terms Related to water cycle management

- **Evaporation**- Process by which a liquid becomes a gas
- **Condensation-** the process of changing from a gaseous to a liquid or state
- **Precipitation-** the falling to earth of any form of water (rain or snow or hail or sleet or mist)
- **Transpiration-** loss of water from a plant through its leaves
- **Infiltration-** seepage of water into soil or
- **Percolation-** the slow movement of water through pores in soil or permeable rock
- **Surface runoff-** water which runs along the surface into collection points (streams, rivers, ponds, lakes, etc)
- **Ground Water-** water found beneath Earth's surface
- **Water Table** the top of the saturated zone
- **Discharge** waters that are emptying from one moving source (stream or river) into another moving or still source (river or lake)
- **Aquifer** a rock layer that stores and allows the flow of
- **Permeability** a rock's ability to let water through it
- **Impermeable** a rock that tends to stop the
- **Water cycle** The continuous process by which water moves from Earth's surface to the atmosphere and back

Self-Check -1	Written Test

Direction: Choose the best answer from the following provided alternative and provide your answer on the space provided. (2pts each)

1. What is evapo-transpiration?
    A. The process by which water enters the atmosphere from open water surface in the form of water vapor
    B. Evaporation takes place at the surfaces of plant leaves
    C. The total movement of water vapor into the air from land , open water surface & plant surface
    D. Evaporation takes place from damp soil
2. The most important processes involved in the hydrologic cycle, are?
    A. Evaporation B. Transpiration C. Condensation
    D. Precipitation E. Runoff F. All
3. The followings are ranges for water cycle and drainage system check **except:**
    A. Water catchments systems B. Determination of irrigation frequency
    C. Water storage systems D. Water distribution systems
4. One of the following is used as an advice sustainable water usage **except:**
    A. Community and household water usage are examined and results documented
    B. Ways to minimize water usage and water conservation are determined.
    C. Ways to minimize and conserve irrigation water is explained to the household and the community in a diplomatic and tactful manner
    D. Omitting research activities from irrigation and drainage system

Note: **Satisfactory rating - 8 points** **Unsatisfactory – below8points**

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

Score = ____________
Rating: _____________

Answer sheet

Name: ___________________________ Date: ________________

Multiple choices

1. ....
2. ....
3. ....
4. ....

Information Sheet 2	Investigation and Analysis of metrological and Hydrological data

2.1 Introduction

An important application of hydrometeorology is the provision of criteria for the design of various water control structures, such as dams and storage reservoirs, storm sewers, bridges and irrigation systems. Hydrology and meteorology are concerned with natural phenomena, and the analysis of problems arising from these phenomena is dependent upon observations of their magnitude, duration and location. There will be little likelihood of obtaining successive measurements of the same event.

Meteorological data: - are quantitative values of meteorological elements and phenomena obtained by meteorological measuring, monitoring and/or their processing in meteorological stations listed in the network Register of state meteorological and hydrological stations and meteorological hydrological additional networks.

Hydrological data: - are quantitative values of hydrological elements and phenomena obtained by hydrological measurements and observations and/or their processing in hydrological stations listed in the network Register of the state meteorological and hydrological stations and meteorological and hydrological stations additional network.

The various types of daily, monthly and annual data required are:-

- Temperature:
- Rain fall: Most common form of liquid precipitation
- Relative humidity: the percentage of water vapor in the air compared to the maximum amount the air could hold at a given temperature
- Wind speed
- Sunshine hour.
- River peak/base flow

Some of the data are measured directly in weather stations.

2.2. Definition of Terms Related to metrological and hydrological data

- **Humidity** the amount of moisture in the air

- **Relative humidity** the percentage of water vapor in the air compared to the maximum amount of the air could hold at a given temperature
- **Psychomotor** Instrument used to measure relative humidity that has two thermometers (wet bulb and dry bulb)
- **Rain Gauge :** Open ended tube that collects rainfall
- **Rain** Most common form of liquid precipitation
- **Sleet** Ice particles smaller than 5 millimeters in diameter
- **Snow** precipitation falling from clouds in the form of ice crystals
- **Hail** Ice pellets larger than 5 millimeters in diameter formed in cumulonimbus clouds by strong updrafts of wind
- **Fog** a stratus cloud that forms when air is cooled to its dew point near the ground
- **Coalescence** when water droplets fuse to create larger water droplets, or when water droplets freeze onto ice crystals
- **cloud seeding** encouraging rainfall by seeding the air with condensation nuclei
- **freezing rain** that freezes when it hits a cold surface
- **drought** a long period without rain

Self-Check 2	Written Test

Direction: Choose the best answer from the ff provided alternative and provide your answer on the space provided. (3pts each)

1. One of the following is **not** included in the metrological and hydrological data:

   A. Relative humidity B. Rainfall

   C. Rain gauges D. Sunshine hours

2. The various types of daily, monthly and annual data required from meteorological and hydrological stations are ---------?

   A. Temperature B. Rain fall

   C. Relative humidity D. Wind speed E. all

Note: Satisfactory rating - 3 point Unsatisfactory - below 3 points

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

Score = ___________

Rating: ____________

Answer sheet

Name: _________________________ Date: _______________

Multiple choices

1............................

2……………………

3……………………

4……………………

Information Sheet-3	Determination of range of water and drainage system

3.1 Introduction to irrigation system and drainage system

The irrigation system consists of:-

- A (main) intake structure or (main) pumping station,
- A conveyance system,
- A distribution system,
- A field application system, and
- A drainage system

The (main) intake structure, or (main) pumping station, directs water from the source of supply, such as a reservoir or a river, into the irrigation system. The conveyance system: assures the transport of water from the main intake structure or main pumping station up to the field ditches. The distribution system: assures the transport of water through field ditches to the irrigated fields. The field application system: assures the transport of water within the fields. The drainage system: removes the excess water (caused by rainfall and/or irrigation) from the fields

The Drainage system consists of:-

- Water catchments systems
- Water storage systems
- Water distribution systems
- Storm water drainage system
- Drainage system

3.1.1 Water catchments systems

A catchment is an area where water is collected by the natural landscape. Rain falling outside the edge of one catchment is falling on a different catchment, and will flow into other creeks and rivers.

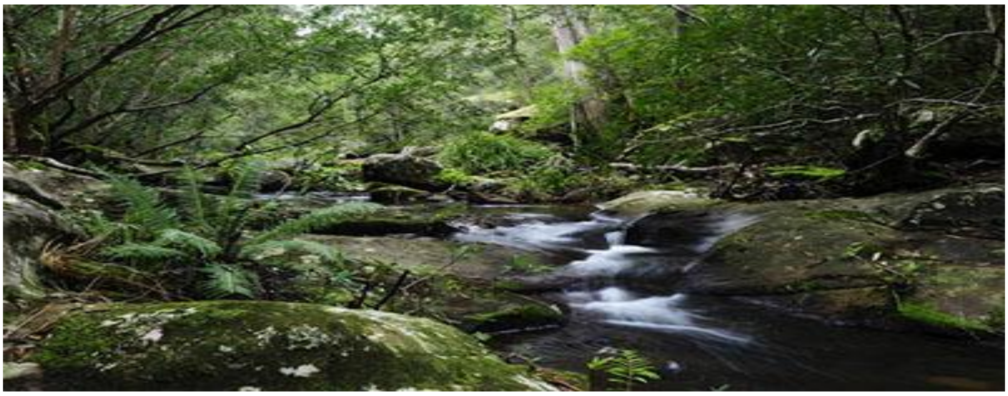
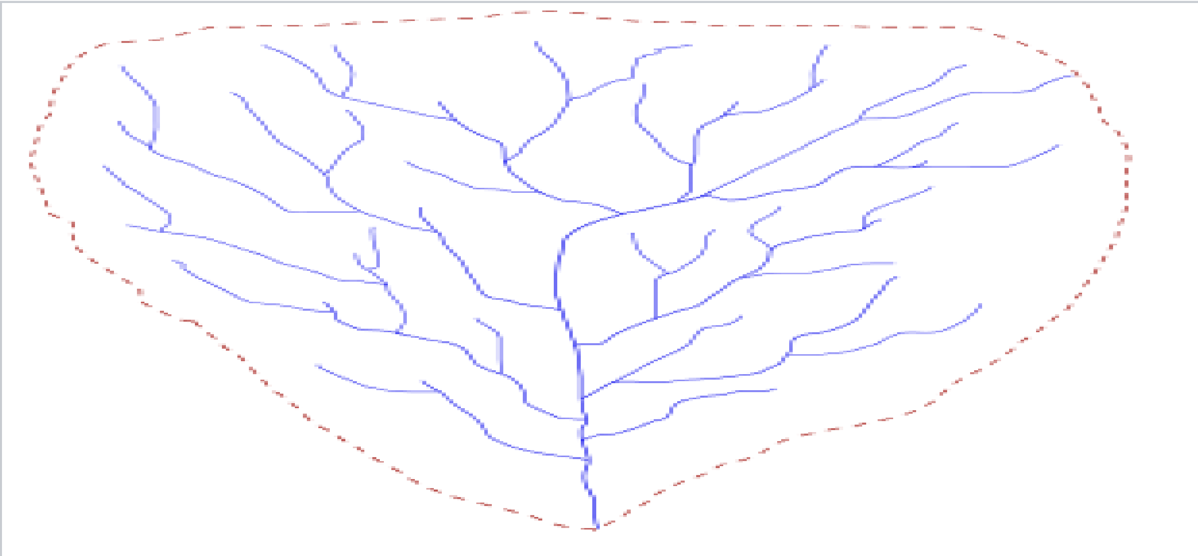


Figure 7. Water catchments systems

Some water also seeps below ground where it is stored in the soil or in the space between rocks. This is called groundwater. We use the water collected by the natural landscape to help supply water for our needs, by building dams and weirs, or tapping into groundwater. This is called the water supply system. After identification of the water source the next step is to determine the catchment system.

A catchment is an area where water is collected by the natural landscape. In a catchment, all rain and run-off water eventually flows to a creek, river, dam, lake, ocean, or into a groundwater system. A drainage basin or catchment area is any area of land where precipitation collects and drains off into a common outlet, such as into a river, or other body of water. The drainage basin includes all the surface water from rain runoff, snowmelt, and nearby streams that run down slope towards the shared outlet, as well as the groundwater underneath the earth's surface. Drainage basins connect into other drainage basins at lower elevations in a hierarchical pattern, with smaller sub-drainage basins, which in turn drain into another common outlet.



Example of a drainage basin. The dashed line is the main water divide of the hydrographic basin.

Figure 8. Drainage basin

3.1.2 Water storage systems

A river does not carry the same quantity of water throughout the year. It may carry little or no water during portions of the year &large quantities (which even, after heavy rains are hazard to all activities along its banks in the other part of the year. A water supply, irrigation, or hydropower project drawing water directly from a river may, therefore, be unable to satisfy the demands of its consumes during low flows.

Such problems can be overcome by constructing a dam across a river to create reservoirs. Reservoirs are man-made lakes created to store water during times of excess flow & supply it from storage when the demand exceeds the inflow. In addition to conserving water for later use, reservoirs can also serve for flood control, recreation, navigation & low flow augmentation.

Having completed your water usage analysis you can now look at how much water you need in your storage tanks or reservoirs to keep your business running when a water emergency occurs in your area. The method to size your water storage tanks will actually be quite simple, but before you get out your calculator there is one important decision that must be considered and that is at what capacity you want your business to operate while on the backup process water supply system.

There are 3 basic levels as described below:

A. Maximum Required Water Storage Capacity

This is the maximum amount of water that any business needs on daily basis to continue operating at 100% capacity. This is business as usual with no restrictions.

B. Reduced Required Water Storage Capacity

The amount of water your business needs on a daily basis when operating at a reduced capacity. Your production line supplies all customers while items list under non-essential usage are stopped. Water available for staff usage may also be reduced but not eliminated completely.

C. Minimum Required Water Storage Capacity

The absolute minimum your business will need to continue operating. Only key customers will be supplied with essential products. Non-essential usage items and most staff usage of water are eliminated.

When choosing one of the above options you should first consider the cost to your company when operating without water. If you can afford to operate at minimum or reduced capacity then the cost of your backup storage tanks and system may be less in comparison to those of a business operating on a 100% backup water supply.

Next, you must decide the number of days of backup water supply that you will have available. Consider carefully the frequency of water outages you experience monthly and how many consecutive days they normally last. Pay particular attention to the age and condition of the water supply infrastructure in your area. Remember, what may not be a big problem now, could become a nightmare in the near future.

3.1.3 Conveyance and distribution systems

The conveyance and distribution systems consist of canals transporting the water through the whole irrigation system. Canal structures are required for the control and measurement of the water flow.

An open channel is a conduit in which a liquid flows with a free surface. The free surface is actually an interface between the moving liquid and an overlaying fluid medium and will have constant pressure. The prime motivating force for open channel flow is due to gravity. In engineering practice, activities for utilization of water resources involve open channels of varying magnitudes in one way or another. Flows in natural rivers, streams, artificial canals for transmitting water from source to a place of need, such as irrigation, water supply and hydropower generation; sewers that carry domestic or industrial waste water; navigation canals are all examples of open channel in their diverse roles.

Need for adjustment and improvement

The service agreement is the result of negotiations between parties whose objectives may differ. One cannot expect that the first service agreement will be perfect. Experience during the first irrigation season will show:

- Whether the irrigation services could be provided according to the agreement, or whether this did not always happen.
- Whether the scheme operators took appropriate corrective action. Whether the farmers made their contributions in return for the services.
- Even with positive experience on the above items, the following questions still need to be asked.
- Whether the irrigation services as provided according to the agreement were adequate for crop production, or whether they could be improved.
- Whether the farmers' contributions were adequate to cover the costs of operating and maintaining the scheme.

These types of questions need to be asked after every irrigation season and, if necessary, the service agreement should be adapted accordingly. This means that the organizational arrangements made to produce the service agreement need to remain in place permanently, to ensure that the scheme is capable of adjustment and improvement.

The most important service that the scheme operators provide to farmers is the delivery of irrigation water. Ideal from a farmer's point of view is freedom in terms of:

- timing,
- flow-rate, and
- Duration of irrigation applications.

Another method is time sharing or rotation; every farm in turn receives the full canal discharge. In the example, this would provide each farmer with a maximum discharge of 60 l/s. The duration of an irrigation delivery to one farm must be chosen in a way that both meets the irrigation water needs of the crops and is convenient to the farmers. With this method, there is no need for a flow division structure. It may be convenient to have structures which allow either closure or passage of the full canal flow. The method does require action from operators or farmers to direct the canal flow to the farm that is scheduled to receive irrigation water.

3.1.4 Storm water drainage systems

- **What is the storm drainage system?**

It's a network of structures, channels and underground pipes that carry storm water (rain water) to ponds, lakes, streams and rivers. The network consists of both public and private systems. It's an integral part of the storm water management system in the country that is designed to control the quantity, quality, timing and distribution of storm runoff. It's not part of the wastewater (sanitary sewer) system, which carries water and waste from drains (sinks, bathtubs, showers, etc.) and toilets to a treatment plant to be treated and filtered. Storm water does not flow to a treatment plant.

- **Who maintains the drainage system?**

The county maintains the public storm drainage system contained within dedicated storm drainage easements. The Virginia Department of Transportation maintains the storm systems in public street rights-of-way. Storm systems on land owned by other public bodies such as the Fairfax County Park Authority, Fairfax County Public Schools and the federal government are maintained by those entities. There are also numerous private systems that are the responsibility of private property owners, including driveway culverts and bridges that cross public drainage systems.

- **Different types of drainage**

Drainage can be either natural or artificial. Many areas have some natural drainage; this means that excess water flows from the farmers' fields to swamps or to lakes and rivers. Natural drainage, however, is often inadequate and artificial or man-made drainage is required. There are two types of artificial drainage: surface drainage and subsurface drainage.

I. Surface drainage

Surface drainage is the removal of excess water from the surface of the land. This is normally accomplished by shallow ditches, also called open drains. The shallow ditches discharge into larger and deeper collector drains. In order to facilitate the flow of excess water toward the drains, the field is given an artificial slope by means of land grading.

II. Subsurface drainage

Subsurface drainage is the removal of water from the root zone. It is accomplished by deep open drains or buried pipe drains.

- **Deep open drains**

The excess water from the root zone flows into the open drains. The disadvantage of this type of subsurface drainage is that it makes the use of machinery difficult.

