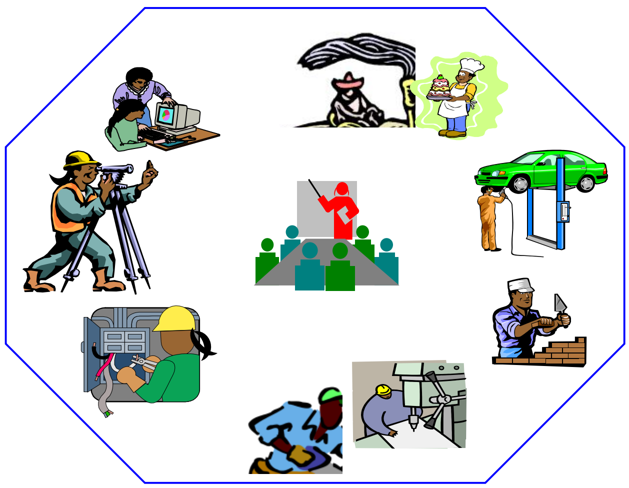
NATURAL RESOURCES CONSERVATION AND DEVELOPMENT

LEVEL III

Based on March, 2018, Version 3 Occupational standards



Module Title: Implementing and Adjusting Irrigation System and Schedule

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LG #100	LO #1- Monitor plant or crop environment for irrigation requirement

Instruction sheet

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

- Plant or crop environment is monitored and results are interpreted according to enterprise policy and procedures.
- Plants or crops are inspected for signs of stress.
- Changes to irrigation shifts are recommended according to environmental conditions and plant or crop requirements.

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Monitor Plant or crop environment and interpret the results according to enterprise policy and procedures.
- Inspect Plants or crops for signs of stress.
- Recommend Changes to irrigation shifts according to environmental conditions and plant or crop requirements.

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". Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.

4. Accomplish the "Self-checks" which are placed following all information sheets.

5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).

1.1. Introduction of irrigation

Looking at the water resource of the country, the river basins cover about 110 million hectare in which on average about 112 billion m^3 of water flows from the catchments annually. The ground water potential in the country is about 2.6 billion m^3. It has 12 river basins, 11 lakes, 9 saline lakes, 4 crater lakes and over 12 major swamps or wetlands.

In Ethiopia, virtually all food crops come from rain fed agriculture. Natural rainfall normally supplies water for crop production. Generally, 75% of the rain fall is concentrated in a period of 3 to 4 months between June and September, causing high flows in the river system during this period followed by periods of dry season of low flows.

In Ethiopia, drought is mainly due to failure of rain fall both in amount and variation in time. The erratic, variable insufficient rain fall together with the high population growth make rain fed agriculture unreliable and insufficient to support the ever increasing food demand of the country.

Based on the present indicative information sources the potential irrigable land is about 3.7 million ha. This figure is believed to be much on a low side, and could change as more reliable data emerge since more detail studies are under way. Irrigation projects are classified as large with a command area greater than 3000 ha; medium projects with a command are between 200 and 3000 ha; small scale with a command is less than 200 ha.

Even though there are many water potential and cultivable lands in the country, not much has been done with this regard due to lack of capital, skilled man power, attitudes and knowledge. The government running to use water resources effectively, to increase the productivity of the land efficiently and to produce production more than once annually, to apply this, having knowledge, skill and attitude of determining crop water requirement and irrigation scheduling as component of small scale irrigation can play a crucial role. While determining crop water requirement and irrigation scheduling the trainees should have knowledge, skill and attitude that enables them to

- Collect & collate all required data

- Identify the types and characteristics of crops
- Compile and analyze data

1. Definition of Irrigation

Irrigation may be defined as the process of artificial application of water to the soil for the growth of agricultural crops or the artificial application of water to the land for the purpose of raising crops in areas where natural watering by rain may not be sufficient for the optimum growth of plants/crops. As such the basic objective of irrigation is to obtain an optimum yield from the crop grown on the land. The three major reasons for practicing irrigation are; irrigation can ensure;

1. A suitable system