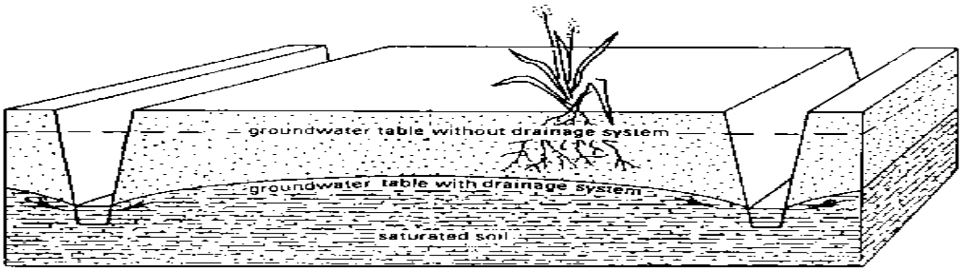


Figure 9. Control of the groundwater table by means of deep open drains

- **Pipe drains**

Pipe drains are buried pipes with openings through which the soil water can enter. The pipes convey the water to a collector drain.

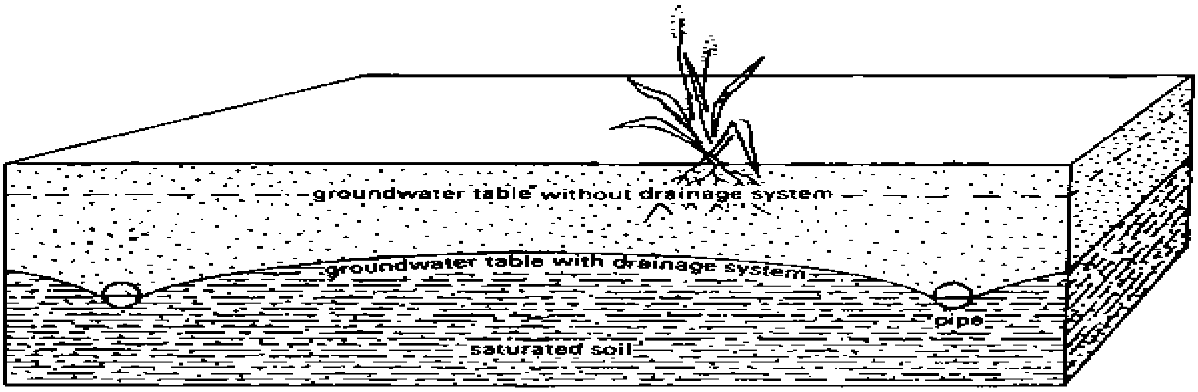


Figure 10. Control of the groundwater table by means of buried pipe

Drain pipes are made of clay, concrete or plastic. They are usually placed in trenches by machines. In clay and concrete pipes (usually 30 cm long and 5 - 10 cm in diameter) drainage water enters the pipes through the joints. Flexible plastic drains are much longer (up to 200 m) and the water enters through perforations distributed over the entire length of the pipe).

- **Deep open drains versus pipe drains**

Open drains use land that otherwise could be used for crops. They restrict the use of machines. They also require a large number of bridges and culverts for road crossings and access to the fields. Open drains require frequent maintenance (weed control, repairs, etc.).
In contrast to open drains, buried pipes cause no loss of cultivable land and maintenance requirements are very limited. The installation costs, however, of pipe drains may be higher due to the materials, the equipment and the skilled manpower involved

Self-Check 3	Written Test

Instruction: Choose the best answer from the provided alternative and provide your answer on the space provided. (2pts each)

1. Drainage system is consists of:-

A. Water catchments systems
B. Water storage systems
C. Water distribution systems
D. Storm water drainage system
E. Drainage system
F. all

2. Why is drainage necessary in an irrigation project?

A. To maximize loss
B. To reduce water loss
C. To remove excess water and salt
D. To supply water to the plant

3. If the canal velocity is very high in the earthen canal, what will happen?

A. The canal will be eroded
B. The canal capacity will be decrease
C. The water will evaporate
D. Water will be delivered efficiently

4. ---- are the main components of Drainage system?

A. Water catchments systems
B. Water storage systems
C. Water distribution systems
D. Storm water drainage system
E. Drainage system.
F. All

5. Ideal from a farmer's point of view is freedom in terms of-------------?

A. Timing
B. flow-rate
C. Duration of irrigation applications
D. ALL

Note: Satisfactory rating - 5 point Unsatisfactory - below 5 points

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

Answer sheet

Name: _________________________ Date: _______________

Multiple choices

1............................
2............................
3……………………..
4……………………..

Score = ___________
Rating: ____________

Information Sheet-4	Methods of capturing, storing & distributing water

4.1. Introduction

Water storage is often a necessary part of a rural water supply system. Storage ensures that a sufficient quantity of water without interruption is used in pipe distribution system, the water source and the treatment and pumping systems must have sufficient capacity to meet the daily demand for water. Due to hourly change in demand for water, it is economically and technically impossible for most systems to meet demand unless storage is provided. Not only is storage necessary for larger piped distribution system, but it needed to be providing for individual families. Household cisterns and storage jars may be used by individual families to store water collected from roofs. Water stored in cisterns can be used as the principal source of water or as the secondary source if the primary one disappears during the dry season.

The choice of household storage design depends on

- The materials
- Skills and economic resources available to each.

Collection and storage of direct rainfall or upland sheet flow may in some cases be a viable alternative to the historic tradition of capturing and storing water that flows within a natural channel.

4.2. Methods for Capturing and Storing Water

Collection and storage of direct rainfall or upland sheet flow may in some cases be a viable alternative to the historic tradition of capturing and storing water that flows within a natural channel. Impounding stream flow is now highly regulated, requiring an appropriative water right from the State Water Resources Control Board (SWRCB). Appropriative rights are difficult, if not impossible to obtain, and require a lengthy and costly application process. More promising options for developing additional agricultural water sources include capture and storage of non-jurisdictional water. Rainwater that falls directly into storage ponds or is collected from roofs of agricultural buildings can be stored and used without an appropriative water right. Roof runoff can be collected via gutter systems and directed to storage tanks, water bladders, or storage ponds. Upland sheet flow that runs off of hillsides can, in many cases, also be stored and used for irrigation or livestock water without an appropriative right.

Table 2. Advantages, disadvantages, and permit requirements for water capture and storage method

Water Capture	Advantages	Disadvantages	Permits Needed
Roof runoff	No permits needed, non-jurisdictional	Only available where sufficient	None for collection from existing roofs
Upland sheet flow	Large volumes can be obtained, often non-jurisdictional	Requires ponds for storage, which are costly to construct	None for sheet flow capture, grading permit or grading permit exemption needed for storage pond construction
Direct capture of rain-water	Non-jurisdictional	Water volume limited by area of pond; pond must be bermed so that runoff is excluded; construction costs for bermed ponds are high due to volume of earth movement required	Grading permit or grading permit exemption needed for bermed ponds
Stream flow	Large volumes can be captured	Requires appropriative water rights which are difficult and very costly to obtain.	Water rights, grading permit or grading permit exemption
Water Storage Method	Advantages	advantages	Permits Needed
Pond	Can store large	High design and	Grading permit or grading
Above ground tank	Relatively low cost	Limited storage capacity	Building permit needed for over 5,000 gallons or for smaller tanks with less than a 2:1 height/ width ratio; Marin County
Portable bladder	Relatively low cost, can be moved when empty	Less storage capacity than ponds but greater than many tanks	Building permit needed for over 5,000 gallons or for smaller tanks with less than a 2:1 height/ width ratio; Marin County agricultural building permit exemption may apply
Underground modular storage systems	These systems are structural, so land area above can be used for vehicle parking or other weight-bearing use	High cost	Building permits are needed for storage over 5,000 gallons; grading permit or grading permit exemption is needed for excavation.

Storage reservoir functions

Service reservoirs provide the following functions:

- provide a reserve of treated water that will minimize interruptions of supply due to failures of mains, pumps, or other plant equipment;
- help to maintain uniform pressure;
- provide a reserve of water for fire fighting and other emergencies;
- act as a relief valve on a system of mains supplied by pumping;
- permit a reduction in the size of distribution mains below that which would be required in the absence of a reservoir; and
- Allow pumping at the average rather than peak flow rate.

4.3 Water distribution within the canal network

Water flowing in a secondary irrigation canal can be divided over the tertiary canal network in several ways. One way is to divide the flow proportionally over these tertiary canals; another is to divide the time of supply and thus to divert the flow to each tertiary canal in turn; and a third way is to supply a tertiary canal with water upon request.

The three options of water distribution system to the field are:-

- proportional distribution;
- rotational distribution; or
- Delivery on demand.

The different methods of water distribution require different structures, and these structures are described here.

4.4.1 Proportional distribution

Proportional distribution of irrigation water means that flow in a canal is divided equally between two or more smaller canals. The flows in these canals are proportional to the areas to be irrigated by each of them.

Division of the flow: Each canal is given a portion of the flow. These portions correspond to the portion of the total area which is irrigated by that canal.

4.4.2 Rotational distribution

Rotational distribution of irrigation water means that the whole flow in an irrigation canal is diverted to the branch canal in turn. For instance, in the case of primary and secondary canals, it means that each secondary canal is without water for part of the time and, when supplied, it transports the whole “primary” flow. The same can apply to the distribution of the flow of secondary canals into tertiary canals, and rotational distribution can be carried out within the tertiary canals.

Division of the time

The portion of the time during which a branch canal carries water is proportional to the area served by that canal.

4.4 Delivery on demand

Instead of water delivery based on areas, as in proportional or rotational supply, delivery can be based on requests from farmers or a group of farmers. In such a delivery system, water is directed only to those canals where farmers have announced that they need water.

Self-Check 4	Written Test

Part I. Choose the Best Answer from the ff provided alternative and provide your answer on the space provided. (3pts each)

1. ------------- are options of water distribution system to the field.
   A. Proportional distribution
   B. Rotational distribution
   C. Delivery on demand

2. Which one of the following are Service reservoirs functions?
   A. provide a reserve of treated water that will minimize interruptions of supply due to failures of mains, pumps, or other plant equipment;
   B. helps to maintain uniform pressure;
   C. provide a reserve of water for fire fighting and other emergencies;
   D. act as a relief valve on a system of mains supplied by pumping;
   E. Allow pumping at the average rather than peak flow rate.
   F. All

3. The choice of household storage design depends on-----?
   A. The materials B. Skills
   C. economic resources available to each D. All

Note: Satisfactory rating - 4 point Unsatisfactory - below 4 points

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

Answer sheet

Name: ____________________________ Date: ________________

Multiple choices

1. ....
2. ....
3. ....
4. ....

Score = ____________

Rating: _____________

Information Sheet-5	Community's use of water services

5.1 Definition and approach of "services" in water systems

The term "services" is used in numerous and extremely diverse meanings from employment and task, assistance, maintenance of cars to religious rite or military corpses just to give an idea of the diversity. The term "service" applied to the water sector is no exception in that respect, many actors of the water business refers to "water services" but not necessarily with the same meaning, this is why at the onset of a document presenting MUS it is critical to clarify our understanding and conceptual approach of Services in order to avoid any further ambiguity.

The term "water service" is also used to define the activity of providing users with water deliveries as well as it can define the company itself who provide the service. The term multiple-use of water is increasingly used in the water sector but often referring to different levels of scale where multiple-use takes place, or originating from different sectoral backgrounds. This note aims to provide an overview of different definitions which are in use, and provide a typology. It does so by conceptualizing actual uses of water at different levels of scale. This serves as basis for defining how at these different levels of scale services are provided to meet these needs.

Multiple uses of water- defines the practice of using water from the same natural or manmade system or infrastructure for multiple uses and functions

5.2 Methods to determine community usage of water service

5.2.1. Use of irrigation water rotation

Water use is the amount of water used by a household or a community, or the amount used for a given task or for the production of a given quantity of some product or crop, or the amount allocated for a particular purpose.

Sustainable water use involves the rigorous assessment of all source of clean water to establish the current and future rates of use, the impacts of that use both downstream and in the wider area where the water may be used and the impact of contaminated water streams on the environment and economic well being of the area. It also involves the implementation of social policies such as water pricing in order to manage water demand.

The question often arises of how to modify a rotational supply during water shortages so that crop yield reductions can be kept to the minimum.

The most commonly adopted solution is to reduce the quantity given at each irrigation usage in proportion to the relationship:

$$\frac{\text{available water}}{\text{crop water recuirements}}$$

Or, more commonly, to stretch the interval between irrigations in proportion to the relationship:

$$\frac{\text{crop water requirements}}{\text{available water}}$$

However, neither of these practices is fully satisfactory since they are not in accordance with the physiological development of the plant. It is known that water stress at certain periods of crop growth adversely affects the crop yields while at other times the effect is much less significant. Therefore, water savings should be made predominantly during those periods when the plant is less sensitive to water stress and reduced to the minimum during the sensitive periods. The critical periods are different for each crop and have variable lengths of time depending on the climatic characteristics.

5.2.2. Community water user association for effective irrigation water use

Proper irrigation water management is essential to minimize negative irrigation caused impacts to the environment. Even the best irrigation system can be mismanaged. Well planned and fully implemented irrigation water, animal waste, pest, and nutrient management plans reduce or help prevent ground water and surface water quality pollution problems associated with irrigation.

5.2.3. Techniques of documenting and reporting findings and results in water usage

Declining water supplies, drought, increased competition from other users, and either existing or anticipated restrictions on the amount of water that can be applied over a specific time period, are encouraging many producers to improve the irrigation efficiency of their irrigation systems. To most people, irrigation efficiency, EIrr, is a general term that indicates how well a water resource is used to produce a crop. Although EIrr can be looked at from several perspectives, this paper deals with it at the field level of a producer.

Typically a producer is concerned primarily about making most effective use of water on his farm and does not pay much attention to how individual fields or his farm affects the water budget of an entire watershed. Water that is applied but not beneficially used to produce a crop is referred to as a loss even though that water may still be physically observed as runoff, etc.

5.2.4. 5.2.4. Levels of Multiple uses

It is obvious to state that people use water for multiple purposes. However, it is important to recognize that multiple uses happen at different levels of scale:

a. **The household or homestead level**: this is the lowest level, where people harvest; gather several sources of water for different uses around or near the homestead, including domestic use, small-scale productive uses, such as backyard gardens, livestock, micro-enterprises, etc.
b. **The water system level**: this is the level of a certain infrastructure, such as a water distribution scheme or a water ecosystem. Often, such schemes are designed with a specific use in mind, such as irrigation of field crops, or domestic supply.
c. **Multiple-use services (MUS)** – defines the conceptual approach of providing water services provision for multiple uses, incorporates also the roles and functions of water related systems for local communities.

Multiple-use approach mainly applies at household and system levels. Although, one can of course also talk about management arrangements at catchment or basin scale to ensure water for multiple uses to different users. Terms as IWRM or integrated catchments are used for that. IWRM is often understood as governance and management for dealing with competing water sectors at, the basin or catchment scale. MUS are an approach for providing multiple uses services at systems level and downwards.

When we talk about MUS, uses such as domestic water supply, irrigation supply and hydropower generation are the ones that immediately come to mind, albeit sometimes at different scales. The concept of MUS may go beyond these very tangible uses, to embrace also other functions, roles and purposes such as flood protection associated with irrigated paddy cultivation, or with multi purposes reservoir.

Multiple use systems can provide the more vulnerable users with low cost services for domestic water, water for agriculture (irrigation, rain fed), homestead, garden, water for cattle, habitats for fish and other aquatic resources and rural enterprise water supplies. The same infrastructure may be used for these services as well as for hydroelectric power and, in some cases, to aid inland waterway navigation. Multiple use systems consider also support important cultural values and functions that are essential for local well-being and livelihoods and might provide ecological benefits which include flood control, groundwater recharge, water harvesting, water purification and biodiversity conservation.

Self-Check 5	Written Test

Instructions: Choose the Best Answer from the given alternative and write your answers in the sheet provided in the next page

1. Levels of Multiple water usages are---?
    A. The household or homestead level
    B. The water system level
    C. Multiple-use services
    D. all

Note: Satisfactory rating - 4 point Unsatisfactory - below 4 points

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

Answer sheet

Name: ___________________________ Date: ________________

Score = ____________

Rating: _____________

Multiple choices

1.............................

6.1. Introduction

6.1.1. sewage versus sewerage

Sewage is the waste matter carried off by sewer drains and pipes, while Sewerage refers to the physical facilities (e.g., pipes, lift stations, and treatment and disposal facilities) through which sewage flows. In other words Sewage is the wastage and unwanted part of material and consists of vegetation, industrial used water, papers etc. while Sewerage is the system through which sewage is carried from city or particular area.

6.2. Rising main or pressure main

There are two types of rising main: Wet Risers and Dry Risers:-

1. Wet Riser is a pipe kept permanently charged with water, which is immediately available for use on any floor at which a hydrant outlet (sometimes known as a landing valve) is provided. The riser is connected to the main water supply of suitable capacity with a shut-off control valve installed. If the building height is such that the pressure in the main is insufficient, a booster pump will be necessary at suitable levels to ensure the maintenance of the required pressure and flow. Where these pumps are employed, the landing valves must be fitted with a pressure regulator to ensure that the pressure head against the pumps is not transmitted to the hose. A similar function to that of a wet riser is performed by what is known as a 'down-comer'. This, like a wet riser, is constructed of vertical piping (or falling main), but is supplied with water from a tank in the roof or at intermediate levels or, in the case of a falling main serving an area below ground or access level, the supply will be direct from the main water supply.

2. Dry riser is simply a vertical pipe, which is normally kept empty of water, fitted with outlets at various floor levels in the building. It is not connected to a water supply, but is charged when required by means of fire service pumps. In effect, it is a substitute for a line of hose, over which it has many advantages. It enables an upper floor level fire to be attacked by the fire brigade with a line of standard hose without the loss of time entailed in having to lay hose up through the building from the street. It obviates the risk of water damage, which might occur if a hose line burst in a part of the building not affected by fire. A dry riser is charged through inlets at ground level, which are usually housed in external glass-fronted boxes. Each box is normally identified by the words.

DRY RISER painted in red on the glass. Inlets may occasionally be found below pavement level in a box with a cover similar to that used for a hydrant. An air valve is usually fitted at the highest point in the pipe to allow contained air to discharge to atmosphere when the riser is charged with water. Without such a provision, air in the riser might be compressed in the upper part of the pipe and prevent it being fully charged. The air valve, if fitted, is constructed to admit air to the pipe where it is drained after use and so prevent the creation of the partial vacuum, which would, result in pockets of water being trapped. Dry risers are provided with a drain cock fitted beneath the inlets to enable the system to be drained after use. Additionally, where an outlet is fixed at a position below the inlet valves, a further drain valve is fitted at the lowest point of the riser.

6.3. Reservoirs and tanks

Water tanks are available for online purchase in many popular sizes and are becoming increasingly important as primary storage for drinking water or as secondary storage for water reserves and fire safety, as the availability of drinking water to the consumer decreases. Plastic Water storage tanks are used for multiple purposes including; above ground cisterns storing residential safe drinking water, rainwater harvesting, long term water storage, emergency potable water storage, fire protection water tanks & farm irrigation. The Tank Depot offers many different sizes and shapes of water tanks, plastic septic tanks and plastic holding tanks. Plastic Water Tanks are made from a food grade, UV stabilized polyethylene and are manufactured using the Roto-Molding Process. The Green color of plastic water storage tanks reduces algae growth and blends in with the environment.

Figure 11. Plastic tanks

Reservoir is a large natural or man-made lake used for collecting and storing water and it is open-air storage area. Reservoirs may be created in river valleys by the construction of a dam or may be built by excavation in the ground or by conventional construction techniques such a brickwork or cast concrete (usually formed by masonry or earthwork) where water is collected and kept in quantity so that it may be drawn off for use. Changes in weather cause the natural flow of streams and rivers to vary greatly with time. Periods of excess flows and valley flooding may alternate with low flows or droughts. The role of water-storage reservoirs, therefore, is to impound water during periods of higher flows, thus preventing flood disasters, and then permit gradual release of water during periods of lower flows. For over 5000 years, people have built reservoirs to store the water they need to live.

There are two main types of reservoir:-

- **Direct supply reservoirs** - store water and supply it straight to a water treatment works.
- **River regulating reservoirs** - store water during rainy periods and release extra water into rivers when needed so that it can be taken out further downstream for treatment.

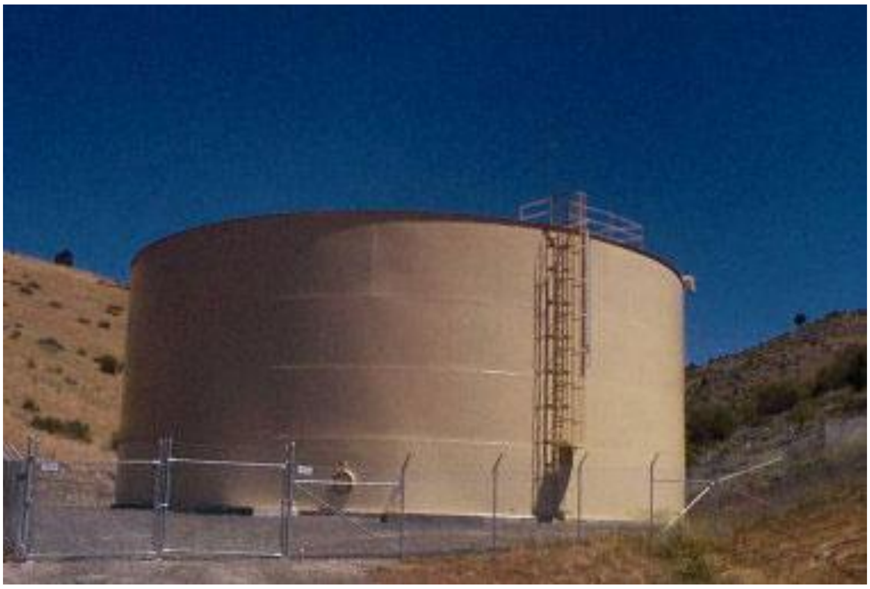


Figure 12. water reservoir

Standpipe (firefighting) is a rigid vertical pipe to which fire hoses can be connected Standpipe (piezometer,) a device that monitors groundwater levels through a borehole. A standpipe (street) is a freestanding pipe fitted with a tap which is installed outdoors to dispense water in areas which do not have a running water supply to the buildings.

6.4. Pumping stations

Are facilities including pumps and equipment for pumping fluids from one place to another. They are used for a variety of infrastructure systems, such as the supply of water to canals, the drainage of low-lying land, and the removal of sewage to processing sites.

Pumping station refers to hydraulic installations, which are used for delivering water at the required rate (discharge) and head (pressure). They generally consist of the following components:

- The pumps (plus accessories:, delivery and suction pipes, valves, air-vessel, etc)
- The intake structure,
- The sump (or suction well) and other ancillary structures.

6.4.1. Raw-water pumping stations (Abstraction from surface sources):

The pumping station is fed from an open-surface such as a canal, a river, or a reservoir, often through a sump and an intake. With water levels varying over a large range, sediment may enter the sump and intake. Sediment traps and screens (to trap floating debris) are therefore usually provided. The station will probably also have multiple pumps (including standby units) which cater for the changes in sump levels.

6.4.2. Clean-water pumping stations (water supply from treatment plants)

In the absence of gravity flow, treated water is supplied to a distribution network or a storage tower reservoir through a pumping station. Silt and debris-free water is directed to either a wet or dry sump (without screens or traps) from which it is pumped to the network (booster pumps) or to another storage tank.

6.4.3. Groundwater pumping station (Abstraction from boreholes)

The installations are normally of the wet well type with pumps located within the wells. In deep wells special multistage (submersible) pumps are used, whereas for shallow wells the pumps may be located at ground level. Well screens are essential to prevent sand from entering into the system. The deep well pumps are normally less bulky (around 100-400 mm diameter) to fit into well diameters of 150-600 mm.

Wastewater, also spelled **waste water**, is any water that has been adversely affected in quality by anthropogenic influence. It comprises liquid waste discharged by domestic residences, commercial properties, industry, and/or agriculture and can encompass a wide range of potential contaminants and concentrations. In the most common usage, it refers to the municipal wastewater that contains a broad spectrum of contaminants resulting from the mixing of wastewater from homes, businesses, industrial areas and often storm drains, especially in older sewer systems. Municipal wastewater is usually treated in a combined sewer, sanitary sewer, effluent sewer or septic tank.

Storm water is water that originates during precipitation events. It may also be used to apply to water that originates with snowmelt that enters the storm water system. Storm water that does not soak into the ground becomes surface runoff, which either flows directly into surface waterways or is channeled into storm sewers, which eventually discharge to surface waters. Storm water is of concern for two main issues: one related to the volume and timing of runoff water (flood control and water supplies) and the other related to potential contaminants that the water is carrying, i.e. water pollution.

Figure 13. Storm water

Inflow and infiltration or I & I are terms used to describe the ways that groundwater and storm water enter into dedicated wastewater or sanitary sewer systems

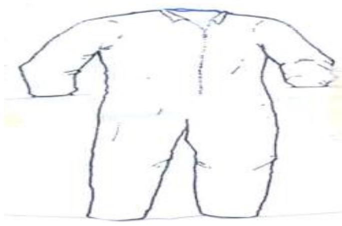
Inflow is storm water that enters into sanitary sewer systems at points of direct connection to the systems. Various sources contribute to the inflow, including footing/foundation drains, roof drains or leaders, downspouts, drains from window wells, outdoor basement stairwells, and drains from driveways, groundwater/basement sump pumps, and even streams. These sources are typically improperly or illegally connected to sanitary sewer systems, via either direct connections or discharge into sinks or tubs that are directly connected to the sewer system. An improper connection lets water from sources other than sanitary fixtures and drains to enter the sanitary sewer system. That water should be entering the storm water sewer system or allowed to soak into the ground without entering the sanitary sewer system.

Infiltration is groundwater that enters sanitary sewer systems through cracks and/or leaks in the sanitary sewer pipes. Cracks or leaks in sanitary sewer pipes or manholes may be caused by age related deterioration, loose joints, poor design, installation or maintenance errors, damage or root infiltration. Groundwater can enter these cracks or leaks wherever sanitary sewer systems lie beneath water tables or the soil above the sewer systems becomes saturated. Often sewer pipes are installed beneath creeks or streams because they are the lowest point in the area and it is more expensive to install the pipe systems beneath a roadway. These sewer pipes are especially susceptible to infiltration when they crack or break and have been known to drain entire streams into sanitary sewer systems.

6.4.4. Appropriate personal protective equipment

- All PPE clothing and equipment should be of safe design and construction, and should be maintained in a clean and reliable fashion.
- Employers should take the fit and comfort of PPE into consideration when selecting appropriate items for their workplace.
- PPE that fits well and is comfortable to wear will encourage employee use of PPE.
- Most protective devices are available in multiple sizes and care should be taken to select the proper size for each employee.
- If several different types of PPE are worn together, make sure they are compatible.
- If PPE does not fit properly, it can make the difference between being safely covered or dangerously exposed.
- It may not provide the level of protection desired and may discourage employee use

Table 3. Selecting and checking **of safety equipment and tool**

1. **Helmet/hard hat: -** protect head of the worker from any falling objects from high level during construction.	 Figure 14. Helmet/hard hat
Over all cloths:-Protects the normal clothes from dust, grease and other spilling materials.	 Figure 15. Over all cloths
Safety shoe (boot):-Protects the worker form nail, sharp objects and heavy falling objects by hard-rolled leather shoes with metal toe caps.	 Figure 16 Safety shoe (boot)
Mask: - Protects eyes of the worker from other endangering object and dust during construction.	 Figure 17. Mask
Goggle: - Protects eyes of the workers during welding of metal works and when placing reinforcement in the form work. **Goggles** or **safety glasses** are forms of protective eyewear that usually enclose or protect the area	 Figure 18. Goggle

surrounding the eye in order to prevent particulates, water or chemicals from striking the eyes. They are used in chemistry laboratories and in woodworking.	
Glove:-Protects the workers from oils, chemicals, and dust and other dangerous material that affect the skin.	 Figure 19. Glove

Self-Check 6	Written Test

Instructions: Choose the best answer from the given alternatives and write your answers on the answer sheet provided.(2 pts)

Part I.

1. Pumping station consists of -------- components
   A. The pumps (plus accessories:, delivery and suction pipes, valves, air-vessel, etc)
   B. The intake structure,
   C. The sump (or suction well) and other ancillary structures.
   D. All
2. One of the ff is not sewerage physical facilities through which sewage flows[3points]
   A. Pipes
   B. Lift stations
   C. Treatment and disposal facilities
   D. None
3. One of the following is NOT construction equipment
   A. Hand and power tools
   B. On and off-road vehicles
   C. Air plane
   D. Motorized equipment
4. Any type of vehicle which is capable of driving on and off paved or gravel surface
   A. On and off-road vehicles
   B. Space vehicles
   C. Wing vehicles
   D. Romantic vehicles
5. The most common types of power tools use.
   A. Electric motors
   B. Shovels
   C. Water
   D. Solar energy

Note: Satisfactory rating - 5 point Unsatisfactory - below 5 points

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

Answer sheet

Name: ______________________________ Date: __________________

Multiple choices

1. ....
2. ....
3. ....
4. ....

Score = ____________
Rating: ____________

Operation Sheet 1	Techniques of sketching and demonstrating hydrology cycle components

Procedures of sketching and demonstrating hydrology cycle components

Step 1: Select and use appropriate PPE

Step 2: Select and use appropriate tools and equipments

Step 3: Sketch hydrology cycle diagram

Step 4: Classify and labeling hydrology cycle components

Step 5: Demonstrating each components

Step 6: Maintain and restore

Operation Sheet 2	Techniques of collecting meteorological and hydrological data

Procedures of measuring evaporation rate by using evaporation pan

Step 1: Select and use appropriate PPE

Step 2: Select and use appropriate tools and equipments

Step 3: Selected suitable site and Clear it correctly

Step 4: Install evaporation pan correctly in the field

Step 5: Fill the pan with known quantity of water (the surface area of pan is known)

Step 6: Measure the water depth

Step 7: Take a read according to the fixed time frequently (usually once a 24 hrs)

Step 8: After the fixed time completed the remain quantity of water depth is measured

Step 9: The amounts of evaporation per unit time (the difference b/n the two measured water depth is computed)

Step 10: Maintain and restore

LAP Test	Practical Demonstration

Name: ______________________________ Date: ________________

Time started: _________________________ Time finished: ________________

Instructions: Given necessary templates, workshop, tools and materials you are required to perform the following tasks with in 30hr.

Task 1: sketch and demonstrate hydrology cycle components

Task 2: collect meteorological and hydrological data

Instruction Sheet	Learning Guide # 47: Advise Sustainable Water Usage

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

- Community and household water usage documentation
- Ways of water conservation and minimizing water usage
- Explaining ways to minimize and conserve irrigation water
- Research study to increase irrigation water supply
- Systems and services of water industry organizations

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:-

- Examine community and household water usage and document the results
- Determine ways to minimize water usage and water conservation
- Explain ways to minimize and conserve irrigation water to the household and the community in a diplomatic and tactful manner
- Study and conduct research on ways to increase irrigation water supply

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the "Information Sheets 1- 5". Try to understand what are being discussed.
4. Accomplish the "Self-checks 1,2,3,4 and 5 " in each information sheets on pages 55, 68, 72, 78 and 83.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to "Operation sheets 1 on pages 84 and do the LAP Test on page 85". However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After You accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result; then proceed to the next LG.

1.1 Purpose and requirements of water

Water is used for the following purposes both in community and at household level.

I. Domestic purposes /residential purposes

Are gallons per capita per day - the total gallons sold for residential use by a public water supplier divided by the residential population served and then divided by the number of days in the year?

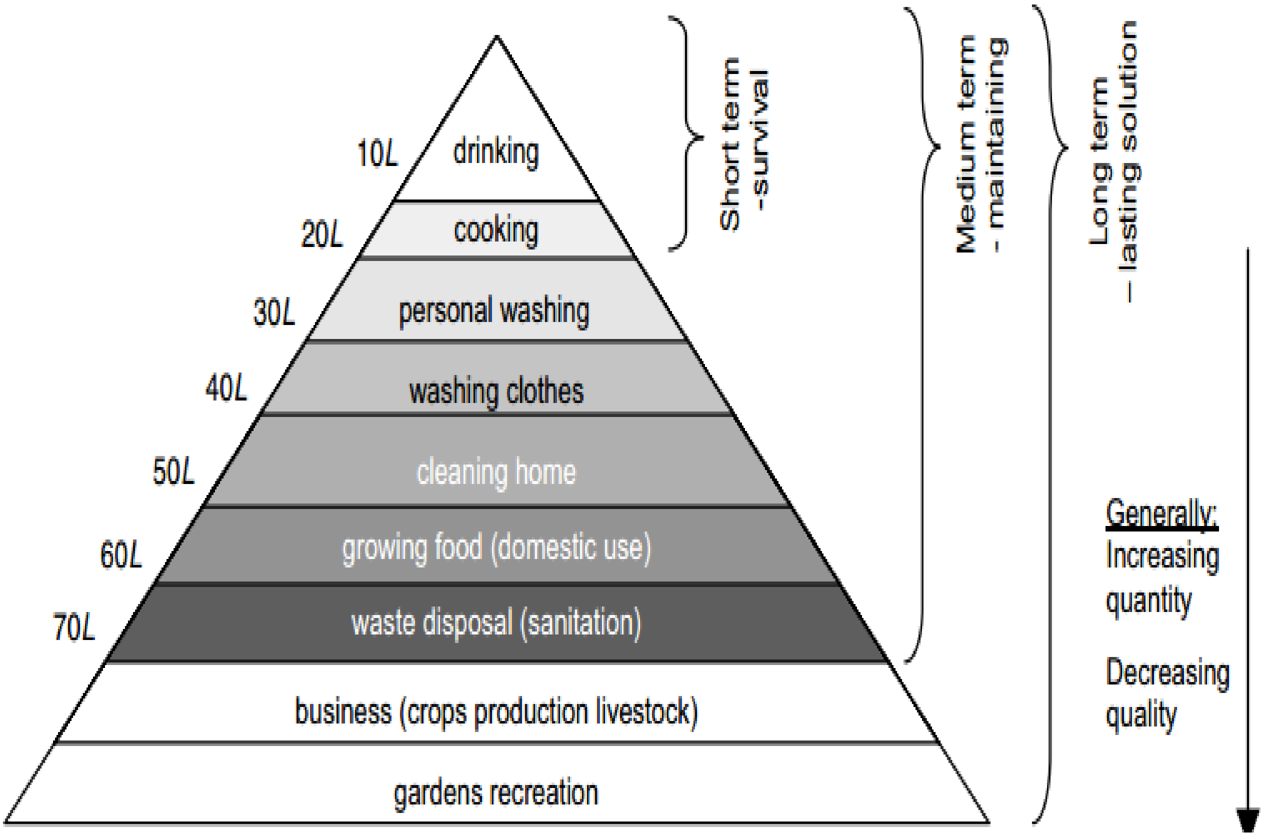


Figure 19. Hierarchy of water requirements

II. Industrial purposes

Industrial use is defined as the use of water in processes designed to convert materials of a lower order of value into forms having greater usability and commercial value, and the development of power by means other than hydroelectric, but does not include agricultural use.

III. Agricultural purposes

Agricultural use is defined as any water use involving agriculture, including irrigation. Agriculture is defined to include the following activities:

- Cultivating the soil to produce crops for human food, animal feed, or planting seed, or for the production of fibers.
- The practice of floriculture, viticulture, silviculture, and horticulture, including the cultivation of plants in containers or non-soil media by a nursery grower.
- Raising, feeding, or keeping animals for breeding purposes or for the production of food or fiber, leather, pelts, or other tangible products having a commercial value.
- Raising or keeping equine animals.
- Wild life management.
- Planting cover crops, including cover crops cultivated for transplantation, or leaving land idle for the purpose of participating in any governmental program or normal crop or livestock rotation procedure

In irrigation, water is required for the following purposes. The following are basic and auxiliary uses of irrigation water in irrigated agriculture. These other uses need to be considered when determining the seasonal water requirements and minimum system capacities. Auxiliary uses of irrigation water include the following.

- To meet crop evapotranspiration water requirements
- Chemigation
- Plant disease control
- Seed germination
- Wind erosion and dust control
- Crop and soil cooling
- Leaching requirement for salinity and sodicity management
- Frost protection (fruits, citrus, berries, vegetables)

IV. Recreational purposes: Watering lawns and gardens, and maintaining swimming pools.

Figure 20. Recreational use of water

1.2 Water capturing and storing structures

- Nets for intercepting fog
- Roofs for direct collection of rainwater
- Terraces, pits, bunds, trenches and vegetation strips for collection of overland flow.
- Natural depressions, check dams, sand dams or flood diversion structures for streams.
- Sub-surface dams for groundwater.

1.3 . Determining community usage of water service

Water use is the amount of water used by a household or a country, or the amount used for a given task or for the production of a given quantity of some product or crop, or the amount allocated for a particular purpose. Sustainable water use involves the rigorous assessment of all source of clean water to establish the current and future rates of use, the impacts of that use both downstream and in the wider area where the water may be used and the impact of contaminated water streams on the environment and economic well being of the area. It also involves the implementation of social policies such as water pricing in order to manage water demand.

1.4. Irrigation water losses

Water losses from agriculture are an important water policy concern, especially in situations of water stress. Depending on site-specific factors, some water is irretrievably lost to the hydrologic system. What returns to the water system is often altered in time, location, and quality. In particular, the characteristics of irrigation losses have important implications for the effectiveness of water efficiency improvement in achieving net water savings. While improvements in the physical efficiency of water use may indeed result in a decline in water consumption, actual water saved is less clear, due to changes in area irrigated and water use per hectare.

The losses from irrigation canals are the greatest in the system; they much influence on the performance of canals and the whole system. When designing, these losses are determined based on estimation. All irrigation water losses can be broken down into separate groups as follows:

- water losses to seepage and evaporation from water surface from irrigation canals;
- water losses to seepage and evaporation from the irrigated field;
- operational losses, leakage and escapage from canals;
- In-process losses.

1.5. Documentation of results and findings of water usage

Water use reports with recommendations are used for improving water use efficiency for each parcel of land. The following points should be considered while reporting the findings of community and household water usage data.

- The level and scope of content depends on to whom the report is intended, e.g., to funders / bankers, employees, clients, customers, the public, etc.
- Be sure employees have a chance to carefully review and discuss the report. Translate recommendations to action plans, including who is going to do what about the research results and by when.
- Include an executive summary; description of the organization and the program, product, service, etc., and any relevant attachments.
- Be sure to record the research plans and activities in a research plan which can be referenced when a similar research effort is needed in the future.

Self-Check -1	Written Test

Directions: Choose the best answer for the following questions and write your answer on the answer sheet provided. All questions have 3 points.

1. Water is used for the following purposes:
   A. Domestic purposes;
   B. Industrial purposes;
   C. Agricultural purposes; and
   D. Recreational purposes
   E. All
2. Techniques used to harvest through:
   A. Nets for intercepting fog
   B. Roofs for direct collection of rainwater
   C. Terraces, pits, bunds, trenches and vegetation strips
   D. Natural depressions, check dams, sand dams or flood diversion structures
   E. All
3. All irrigation water losses can be broken down into separate groups what are those separate groups:
   A. water losses to seepage and evaporation from water surface from irrigation canals;
   B. water losses to seepage and evaporation from the irrigated field;
   C. operational losses, leakage and escapage from canals;
   D. In-process losses.
   E. ALL

Note: Satisfactory rating - 4 point Unsatisfactory - below 4 points

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

Answer sheet

Name: ___________________________ Date: ________________

Multiple choices

1. ....
2. ....
3. ....
4. ....

Score = ____________

Rating: _____________

2.1. Strategies of saving irrigation water

Irrigation system application is based on managing the proper amount of water to the plant in order to: meet crop needs, apply amounts adequate for the soil, and avoid runoff while maintaining or improving water quality.

- **Capturing and Storing Water:** Is excavated water holding reservoir was dug to collect water during heavy rains. It was built lower than the remaining field where some terracing work was also done, so that gravity could do the collecting. A drip irrigation system with some type of pump might be added, and the small pond can also be lined with plastic. Holding ponds or small storage tanks on small farms can also be fed through canal irrigation. They can collect the water when it is available to be used by the farmer; when needed or when it is a convenient time to irrigate.

Figure 21. Open water collecting and storing pond

Irrigation Scheduling: Smart water management is not just about how water is delivered but also when, how often, and how much. To avoid under or overwatering their crops, farmers carefully monitor the weather forecast, as well as soil and plant moisture, and adapt their irrigation schedule to the current conditions. Farms which use flood irrigation in their orchards, should water at night to slow down evaporation, allowing water to seep down into the soil and replenish the water table.

- **Drought-Tolerant Crops**: Growing crops that are appropriate to the region's climate is another way that farmers are getting more crop per drop. Crop species that are native to arid regions are naturally drought-tolerant, while other crop varieties have been selected over time for their low water needs. Olives, Armenian cucumbers, tepary beans, and orchards are a few of the more drought-tolerant crops. Grow the right crop for the growing region. Regions which suffer water shortages are wise to plant crops which are more tolerant to drought. These include finger millet, pearl millet, Guinea millet, cowpea, teff, lentils, amaranth, fonio, emmer, various sorghums, African rice, Ethiopian oats, irregular barley, mung beans and many grasses.

Figure 21. Drought resistant Finger Millet

- **Dry Farming:** Many dry farmers don't irrigate, relying on soil moisture to produce their crops during the dry season. Special tilling practices and careful attention to microclimates are essential. Dry farming tends to enhance flavors, but produces lower yields than irrigated crops. Wine grapes, olives, potatoes, and apple trees can also be successfully dry farmed.
- **Rotational Grazing:** Rotational grazing is a process in which livestock are moved between fields to help promote pasture re growth. Good grazing management

increases the fields' water absorption and decreases water runoff, making pastures more drought-resistant. Increased soil organic matter and better forage cover are also water-saving benefits of rotational grazing.

- **Compost and Mulch:** Compost, or decomposed organic matter used as fertilizer, has been found to improve soil structure, increasing its water-holding capacity. Mulch is a material spread on top of the soil to conserve moisture. Mulch made from organic materials such as straw or wood chips will break down into compost, further increasing the soil's ability to retain water. Farmers may also use black plastic mulch as a soil cover to suppress weeds and reduce evaporation ***(See the video at: http://youtube.com/watch?v=BQB_kdefK9I)***
- **Cover Crops:** Planted to protect soil that would otherwise go bare, cover crops reduce weeds, increase soil fertility and organic matter, and help prevent erosion and compaction. This allows water to more easily penetrate the soil and improves its water-holding capacity.
- **Conservation Tillage:** The Dust Bowl of the 1930s was created by a perfect storm of deep plowing and loss of perennial grasses followed by extreme drought and wind erosion. Conservation tillage uses specialized plows or other implements that partially till the soil but leave at least 30 percent of vegetative crop residue on the surface. Like the use of cover crops, such practices help increase water absorption and reduce evaporation, erosion, and compaction.
- **Avoid Using Chemical Fertilizers:** A research showed that corn grown in organic fields had 30 percent greater yields than conventional fields in years of drought. In addition to keeping many of the more toxic pesticides out of our waterways, organic methods help retain soil moisture. Healthy soil that is rich in organic matter and microbial life serves as a sponge that delivers moisture to plants. The trial also found that organic fields can recharge groundwater supplies up to 20 percent.
- **Sand Dams:** Sand dams were developed by the Romans in 400 BC.As a rain water collection system, they create a life generating spring where there was none before, by storing wet season water in sand, which filters the water and keeps it from evaporating. A hand pump can be installed in sand dams to access the deeper, stored, clean water. Fruit and other trees can be planted near the dams and grass can be added for erosion control.

Figure 22. Sand Dam

To construct the dams, villager's line up to dig a deep trench which is filled with concrete and the rainy season backfills the new wall with sand over several rainy seasons. These walls might be 90 meters long and 2-4 meters high. Located across small rivers which stop flowing in the dry season, the sand becomes about 40% saturated with water and can hold 2 to 10 million liters.

- **Physical SWC Structures (Half Moons, Bunds, and Terraces)**: These methods can conserve both water and soil while requiring little capital investment. Terracing, contour bunds, infiltration pits, tillage, integration of tree crops, and green mannuring all help to increase water infiltration and storage in the soil.

Bunds: On land with slight or moderate slopes and light to medium weight soils, bunds can be constructed to reduce rainwater runoff, gully formation, and soil loss. Bunds are raised earthen barriers which must be constructed by machine or by hand. They require a significant amount of labor and take a small amount of land out of production. They help rainwater to percolate into the soil. Bunds are used in terraced rice farming to retain water in the paddies.

Newly constructed soil bunds in Ethiopia topped with compost.
Credit: Flickr CC via treesftf's photostream

Figure 23: Soil bund

- **Half Moons:** By constructing half moon structures on slight slopes, rainwater is collected and erosion is stopped. Like bunds, they are appropriate for lighter soils that form surface crusts. They help enable the production of drought resistant crops like millet, where there is little rainfall. Half moons can be used for forage crops in rangeland degraded areas, too.

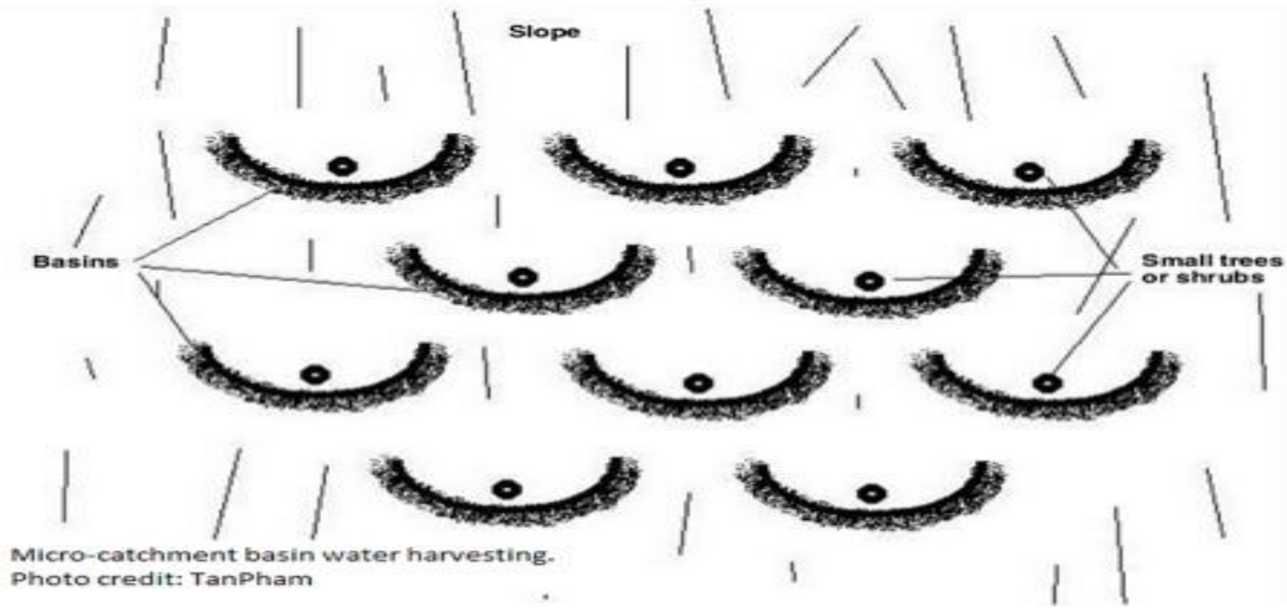


Figure 24. Soil bund

- **Terraces:** These serve as small dams on sloped farmland and prevent gully washing. While expensive to construct they help preserve soil and water quality and grassy buffer strips provide nesting habitat for wildlife.

Figure 25. Terraces and Buffer Strips

- **Collecting Fog or Mist:** It is harvesting water from thin air. Started by ancient Egypt and Israel. By using nets strung across mountain passes, or stretched on poles located in foggy areas, gravity collects clean potable water. Water droplets attach to the netting and run down into gutters beneath the nets. The collected water may be further collected into tubes, taking it to a lower village or point of water storage.

One square meter of netting can provide five liters of water per day. The plastic netting is a coarse woven mesh, used to shade fruit trees. It is inexpensive and readily available. Various collection methods can be constructed, to fit the specific setting. In addition to gaining potable water for drinking, collecting water from fog can be used for agriculture and starting trees for reforestation, too.

To learn more, watch this video: ***https://www.youtube.com/watch?v=FZCl0dyN6pc***

Figure 26. Plastic Netting Collecting Fog or Mist

2.2. Irrigation methods for irrigation water conservation

Many of the methods known to conserve water and use it efficiently have been practiced for thousands of years in some very arid regions of the world with great success. The best systems require little maintenance while yielding maximum results.

- **Drip or Micro-Irrigation:** Drip irrigation systems deliver water directly to a plant's roots, reducing the evaporation that happens with spray watering systems. Properly installed drip irrigation can save up to 80 percent more water than conventional irrigation, and can even contribute to increased crop yields.

Watch the video using the link given below

- ***https://www.youtube.com/watch?v=QYskLFMoGcY***
- ***https://www.youtube.com/watch?v=89S1WIosRzo***
- ***https://www.youtube.com/watch?v=QCYABTCGzwM***

Figure 27. Surface Drip Irrigation system

Drip irrigation delivers water (and fertilizer) either on the soil surface or directly to the roots of plants through systems of plastic tubing with small holes and other restrictive outlets. By distributing these inputs slowly and regularly, drip irrigation conserves 50 to 70 percent more water than traditional methods while increasing crop production by 20 to 90 percent.

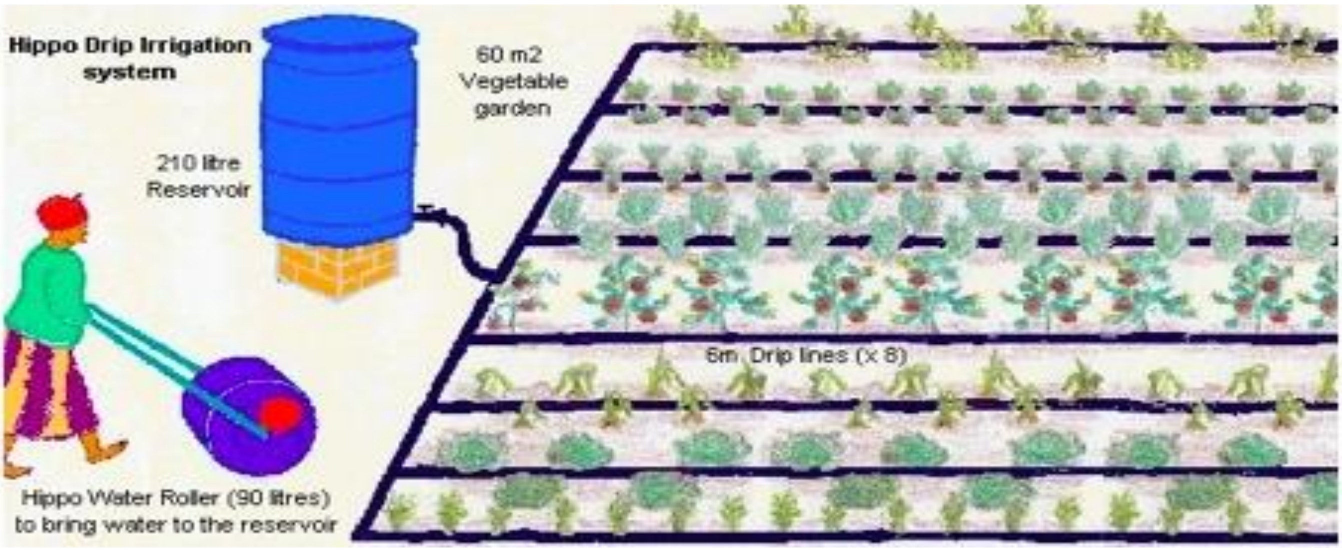


Fig 28. Elevated buckets drip irrigation system

Usually operated by gravity, drip irrigation saves both the time and labor that would otherwise be needed to water crops, leading to larger harvest yields. Small systems on timers can easily be set up by the home gardener, too. Small stream diversions, water collection tanks, or holding ponds can be used to provide a gravity water supply for drip irrigation systems. Hand or peddle powered pumps or elevated buckets can also be used.

Figure 29. Drip irrigation system equipped with water collection tanks

- **Subsurface Irrigation Systems:** Subsurface irrigation is especially suitable for hot, windy regions. See the following videos.

Watch the video using the link given below

- ***https://www.youtube.com/watch?v=lbxG0K4kQuY***
- ***https://www.youtube.com/watch?v=8l_k_qy722U***
- ***https://www.youtube.com/watch?v=S5S0iqRMBQI***
- ***https://www.youtube.com/watch?v=3oEy8hUFIt0***
- ***https://www.youtube.com/results?search_query=Subsurface+drip+irrigation+system***

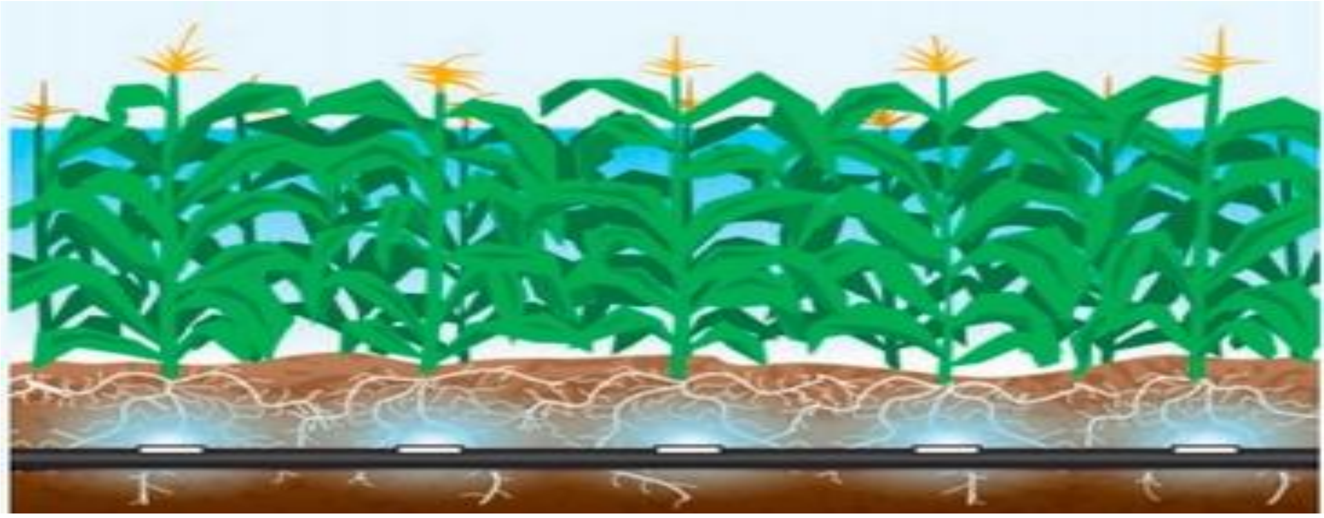


Figure 30. Sub surface drip irrigation system

Advantages of subsurface irrigation systems include:

- water savings
- improved crop yields
- no surface evaporation
- no soil and nutrient run-off
- nutrients can be applied at the root
- there is less disease and fewer weeds
- it requires less labor
- produces uniform moisture at the root zone
- reduced amount of energy is required for pumping

Efficiency through Center Pivot Irrigation

Figure 31. Center Pivot Irrigation

As compared to the old days when center pivot irrigation lost an enormous amount of water through evaporation by spraying the water high into the air during hot weather, today's

systems are much more efficient. This efficiency comes from putting sprinkler heads, or nozzles on hose drops, as pictured above, to minimize water drift and evaporation.
See this video on: ***https://www.youtube.com/watch?v=DE3tJzL-LT0***

- **Gravity Drip Bucket Irrigation Systems:** Bucket gardens are a simple technology that is gaining a foothold for subsistence farmers. Buckets need to be elevated on stands that are at least three feet above the ground; on the high end of the garden, if it is not flat. Beds should be prepared with compost or organic material and manure and then leveled. The drip tape can then be set up, and with care, the system should last 5-7 years.

Watch this video on*: **https://www.youtube.com/watch?v=UpvvJVo4ehU***

source: double harvest.org in Kenya

Figure 32. Gravity Drip Bucket Irrigation Systems

- **Canal or Ditch Irrigation**: Canal irrigation is a surface flooding irrigation method, the most common type of irrigation in the world. Because surface flooding accounts for most irrigation, it is very important to develop and promote methods or technologies which improve the efficiency of canal irrigation. This is a method of transferring water from a water source to fields. Canals, ditches, basins, furrows, borders, pipes, and surface flooding provide ways to move the water by gravity.

Watch the video using the link given below

- ***https://www.ssyoutube.com/watch?v=uDWcg1Pmf6U***

Figure 33. Canal or Ditch Irrigation

- **Advantages of Canal Irrigation:** Most of the canals provide perennial irrigation and supply water as and when required. This saves the crops from drought conditions and helps in increasing the farm production. Canals carry a lot of residue brought down by the rivers. This sediment is deposited in the agricultural fields which make soil more fertile. Some of the canals are parts of multipurpose projects and, therefore, provide inexpensive source of irrigation. Although the initial cost involved in canal irrigation is more, it is quite cheap in the long run.

See also these videos on: http://youtube.com/watch?v=TTyN268VqOc and https://www.youtube.com/watch?v=uDWcg1Pmf6U

Self-Check -2	Written Test

Direction I: Match items under column 'A' with items listed under column 'B'. Use the answer sheet provided to write your answers.(2 pt each)

A	B
1. Drip, or Micro-Irrigation	A. Especially suitable for hot, windy regions.
2. Subsurface Irrigation Systems	B. Surface flooding irrigation method
3. Pond	C. Drip irrigation systems deliver water directly to a plant's roots, reducing the evaporation
4. Terraces	D. Half moon structures constructed on slight slopes to collect rainwater and stop soil erosion
5. Bund	E. **S**erve as small dams on sloped farmland and prevent gully washing.
	F. Water capturing and storing structure
	H. Raised earthen barriers which is used to protect gully formation and reduce rain runoffand soil loss

Note: Satisfactory rating - 4 point Unsatisfactory - below 4 points

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

Answer sheet

Name: ___________________________ Date: ________________

Multiple choices

1. ....
2. ....
3. ....
4. ....

Score = ____________

Rating: _____________

Information Sheet-3	Explaining Ways to Minimize and Conserve Irrigation Water to Community

3.1. Sustainable use of water

The concept of sustainability is coming at the right time and needs to be taught to all levels. There is mostly need to reach out to the public and communities to ensure that all individuals learn how to use their water efficiently. Besides this, society can achieve equitable health only when provided with safe water that can be used for promoting hygiene and sanitation.

Sustainable water supply means to full fill reliable and resilient approaches to various human needs for water for that does neither exhaust the water sources and the local economy nor have long term negative impact on the environment. There are many benefits of using water more efficiently. Efficient water use helps to maintain the integrity of aquifers and surface water systems, while lowering costs for water users, providers, and taxpayers. Sustainable water use is an important step towards ensuring that sufficient water is available to meet the needs of both people and nature.

3.2. Community awareness on water conservation

The main aim of community awareness programs is to make the community more informed, alert, self-reliant and capable of participating in all activities and programs of disaster management in close collaboration with government and non-governmental organizations.
The awareness will not only promote community participation but also enable them to understand the following.

- What can be the impact of particular disaster and what an individual, a family or community can do to reduce its impact and save life and property.
- Government's plan for disaster reduction and available assistance in time of disasters.
- Government's limitations of resources and responsibilities.
- Need to cooperate with government to overcome th4e crisis and recover the community as it is in their own interest.
- Implementation of self-preparedness measures whenever required.
- What community can do till any external help is available?

Community awareness is the key to community participation. Well-informed and well aware people will have more role-clarity in disaster reduction and preparedness programs. They will be able to contribute their best if they know the issues involved as well as various participants in the past disaster management instances and their own expected roles in the process. The most important benefit of the community awareness is that they will be able to judge their strength and the weakness and to identify the areas in which they really need outside assistance.

Awareness can be achieved through seminars, workshops, television, radio, newspapers, magazines, journals, posters, and leaflets. Awareness and education are not about coercion but a way of bringing about change in behavioural patterns of the people. The provision of information to the consumers about, for example, the cost of pumping, treatment, supply and their relation to the water tariff can make consumers appreciate the water issues and become more willing to pay. Issues of quality of water, billing system, maintenance of lines, disconnection and reconnection problems and the price of water should be covered adequately through awareness in order to bring about the desired change in attitude of the consumers.

3.3. Principles of best management practices

The basic principles of the BMPs are focused on helping developers avoid these violations and impacts to water. These include:

- Avoid working in or around water bodies.
- Minimize the work-site footprint; only clear and excavate to the extent necessary.
- Control for erosion and sedimentation by managing sediment-laden runoff:
  - ✓ Cover excavated and exposed surfaces, including stockpiled materials
  - ✓ Install silt fences when necessary
  - ✓ Avoid scraping down to mineral soil
  - ✓ Revegetate disturbed surfaces as soon as possible
- When clearing vegetation, only cut down to ground level, leaving rootstock in place.
- Stockpile mineral soil and organic soil separately; when spreading, spread mineral soil first and organics last.
- Equipment should be refuelled and serviced >30m from a water body such that no deleterious substance enters any water body; all equipment must be clean and free of deleterious substances and invasive plant species before working in or near a water body.
- Wash off rock used as filling materials such as for riprap, is coarse gravel and non-acid

generating rock in the water body prior to placement.

- Never pump construction water directly into a natural water body. Pump it to a vegetated depression, sump or sediment trap to remove sediment and avoid erosion of the natural water body.

Self-Check -3	Written Test

Direction: Choose the best answer from the given alternative and provide your answer on the answer sheet. (3pts each)

1. --------------means to find reliable and resilient approaches to various human needs for water for that does neither exhaust the water sources and the local economy nor have long term negative impact on the environment.
   A. Sustainable water use
   B. Water usage
   C. Community water use
   D. Household water use
2. Awareness about sustainable water use can be created by:
   A. Meetings
   B. Seminars
   C. Leaflets
   D. Radio
   E. All

Note: Satisfactory rating - 3 point Unsatisfactory - below 3 points

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

Answer sheet

Name: ____________________________ Date: ________________

Multiple choices

1. ....
2. ....
3. ....
4. ....

Score = ____________

Rating: _____________

Information Sheet-4	Study and Research on Ways to Increase Irrigation Water Supply

4.1. Definition of terms

Water Use Efficiency: water use efficiency can be defined as a ratio of beneficial water use to the applied water (AW) to the field. Water use efficiency is calculated by a ratio of terms which is then multiplied times a hundred to report the efficiency as a percentage. Different measurements may be used in the ratio resulting in different numbers and yet all may be referred to as water use efficiency.

Water conservation: is to use less water. This can be accomplished by various means, each with a specific consequence. A farmer can grow a crop and apply a small amount of water resulting in very low crop production. Farmers can also grow a crop for high production and either eliminates runoff or captures runoff and uses it as part of the irrigation supply.

Water consumption: is water that is lost for future use. For example, ET is water consumption. It is water that is lost and not available until it is returned again in the form of precipitation, usually at a different location.

Irrigation Scheduling: Irrigation scheduling refers to the time, duration, and quantity of irrigation.

Irrigation efficiency: is a general term that indicates how well a water resource is used to produce a crop. Is mathematically defined as:

IR eff = Vol beneficial / Vol gross

Where:-

IR eff:is Irrigation efficiency

Vol beneficial: the volume of water used to produce a crop

Vol gross: the volume of water taken from the water resource

4.2. Factors Affecting Irrigation Water Supply

The following factors which can increase or decrease the amount of water needed for irrigation.

- **Solar radiation:** The level of radiation that reaches the plants is reduced by 10% to 40% due to the glazing and the structural members in the greenhouse. This reduces the transpiration.

- **Shading:** The use of shading outside or inside will reduce the radiation level on the plants. Depending on the level of shade, this will reduce evapotranspiration and therefore water needs.
- **Air movement**: Fan ventilation and HAF systems increase the rate of evapotranspiration. Depending on location and nearby greenhouses or other buildings, sidewall vents and open-roof designs can also have an influence. A 5 miles/hour breeze can increase evapotranspiration by 20%.
- **Type and size of the plants:** Seedlings or small potted plants require less water than a full-grown tomato or cucumber crop. A large root mass or heavy leaf canopy will increase water needs.
- **Type of irrigation system**: Only 20% of the irrigation water applied with an overhead sprinkler system may reach the soil in a potted plant crop with a large foliar canopy. In-pot drips systems are much more efficient as all the water applied with an in-pot drip system gets to the soil. Sub irrigation systems such as ebb and flood systems, flooded floors and hydroponics conserve water by recycling and reusing the excess water.
- **Leaching**: Traditionally, the recommendation that at least 10% of the water applied is allowed to leach out to remove excess fertilizer salts increases water usage. Often leaching accounts for a much higher percentage and can increase water needs significantly. The type of growing mix used also affects the amount of water holding capacity and therefore the frequency of watering.

4.3. Maximizing irrigation water supplies

- **Improve water use efficiency:** There is still ample scope for water use efficiency improvements (getting more yields per cubic meter of water) and reducing the risk of causing diffuse pollution through over-irrigating by improving the farm irrigation system.

One way of doing so is implementing a drip irrigation system which enhances irrigation efficiency relative to conventional techniques (such as gravity systems, which include flood irrigation of entire fields, and furrow irrigation using shallow channels or ditches to carry water to the crop).Farmers using a pumping systems to irrigate their fields should ensure that the pump and pipe size are fitting with their needs, thus avoiding water and energy over use and consequent leakages.

- **Use Alternative sources of water:** An alternative source of water that farmers can use is rainwater collected from containers, roofs of farm buildings. This source of water can be used for a variety of activities, including washing down yards and washing equipment.

The quantity of rain farmers can harvest will depend on the location of the farm and the climatic conditions as well as size, slope and material of the collecting container.

Prevent and repair leaks: Prevention and repairing infield leaks can save water in the farm. A simple ways to detect leaks is to check leaks visually by looking at unusually damp areas of the farm and unexpected vegetation (for a recent leak) and reduced vegetation (for a long-term leak, because of reduced soil quality). A more complicated way of detecting leaks in case the farmer could not detected visually is by using special leak detectors as listening sticks, remote listening devices, pressure fluctuation sensors.

To prevent leak it is recommendable to insulate pipes, to install drinking systems properly, read water metering frequently and to implement and fit trigger controls in all hoses, hand lances and washing equipment.

Schedule of Irrigation: Irrigation scheduling takes into account the evapotranspiration rate, soil moisture deficits and climate conditions to calculate the exact amount of crop water requirement per day. An efficient use of water results when providing the crop with the exact amount of water.

Understand soil structure and manage moisture conditions: Understanding how soil properties affect water storage before designing an adequate irrigation system can help optimizing water use by plants. Soil moisture depends on climate, topography and other soil characteristics. Some plant species are highly adaptable and can tolerate a range of moisture conditions. Others have very specific moisture requirements.

Minimize land degradation: Reducing land degradation is important for increasing water use efficiency and also minimize soil erosion. No-tillage, for example, not only protects soil architecture through minimal soil disturbance, but also can increase water use efficiency by permitting an efficient water and nutrient cycling as a result of root development and stable biological porosity. These soil organisms undertake biological ripping that improves soil structure, preventing compaction and facilitating root penetration.

Manage pesticides on a responsible way: The use of pesticides can result on water pollution if not managed on a responsible way. It is recommended to assess the risk of pesticides use on water resources.

The adoption of Integrated Pest Management (IPM) practices can reduce pesticide use which in turn can reduce the impact on surface and groundwater from pest management practices.

Avoid water pollution: Agricultural processes such as tillage, ploughing of the land, use of pesticides, fertilizers, over- irrigation, spreading of slurries and manure can cause the contamination of water if not properly managed. Some ways of avoiding water pollution is by implementing conservation measures such as riparian buffers, integrated pest management and manure management.

Use alternative washing and cleaning processes: To diminish the water use in washing materials it is recommendable to use alternative washing such as dry cleaning techniques. Scrapers, squeegees and brushes can be used to remove solid waste before cleaning them with water. Instead of letting water go to waste, it can be recycled and used where high quality water is not needed, or even cleaned and recycled for high quality use.

Establish a Water Management Plan: A good way of managing water use and water pollution is to establish a comprehensive Water Management Plan (WMP) for the farm that identify water use and sources of pollution, water footprints of the crops, water efficiency plans within the farm.

4.4. Methods of increasing irrigation water supply

When available water supply is limited, water is not supplied uniformly at the right time and amount because percolation and runoff are maximum. In adopting new technologies site-specific management of fields, there are additional opportunities for improving irrigation efficiency by increasing the volume of water used to produce a crop in the water stressed areas.

There is still ample scope for water use efficiency improvements (getting more yields per cubic meter of water) and reducing the risk of causing diffuse pollution through over-irrigating by:

- Avoiding water and energy overuse and consequent leakages when using pumps.
- Ensuring that land is properly leveled (in the case of flood or furrow irrigation)
- Checking the condition of the irrigation system, pumps, mains and hydrants periodically and to repair worn items such as seals (for overhead and drip systems).
- Improve application uniformity to reduce deep percolation.
    - ✓ For surface systems, quicker furrow advance to reduce the differences in infiltration opportunity time along a furrow. Options include land leveling, surge irrigation, furrow firming, etc.

- ✓ For sprinkler systems, options include changing sprinkler types, re nuzzling the system or changing nozzle spacing to improve the overlap between heads.

- Modify the timing and amount of an irrigation to match the WHC of the soil profile better, thereby reducing percolation and runoff losses.
- Convert to a more efficient irrigation system (e.g. furrow to sprinkler or drip) to reduce application losses. If the new system is well designed and managed, applications are more uniform reducing deep percolation and runoff. For example, converting from surface to sprinkler irrigation can greatly reduce water application depths.

Irrigation system manufacturers have found ways to enhance performance and increase the uniformity of application through the use of technology. These technologies include soil moisture sensors, automated control boxes, variable rate systems and subsurface drip irrigation.

Self-Check -4	Written Test

Direction: Choose the best answer from the given alternative and provide your answer on the answer sheet. (3pts each)

1. --------------refers to the time, duration, and quantity of an irrigation.
   A. Water conservation:
   B. Water Use Efficiency
   C. Water consumption
   D. Irrigation Scheduling
2. Factors Affecting Irrigation Water Supply include:
   A. Type and size of the plants
   B. Type of irrigation system
   C. Leaching
   D. Solar radiation

Note: Satisfactory rating - 3 point Unsatisfactory - below 3 points

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

Answer sheet

Name: ____________________________ Date: _________________

Multiple choices

1. ....
2. ....

Score = ____________

Rating: _____________

Information Sheet-5	Systems and Services of Water Industry Organizations

5.1. Introduction

Water Utilities industry own and operate water supply and wastewater treatment systems or provide operational and other specialized water services to system owners . Water supply systems include the sourcing, treatment, and distribution of water to residences, government customers, and businesses. These companies deliver water to your faucet and efficiently take wastewater away. Private water industries deliver safe, reliable water at the tap, and operating efficient wastewater systems, not owning water.

The Water Utility Industry is made up of domestic companies responsible for the safe and timely distribution of water and other related services, such as wastewater treatment. Most water systems are local or regional, but some of the companies under our review have operations across many states. Since water is an essential resource, it would be easy to assume that the stocks of these companies would be high fliers. Demand from the industrial, agricultural and residential markets is expanding and the supply of potable water is shrinking. Big earnings and share-price gains have not been the case, here, however. The industry is subject to regulation, which can raise service costs, while limiting rates and return on investment.

5.2. Systems and services of irrigation and water sectors

The Irrigation and Water Development falls under the Ministry of Irrigation , Water and Electric in Ethiopia. It manages and develops water resources for the sustainable, effective and efficient provision of safe water supply and sanitation services and irrigation systems in a more coordinated manner in support of the countries socio-economic growth and development agenda.

5.3. Core services delivered by water industry

5.3.1 General services

The following are the core and the most common services delivered by Water and Irrigation sectors.

- Water supply and sanitation
- Medium and large scale irrigation and drainage

- Electricity study and design
- Dam safety and hydropower
- River basin study
- Trans-boundary water affairs
- Groundwater study and development
- Water quality and hydrology
- Water use permit and licensing
- Water sector research and development

Generally, Water and Irrigation sectors have the following functions.

- Preparation of Master Plan for development of the different river basins for the optimum utilization of land and water resources giving priority to the environmental factors
- Project formulation and detail designs of irrigation, hydro-power, flood control and reclamation Projects
- Construction of irrigation and settlement projects for the conservation, diversion and distribution of water under gravity and lift Irrigation to new and existing land for cultivation by farmers for an enhanced food crop production and to upgrade their living conditions.
- Construction of drainage, flood protection and salt water exclusion projects for the protection of land to enable the cultivation of such lands with rainfall for food crop production with minimized risk.
- Providing drainage and flood protection facilities to minimize or mitigate the damages caused by floods.
- Operation, maintenance, improvements, rehabilitation and water management for medium and major irrigation schemes. Drainage and flood protection scheme and salt water exclusion schemes for optimum productivity enlisting the participation of beneficiaries.
- Maintaining and upgrading the water infrastructure including dams for sustainable water supply to agriculture and domestic purposes
- Research in Hydraulics, Hydrology, Soil Mechanics, Engineering Geology, Geographic Information System (GIS), Engineering Materials and Land Use as applied to Water Resources Development Projects
- Human resources development for optimum utilization of human resources

- Operation and maintenance of financial management system, accounting, reporting, auditing systems of irrigation department in accordance with the financial regulation of the government.
- Providing consultancy Services to government department, statutory boards/corporation, public and private institutions and individuals; in the fields of Water Resources Development; Foundation Engineering; Quality Control of Earthwork and Concrete; Hydraulic Model Testing and Land Use Planning.

5.3. 2. Irrigation services

The overall irrigation policy goal is to contribute to sustainable economic growth and development by enhancing irrigated agricultural production. The broad objectives of the irrigation sub sector include;

- Create an enabling environment for irrigated agriculture;
- Optimize government investment in irrigation development;
- Enhance capacity for irrigated agriculture in the public and private sectors;
- Promote a business culture in the small-scale irrigated agriculture sector.
- Increase land under sustainable irrigation farming;
- Extend cropping opportunities and facilitate crop diversification;

5.3. 3. Water supply services

The specific objective of the water supply sub sector is to increase availability and accessibility of potable water for socio- economic growth and development.

The main functions of the department include the following:

- Formulating/initiating sector policies, strategies, setting technical standards and procedures for the provision of water supply services
- Planning, designing and construction of water supply schemes
- Training of communities in proper operation and management of water supply systems
- Providing technical advice to all Water Boards regarding new developments, operations and maintenance
- Promoting water-based sanitation in all water supply schemes
- Supporting professional training and capacity building of engineers and technicians in the Sector.

5.3. 4. Management and support services

The overall objective of management and support service subsector is to provide policy direction and support services to the Technical Departments. These departments comprise General Administration and Management, Human Resource Management and Development, Finance and Planning.

5.4. Types of irrigation organizations

- **State farms:** State Farms are often established where the land is nationalized or where land reform processes have taken place. The purpose of establishing a State Farm can be to maximize agricultural production or to gain experience on newly reclaimed lands for its later transfer to farmers as settlement projects. It is the most commonly found.
- **Irrigation settlement projects:** Irrigation settlement projects aim at improving the economic and social welfare of landless people or poor farmers by providing them with irrigated land and agricultural production means. The organizational structure of settlement projects generally has the following two units:

a. The Manager's Office: This is the highest executive body of the scheme and frequently consists of the Manager himself and some advisory members. He is directly dependent on the national institution responsible for the management of all irrigation schemes in the country.

b. The executive units Includes: -operation, finance, maintenance, marketing, training, production, social assistance and administration units.

- **Irrigation cooperatives:** Many types of cooperatives exist but here reference is made to a particular type in which a group of farmers associate to develop a common irrigation system for their properties, and jointly farm the land. Such a type of cooperative occurs mostly among progressive farmers and is generally found in developed countries. It is often financially attractive to farmers because they enjoy the advantages (tax exemptions or reductions) applicable to any other cooperative.

Self-Check -5	Written Test

Direction: Choose the best answer from the given alternative and provide your answer on the answer sheet. (2pts each)

1. Types of irrigation organization aim at improving the economic and social welfare of landless people or poor farmers by providing them with irrigated land and agricultural production means is:
   A. Settlement projects B. Cooperatives C. Administration units D. State farms
2. Core areas of the services delivered by water industry
   A. River basin study B. Dam safety and hydropower C. Water quality and hydrology
   B. Water supply and sanitation D. All
3. The broad objectives of the irrigation sub sector include;
   A. Create an enabling environment for irrigated agriculture;
   B. Optimize government investment in irrigation development;
   C. Enhance capacity for irrigated agriculture in the public and private sectors;
   D. Promote a business culture in the small-scale irrigated agriculture sector.
   E. Increase land under sustainable irrigation farming;
   F. Extend cropping opportunities and facilitate crop diversification;
   G. all

Note: Satisfactory rating - 3 point Unsatisfactory - below 3 points

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

Answer sheet

Name: ___________________________ Date: ________________

Multiple choices

1. ....
2. ....
3. ....

Score = ____________

Rating: _____________

Operation Sheet 1	Assessing Community and Household Water Usage

Procedures of assessing community and household water usage

Step 1: Plan and organize the water use assessment.

Step 2: Gather data on the present community and household water use and water fees.

Step 3: Analyze the data on community and household water use, costs and efficiency.

Step 4: Assess opportunities for improvement on water use and other water conservation measures at community and household level

Step 5: Document and report outcomes of water use assessment.

LAP Test	Practical Demonstration

Name: ______________________________ Date: ________________

Time started: ________________________ Time finished: ________________

Instructions: Go to nearby irrigation development project around your locality and using the necessary templates, tools and materials, perform the following tasks within 12 hour.

Task 1 - Assess community and household water usage.

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

- Identify Responsible water quality management Bodies/Agency
- Methods and procedures to maintain water quality
- Factors affecting water quality
- Environmental risk and impact of quality of water services
- Measures to ensure quality of water services

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 and confirm bodies/agency responsible for establishing and managing water quality following standard procedures.
- Determine and verify with discretion methods and procedures applied in maintaining water quality
- Analyse and report factors affecting water quality following standard procedures.
- Identify, document and convey environmental risk and impact of the quality of water services to appropriate personnel.
- Communicate measures of water services to appropriate people to ensure quality or individuals

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the "Information Sheets 1- 5". Try to understand what are being discussed.
4. Accomplish the "Self-checks 1,2,3,4 and 5 " in each information sheets on pages 90, 99, 103, 109 and 113.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).

6. If you earned a satisfactory evaluation proceed to “Operation sheets 1-3 on pages 114 and do the LAP Test on page 115”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After You accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result; then proceed to the next LG.

Information Sheet-1	Identify Responsible Water Quality Management Bodies/Agency

1.1. Introduction

Integrated water quality management is essential because water quality can be affected at each of these points and because they are all interrelated,. Drinking water supplier is responsible for delivery of water to the consumer's meter. Suppliers should consider how drinking water quality may be affected in private plumbing systems and provide appropriate information to consumers..

1.2. Stake holders in water quality management

The range of organizations involved in individual water supply systems will vary depending on local organizational and institutional arrangements. Agencies may include:

- Health and environment protection authorities
- Environmental Protection Agency (EPA)
- Catchment and water resource management
- Local government and planning authorities
- Non-government organizations (NGOs)
- Community-based groups

An integrated management approach with collaboration from all relevant organizations is essential for effective drinking water quality management. All major stakeholders that could affect (e.g. regulators, catchment basins) or be affected by (e.g. consumers, industry) decisions or activities of the drinking water supplier should be identified. The list of stakeholders should be regularly updated. The various agencies involved should be encouraged to define their accountabilities and responsibilities to support the drinking water supplier and to coordinate their planning and management activities.

Table 4. Responsibilities of Major Stakeholders in Water Quality Management

Stakeholders	Responsibility in protecting drinking water quality
Department of Agriculture and Food	•Ensures sustainable management practice is developed and promoted foragriculture.Thisincludeson-siteandoff-siteimpactsofagricultural land use.
Department of Environment and Conservation	•Manages land and water entrusted to the department which includes national parks, nature reserves, state forests and timber reserves and associated forest produce, flora and fauna.
Department of Water	•Implementation of catchment management aspects •Sustainable management of water resources. •Identifies, assesses, manages,
Department of Health	•Promotes the effective implementation and operation of the in the catchment. •Regulates the delivery of safe drinking water to consumers via treatment and distribution systems.
Department of Industry and Resources	• Regulate and promote environmental management in both the minerals and petroleum industries.
Department of Land Information	•Administration of government-controlled land, including unallocated land.
Developers, landowners and the community	• Responsible for ensuring their activities and land-use practices do not result in the release of materials which have the potential to contaminate our drinking water sources.
Local government	• Are recognized within planning schemes and strategies.
Water service providers	•Collect, treat and distribute drinking water to consumers.

Self-Check -1	Written Test

Direction: Choose the best answer from the given alternative and provide your answer on the answer sheet. (4pts)

1. Stake Holders in Water Quality Management Agencies may include:

   A. Health and environment protection authorities
   B. Environmental Protection Agency (EPA)
   C. Catchment and water resource management
   D. Local government and planning authorities
   E. Non-government organizations (NGOs)
   F. all

Note: Satisfactory rating - 2 point Unsatisfactory - below 2 points

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

Answer sheet

Name: ____________________________ Date: ________________

Multiple choices

1............................

Score = ____________

Rating: _____________

2.1. Overview of water supply system

The drinking-water supply system is defined as everything from the point of water source to the consumer and can include:

- harvesting system; Storage reservoirs, water impoundment for treatment systems;
- Service reservoirs and distribution systems;
- catchments, including surface and ground water systems, points source, rain water
- Household reservoirs and handling of water in household.
- Water supply systems include all type of water supply scheme ranging from households point source e.g. dug-well or hand-pump to a large water supply.

Water quality can be affected at each of these points and because they are all interrelated, integrated management is essential. Generally, a drinking water supplier is only responsible for delivery of water to the consumer. However, although it is not possible to control consumers' actions, suppliers should consider through relevant organization how drinking water quality may be affected during handling and storage at households and provide appropriate information to consumers to maintain water safety and protect health.

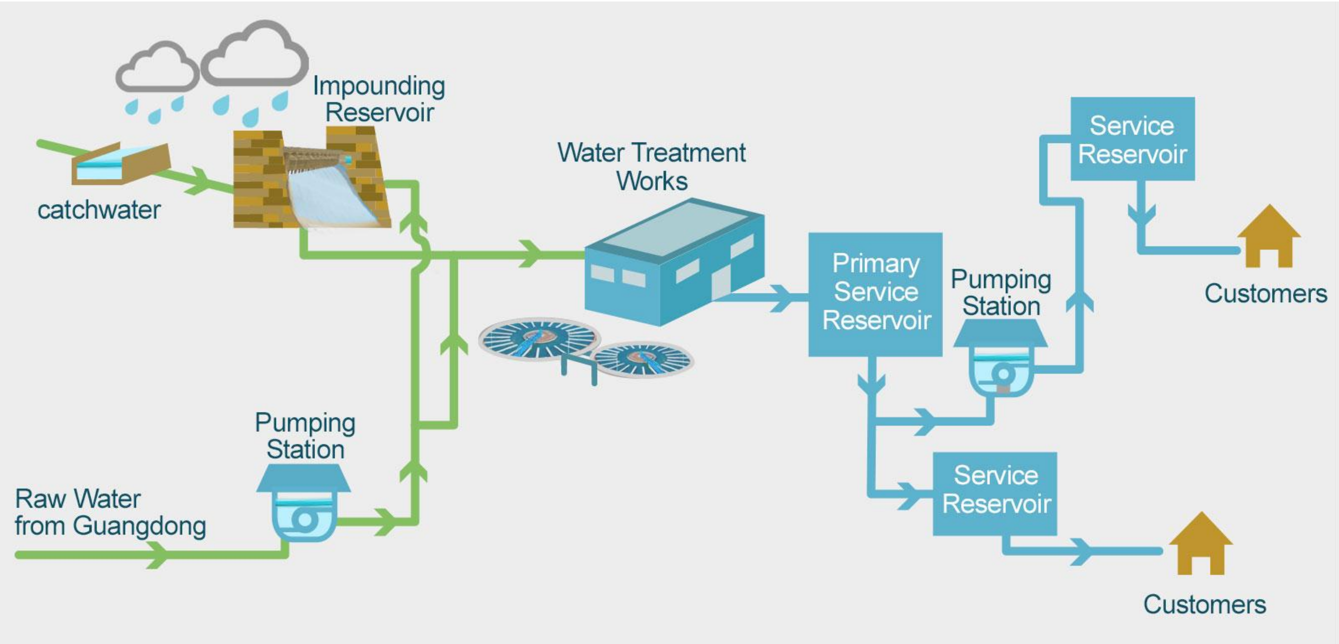


Figure 34. Water Supply System

2.2. Hazard identification

Identification of all potential hazards, hazard sources and hazardous events within a facility is important to enable a thorough risk assessment to be undertaken. A hazard may be a biological, chemical agent or physical property of water that has the potential to cause injury or illness to an individual.

2.2.1. Categories of hazard

- Biological hazards may include, but are not limited to, enteric pathogens (Escherichia coli (E. coli)), Campylobacter, Cryptosporidium, Giardia, and Enterovirus) and environmental pathogens (Legionella, Non-tuberculous mycobacteria (NTM), Pseudomonas aeruginosa).
- Chemical hazards may include, but are not limited to, metals (manganese, aluminium, copper, lead, nickel and cadmium) and trihalomethanes (THMs). THMs are a category of disinfection by-product formed by the reaction of chlorine with organic substances in water.
- Physical hazards may include, but not be limited to, high water temperatures, high or low pH and high levels of turbidity.

2.2.2. Sources of hazard

A hazard source is a location or condition that can give rise to a hazard. Hazard sources include:

- Areas of low flow or stagnant water within the facility distribution system (dead legs and disused taps)
- Location of hot and cold water pipes too close together such that the hot water pipes raise the temperature of the cold water to temperatures favorable to legionella growth.
- Biofilm growth within pipework, storages and the plumbing fixtures
- Incoming water to the facility which may contains hazards or contribute to the development of a hazard within the facility water distribution system
- Poorly maintained or inadequate infrastructure including tempering valves, backflow preventions devices.

2.2.3. Hazardous events

A hazardous event is a situation that can lead to the presence of a hazard or increase its adverse impact. Hazardous events include:

- Interruption to supply - scheduled or unscheduled e.g. Building/facility maintenance, natural disaster, road works, nearby construction or a water main break
- Contamination of the incoming water leading to a boil water alert
- Temperature changes in water (e.g. A decrease in temperature in a hot water system to below 60°c provides conditions conducive to legionella growth).

2.3. Hazards in drinking water

Table 5. Examples of hazards and hazardous events in drinking water

Hazard Source	Hazards	Hazardous events
Incoming water	• Enteric pathogens • Chemical contamination • Environmental pathogens • Loss of water • High turbidity	• Boil water advice • Water main break • Service shutdowns • Discolored water • Cross connection • Natural disaster
Boundary to building plumbing	• Enteric pathogens • Environmental pathogens • Chemical contamination	• Untreated water ingress • Cross connections
Cold water storage	• Enteric pathogens • Environmental pathogens • Chemical contamination	• Untreated water ingress • Sludge build-up • Stagnation • Low chlorine residual
Cold water distribution	• Environmental pathogens • Chemical contamination	• Discoloured water • Low chlorine residual • Dead legs
Central hot water system	• Environmental pathogens Scalding • Chemical contamination	• Loss of power/heat source • System corrosion • Circulation pump failure • System failure

Warm water loops	• Environmental pathogens	• Stagnation • Heating unit failure/heat loss • Circulation pump failure • Thermostat failure • Dead legs • Low chlorine residual
Drinking water fountains	• Environmental pathogens • Chemical contamination • High turbidity	• Discoloured water • Temperature failure • Filter failure • Stagnation • Low chlorine residual

2.4. Preventive measures of drinking water hazardous agents

The most effective approach to managing drinking water quality is to prevent a water quality incident occurring or to prevent the introduction of a water quality hazard to the drinking water system. Preventive measures will be required to remove the hazard or to reduce it to an acceptable level. The effectiveness of existing measures should be assessed, but if these are not sufficient, alternative measures will need to be identified. As with all systems, assessment of preventive measures should include consideration of the important principle of the multiple barrier approach. The types of barriers and the preventive measures required will depend on the characteristics of the source water and the associated catchment as follows.

Groundwater: Groundwater in confined or deep aquifers will generally be free of pathogenic microorganisms and, providing the water is protected during transport from the aquifer to consumers, microbial quality should be assured. The local vicinity of the bore head should be protected from livestock access, and buffer zones should be established between the bore and disposal or discharge of septic wastes. Bores should be encased to a reasonable depth and bore heads should be sealed to prevent ingress of surface water or shallow groundwater. Once the groundwater is pumped out of the aquifer, protection can be achieved by delivering the water through enclosed water systems. Storage tanks should be roofed, pipelines should be intact and cross- connections should be protected by the installation of backflow prevention devices.

Rainwater: Rainwater systems, particularly those involving storage in above-ground tanks, generally provide a safe supply of water. The principal sources of contamination are birds small animals and debris collected on roofs. The impact of these sources can be minimized by a few simple measures: guttering should be cleared regularly; overhanging branches should be kept to a minimum, because they can be a source of debris and can increase access to roof catchment areas by birds and small animals; and inlet pipes to tanks should include leaf litter strainers. First-flush diverters, which prevent the initial roof-cleaning wash of water (20–25 L) from entering tanks, are recommended. If first flush diverters are not available, a detachable downpipe can be used to provide the same result.

Surface water: Assurance of quality from surface water sources is more difficult than from most groundwater or rainwater systems. In general, surface waters will require at least disinfection, and in some cases filtration, to assure microbial safety. However, as for groundwater systems, the first barrier is to prevent contamination at source by minimizing contamination from human waste, livestock and other hazards as discussed above. The greater the degree of protection of the water source, the less the reliance on treatment and disinfection. After treatment or disinfection, water should be protected during delivery to consumers in the same manner as groundwater, by ensuring that distribution systems are enclosed.

2.4.1. Community awareness

Community awareness programs should be developed to promote the protection of water quality. Diffuse sources of pollution arising from illegal gold mining, agricultural and animal husbandry activities are difficult to manage but their effect on water quality can be minimized by the use of best practice management such as fencing of streams, management of buffer zones. Landowners can be encouraged to protect stream banks and provide buffer strips through community awareness programs and by subsidizing tree planting and fencing works.

2.4.2. Water resource management

Water resource management is an integral aspect of the preventive management of drinking-water quality. Prevention of microbial and chemical contamination of source water is the first barrier against drinking-water contamination of public health concern. Water resource management and potentially polluting human activity in the catchment will influence water quality downstream and in aquifers. This will have an impact on the treatment steps required to ensure safe water, and preventive action may be preferable to upgrading treatment. The influence of land use on water quality should be assessed as part of water resource management. This assessment should take into consideration:

- Land cover modification;
- Extraction activities;
- Construction/modification of waterways;
- Application of fertilizers, herbicides, pesticides and other chemicals;
- Livestock density and application of manure;
- Road construction, maintenance and use;
- Various forms of recreation;
- Urban or rural residential development, with particular attention to excreta disposal, sanitation, landfill and waste disposal;
- Other potentially polluting human activities, such as industry, mining and military sites.

2.5. Hazards associated with irrigation water quality

There are three principal problems that can arise from the quality of irrigation water delivered to the agricultural fields.

- **Salinity hazard:** This is directly related to the quantity of salts dissolved in the irrigation water. All irrigation water contains potentially injurious salts and nearly all the dissolved salts are left in the soil after the applied water is lost by evaporation from the soil or through transpiration by the plants. Unless the salts are leached from the root zone, sooner or later they will accumulate in quantities which will partially or entirely prevent growth of most crops.
- **Sodicity (alkali) hazard:** This is another problem often confronting long-term use of certain water for irrigation and relates to the maintenance of adequate soil permeability so that the water can infiltrate and move freely through the soil. The problem develops when irrigation water contains relatively more sodium ions than divalent calcium and magnesium ions while the total concentration of salts is generally not very high. Accumulation of sodium ions on to the exchange complex results in a breakdown of soil aggregates responsible for good soil structure needed for free movement of water and air through the soils. As in the case of sodic soils, accumulation of sodium on the exchange complex can be reduced by applying appropriate quantities of amendments, e.g. gypsum.

- **Toxicity hazard:** A third problem results from the existence, in some water, of such toxic substances as boron or heavy metals. Boron, though an essential element for plant growth and nutrition, is required only in very small amounts. A high concentration of boron in the irrigation water can have a toxic effect on the growth of many plants. Similarly, certain other ions, e.g. chloride, sodium, etc., could prove toxic to specific crops if present in excessive quantities.

2.6. Control measures of hazards in irrigation water

Agricultural Water Quality Management Plan requires all landowners and operators to manage their irrigation in a way that minimizes effects on streams and rivers. Efficient irrigation systems and irrigation water management will provide the most effective delivery of water to crops, minimizing overwatering and potential runoff of sediment and agro-chemicals. Some of these methods include:

- Implementing an irrigation water management
- Plan Irrigation efficiency upgrades
- Installing catch basins
- Grassed waterways
- Soil moisture monitoring
- Maintaining vegetative filter strips and riparian
- Buffers contour farming

Figure 35. Grassed water ways

Self-Check -2	Written Test

Directions: Choose the best answer for the following questions and write your answer on the answer sheet provided. All questions have 3 points.

1. Efficient irrigation systems and irrigation water management will provide
   A. Most effective delivery of water to crops,
   B. Minimizing overwatering
   C. Minimizing potential runoff of sediment
   D. Minimizing agro-chemicals.
   E. All
2. Efficient irrigation systems and irrigation water management includes:
   A. Implementing an irrigation water management
   B. Plan Irrigation efficiency upgrades
   C. Installing catch basins
   D. Grassed waterways
   E. Soil moisture monitoring and Maintaining vegetative filter strips and riparian
   F. Buffers contour farming
   G. All
3. Hazardous events include:
   A. Interruption to supply
   B. Contamination of the incoming water leading to a boil water alert
   C. Temperature changes in water
   D. All

Note: Satisfactory rating - 4 point Unsatisfactory - below 4 points

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

Answer sheet

Name: ___________________________ Date: ________________

Multiple choices

1. ....
2. ....
3. ....

Score = ____________

Rating: _____________

Information Sheet-3	Factors Affecting Water Quality

3.1. Introduction

Water quality refers to the chemical, physical, biological, and radiological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose. It is most frequently used by reference to a set of standards against which compliance, generally achieved through treatment of the water, can be assessed. The most common standards used to assess water quality are health of ecosystems, safety of human contact, and drinking water. Water quality is measured by several factors, such as the concentration of dissolved oxygen, bacteria levels, the amount of salt (or salinity), or the amount of material suspended in the water (turbidity). In some bodies of water, the concentration of microscopic algae and quantities of pesticides, herbicides, heavy metals, and other contaminants may also be measured to determine water quality.

There are several factors, both environmental and “manmade,” that influence water quality. Some of the biggest factors include:

- Sedimentation
- Runoff
- Erosion
- Dissolved oxygen
- pH
- Temperature
- Pesticides
- Detergents
- Litter/garbage
- Oil/grease
- Household cleaners
- Population growth

3.2 Irrigation water quality performance indicators

Poor quality water may affect irrigated crops by causing accumulation of salts in the root zone, by causing loss of permeability of the solid to excess sodium or calcium leaching, or by containing pathogens or contaminants which are directly toxic to plants or to those consuming them. Contaminants in irrigation water may accumulate in the soil and, after a period of years, render the soil un fit for agriculture. Quality criteria may also differ considerably from one country to another, due to different annual application rates of irrigation water. Water quality criteria for irrigation water generally take in to account factors, such characteristics as crop tolerance to salinity, sodium concentration and phototoxic trace elements.

Table 6. Selected water quality criteria for irrigational waters(mgl^{-1})

Element	FAO	Canada	Nigeria
Aluminium	5.0	5.0	5.0
Arsenic	0.1	0.1	0.1
Cadmium	0.01	0.01	0.01
Chromium	0.1	0.1	0.1
Copper	0.2	0.2-1.0[1]	0.2-1.0[1]
Manganese	0.2	0.2	0.2
Nickel	0.2	0.2	0.2
Zinc	2.0	1.0-5.0[2]	0.0-5.0[2]

1 Range for sensitive and tolerant crops, respectively.

2 Range for soil pH > 6.5 and soil pH > 6.5, respectively.

Sources: FAO, 1985; CCREM, 1987; FEPA, 1991

3.3 Factors affecting irrigation water quality

A. Temperature: affects biological and chemical activity. At the lower temperatures, plant growth and nutrient up-take are reduced.

B. Precipitation: directly affects the runoff of water and dislodgement and transport of pollutants. Runoff will generally be grater if rainfall is of high intensity or soil moisture levels are high. High-intensity storms increase both detachment, and transport.

C. Infiltration rate: depends in part on its physical, chemical, and biological characteristics. Also, the prior soil moisture content markedly affects the amount of water that can infiltrate. The infiltration rate affects the ration of surface flow to subsurface flow. With an increase in the infiltration rate, the pollutant load associated with surface runoff should decrease.

D. Cropping practices: affect water quality too. Crop cover and surface residue protect the land form the impact of rainfall by absorbing the energy of the raindrops. Close growing crops will generally have less pollution potential then row crops because of the additional canopy. Close-growing vegetation tends to have less pollution potential then row crops because of the additional canopy. Close-growing vegetation tends to reduce soil detachment and filters out suspended organic materials from surface runoff. The longer the growing period of the crop and the ore residue that is left on the field after harvest, the less soil erosion will occur.

Generally, the following three major factors affect water quality.

A. Biological factors
B. Physical factors
C. Chemical factors

The above factors could be described as:

- Chemical composition of water (TSS, pH, CO3, HCO3, CI, SO4, Ca, Mg, Na, and B).
- Total concentration of soluble salts or salinity (EC).
- Concentration of sodium ions or sodicity (SAR).
- Accumulation of excessive quantities of soluble salts in the root zone
- Sodium percentage (ESP) of soil
- Soil characteristics like structure, texture, organic matter, nature of clay minerals, topography etc.
- Plant characteristics like tolerance of plant vary with different stages of growth.
- Climatic factors can modify plant response to salinity.
- Management practices

Self-Check -3	Written Test

Directions: Choose the best answer for the following questions and write your answer on the answer sheet provided. All questions have 3 points.

1. What are the major factors affect water quality?
   A. Biological factors
   B. Physical factors
   C. Chemical factors
   D. all
2. Factors Affecting Irrigation Water Quality
   A. Temperature:.
   B. Precipitation:
   C. Infiltration rate:
   D. Cropping practices:
   E. all

Note: Satisfactory rating - 3 point Unsatisfactory - below 3points

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

Answer sheet

Name: ___________________________ Date: ________________

Multiple choices

1. ....
2. ....

Score = ____________

Rating: _____________

Information Sheet- 4	Environmental Risk and Impact on Quality of Water Services

4.1. Definition of terms

Environmental Risk: Is a risk that arises from the relationship between human activities and the environment.

Environmental Hazard: A source or situation with the potential for harm to the natural environment.

Environmental Aspects: Those elements of the University's activities, which can interact with the environment, eg. energy consumption, and hazardous waste.

Environmental Impact: Any change to the environment, whether adverse or beneficial, wholly or partially resulting from the University's environmental aspects. Also includes impacts to the University's operations arising from environment related issues.

Environmental Impact Assessment: Environmental Impact Assessment (EIA) is the process of examining the anticipated environmental effects of a proposed project - from consideration of environmental aspects at design stage, through consultation and preparation of an Environmental Impact Assessment.

An incident: Any event that has caused or has the potential for an adverse impact(s) on the environment. For example atmospheric emissions, and noise pollution or waste.

Environmental Legal or Other Requirements: Includes Acts and Regulations (Local Government, State and Commonwealth), Standards, Codes, industry standards and other guidance material related to environmental management.

Environmental management system (EMS): refers to the management of an organization's environmental programs in a comprehensive, systematic, planned and documented manner. It includes the organizational structure, planning and resources for developing, implementing and maintaining policy for environmental protection.

4.2. Objectives of environmental water quality management

- Minimize or eliminate our negative environmental impacts and use of water resources to continually improve our work practices and operations by setting environmental objectives and targets in accordance with best-practice standards;
- Incorporate best-practice environmental management into our core business plans and management practices, including the preparation, fit out and ongoing operation of new accommodation;

- Regularly monitor and report on our environmental performance;
- Actively promote and encourage the adoption of ecologically sustainable work practices; and Operations within the university and the general community;

4.3. Environmental impact assessment

It makes the concerned ministries/agencies assess the potential results of the project before a decision is given. Project developers and administrative agencies who have a responsibility for environmental consideration can use environmental impact assessment technique to improve the quality of both the project plan and decision-making by identifying possible effects in the early stages. The objectives the environmental impact assessment system:

- To offer information to decision makers concerning matters that may be brought about as a result of decisions relating to a new project, program, plan or policy.
- To disclose significant environmental effects of proposed projects to decision-makers and the public.
- To identify ways to avoid or reduce environmental damage.
- To prevent adverse environmental impacts by requiring implementation of feasible alternatives or mitigation measures.
- To disclose reason of approvals for the projects with significant environmental impacts to the public.
- To foster interagency co-ordination.
- To enhance public participation.

4.4. Effects of irrigation development on environment

The environmental impacts of irrigation relate to the changes in quantity and quality of soil and water as a result of irrigation and the effects on natural and social conditions in river basins and downstream of an irrigation scheme.

A. Direct Effect: Hydrological, or direct, effects of doing this include: reduction in downstream river flow, increased evaporation in the irrigated area, increased level in the water table as groundwater recharge in the area is increased and flow increased in the irrigated area.

B. Indirect Effect: Indirect effects are those that have consequences that take longer to develop and may also be longer-lasting. The indirect effects of irrigation include the following:

- Water logging
- Soil salinazation

- Ecological damage
- Socioeconomic impacts

C. Adverse effects

I. Reduced river flow: The reduced downstream river flow may cause:

- reduced downstream flooding
- disappearance of ecologically and economically important wetlands or flood forests
- reduced availability of industrial, municipal, household, and drinking water
- reduced fishing opportunities.
- reduced discharge into the sea, which may have various consequences like coastal erosion

II. Increased groundwater recharge, water logging, and soil salinity: Increased groundwater recharge stems from the unavoidable deep percolation losses occurring in the irrigation scheme. The lower the irrigation efficiency leads the higher the losses. This may cause the following issues:

- Rising water tables
- Increased storage of groundwater that may be used for irrigation, municipal, household and drinking water by pumping from wells
- Water logging and drainage problems in villages, agricultural lands, and along roads - with mostly negative consequences.
- Shallow water tables - a sign that the aquifer is unable to cope with the groundwater recharge stemming from the deep percolation losses where water tables are shallow, the irrigation applications are reduced.

III. Reduced downstream river water quality: Owing to drainage of surface and groundwater in the project area, which waters may be salinized and polluted by agricultural chemicals like biocides and fertilizers, the quality of the river water below the project area can deteriorate, which makes it less fit for industrial, municipal and household use. It may lead to reduced public health. The natural buildup of sedimentation can reduce downstream river flows due to the installation of irrigation systems. Sedimentation is an essential part of the ecosystem that requires the natural flux of the river flow.

IV. Affected downstream water users: Downstream water users often have no legal water rights and may fall victim of the development of irrigation. Pastoralists and nomadic tribes may find their land and water resources blocked by new irrigation developments without having a legal recourse. Flood-recession cropping may be seriously affected by the upstream interception of river water for irrigation purposes.

Table 7. Main problems and mitigation measures of irrigation water quality

Common Problems	Mitigation Measures
1. Degradation of irrigated land	• Improve I & D operation to match demand both 'how much & when'.
2. Salinization	• Provide drainage including disposal of water to evaporation ponds or the sea if quality of river flow adversely affected by drainage water.
3. Alkalization	• Maintain channels to prevent seepage, and reduce inefficiencies resulting from siltation and weeds. Allow for access to channels for maintenance in design.
4. Water logging	• Provide water for leaching as a specific operation.
5. Soil acidification	• Set-up or adjust irrigation management infrastructure to ensure sufficient income to maintain both the irrigation and drainage systems. • Analyze soils and monitor changes so that potential problems can be managed.
6. Reduced socio-economic conditions	• Manage I& D to prevent disease spread.
7. Water borne diseases	• Educate about causes of disease.
8. Poor water quality	• Define and enforce return water quality levels (including monitoring).
9. Reduction in irrigation water quality	• Control industrial development.
10. Water quality problems for downstream users caused by irrigation return flow quality	• Designate land for saline water disposal; build separate disposal channels. • Educate for pesticide or sewage contamination dangers. • Monitor irrigation water quality
11. Ecological degradation	• Define ecological requirements.
12. Reduced big-diversity in project area	• Operate dams to suit downstream requirements and encourage wildlife around reservoirs
13. Damage to downstream ecosystems due to	• Designate land (in law and supported by protection institutions) for flood plains; wetlands; watersheds;

reduced water quantity and quality	drainage water disposal; river corridors.
14. Ground water depletion	• Define and enforce abstraction regulations.
15. Dry drinking & irrigation wells	• Monitor ground water levels.

Self-Check -4	Written Test

Directions: Choose the best answer for the following questions and write your answer on the answer sheet provided. All questions have 3 points.

1. The lower the irrigation efficiency, leads to the higher the losses. This cause includes --
   A. Rising water tables
   B. Increased storage of groundwater that may be used for irrigation, municipal, household and drinking water by pumping from wells
   C. Water logging and drainage problems in villages, agricultural lands, and along roads - with mostly negative consequences.
   D. Shallow water tables - a sign that the aquifer is unable to cope with the groundwater recharge stemming from the deep percolation losses where water tables are shallow, the irrigation applications are reduced.
   E. All
2. The reduced downstream river flow cause:
   A. Reduced downstream flooding
   B. Disappearance of ecologically and economically important wetlands or flood forests
   C. Reduced availability of industrial, municipal, household, and drinking water
   D. Reduced fishing opportunities.
   E. Reduced discharge into the sea, which may have various consequences like coastal erosion
   F. All

Note: Satisfactory rating - 3 point Unsatisfactory - below 3 points

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

Answer sheet

Name: ___________________________ Date: ________________

Multiple choices

1. ....
2. ....

Score = ____________

Rating: _____________

5.1. Communicating with customers

Maintaining consumer confidence and trust during and after an incident or emergency is essential, and this is largely determined by how incidents and emergencies are handled. A public and media communication strategy should be developed before any incident or emergency situation occurs. Develop an active two-way communication programtoin form consumers and promote awareness of drinking water quality issues. Effective communication is vital in managing incidents and emergencies. Clearly defined protocols for both internal and external communications should be established in advance, with the involvement of relevant agencies, including health and other regulatory agencies.

5.2. Education programs

Draft public and media notifications should be prepared in advance and formatted for the target audience. An appropriately trained and authoritative contact should be designated to handle all communications in the event of an incident or emergency. All employees should be kept informed during any incident, because they provide informal points of contact for the community.

Consumers should be told when an incident has ended and be provided with information on the cause and actions taken to minimize future occurrences. This type of communication will help allay community concerns and restore confidence in the water supply. Interviews and surveys of a representative portion of the community are valuable for establishing consumer perceptions of events and how they were managed.

5.3. Topics to communicate

Wastewater treatment: Wastewater treatment consists of removing pollutants from wastewater through a physical, chemical or biological process. The more efficient these processes are, the cleaner the water becomes

Green agriculture: it is essential to have climate-friendly crops, efficient irrigation that reduces the need for water and energy-efficient food production. Green agriculture is also crucial to limit the chemicals that enter the water.

Storm water management: is the effort to reduce runoff of rainwater or melted snow into streets, lawns and other sites and the improvement of water quality.

Air pollution prevention: Air pollution has a direct impact on water contamination as 25% of human induced CO2 emissions are absorbed by oceans. This pollution causes a rapid acidification of our oceans, and threatens marine life and corals.

Plastic waste reduction: 80% of plastic in our oceans is from land sources. In order to reduce the amount of plastic entering our ocean, we need to both reduce our use of plastic globally, and to improve plastic waste management.

Water conservation: Be aware that water is a scarce resource, take care of it accordingly, and manage it responsibly.

5.4. Outline for communicating the quality of water

The following schematic visually demonstrates how a water system can:

a. Identify its community's needs or issues through surveys, focus groups or other data-gathering techniques.
b. Develop a message and communicate it through campaigns or community engagement efforts including public meetings and events, social media, Web sites and software applications for mobile devices.
c. Continue to engage their community and adjust their communication efforts based on changing needs and issues.

Using stakeholders to identify and develop messages gathering data helps water systems have an accurate picture of their community's needs and priorities.

5.5. Communication processes

While the detailed implementation of communication processes varies between companies, they follow a reasonably consistent life-cycle, with distinct activities in four key areas:

- Pre-event preparation
- Event detection and escalation
- Communication management
- Review and testing.

Processes for determining how to communicate with customers about different levels of events generally addressed prioritization of protection of customer health and management of customer concerns adequately.

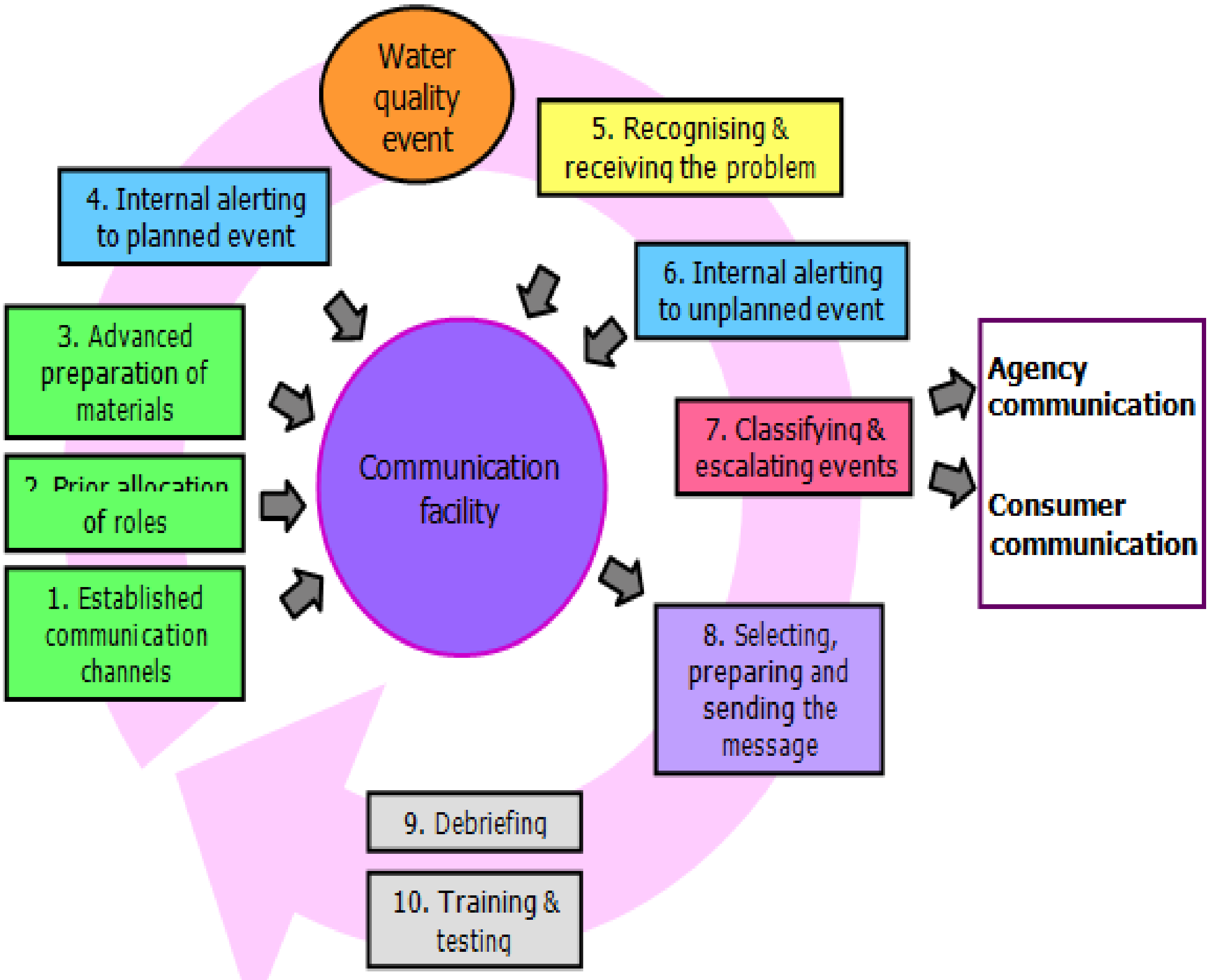


Figure 36. Water quality communication life cycle

Self-Check -5	Written Test

Directions: Choose the best answer for the following questions and write your answer on the answer sheet provided. All questions have 3 points.

1. Which one of the following schematic visually demonstrates how a water system can?
   A. Identify its community's needs or issues through surveys, focus groups or other data-gathering techniques.
   B. Develop a message and communicate it through campaigns or community engagement efforts including public meetings and events, social media, Web sites and software applications for mobile devices.
   C. Continue to engage their community and adjust their communication efforts based on changing needs and issues.
   D. All
2. Communication processes varies between companies, they follow a reasonably consistent life-cycle, with distinct activities in d/t key areas what are those?
   A. Pre-event preparation
   B. Event detection and escalation
   C. Communication management
   D. Review and testing.
   E. All

Note: Satisfactory rating - 4 point Unsatisfactory - below 4 points

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

Answer sheet

Name: ___________________________ Date: ________________

Multiple choices

1. ....
2. ....

Score = ____________

Rating: _____________

Operation Sheet 1	Assessing and Identifying Water Quality Hazard and Risk

Procedures of assessing and identifying water quality hazard and risk

Step 1: Define the approach and methodology to be used for hazard identification and risk assessment.

Step 2: Identify and document hazards, sources and hazardous events for each component of the water supply.

Step 3: Estimate the level of risk for each identified hazard or hazardous event.

Step 4: Evaluate the major sources of uncertainty associated with each hazard and hazardous event and consider actions to reduce uncertainty.

Step 5: Determine significant risks and document priorities for risk management.

Step 6: Review and update the hazard identification and risk assessment to incorporate any change.

Operation Sheet 2	Preventing and Controlling Water Quality Hazards

Steps of effective strategies for preventing and controlling drinking water quality hazards

Step 1: Understand the characteristics of the drinking water system.

Step 2: Identify hazards and hazardous events.

Step 3: Determine and validate the existing control and measures; How important are the risks?

Step 4: Access and prioritize risk to public health.

Operation Sheet - 3	Assessing Water Quality Data

Steps used to assess water quality data for different purposes.

Step 1: Assemble historical data from source waters, treatment plants and finished , water supplied to consumers.

Step 2: List and examine exceedances of the characteristics.

Step 3: Identify trends and potential problems

Step 4: Document the data for future retrieval.

LAP Test	Practical Demonstration

Name: ____________________________ Date: ______________________

Time started: ________________________ Time finished: ________________

Instructions: Visiting the nearby irrigation development area at your locality and using the necessary templates, tools and materials perform the following tasks within 100 hour.

Task 1: Assess and identify water quality hazards and risks

Task 2: Prevent and control water quality hazards

Task 3: Assess water quality data from the respective institutes.

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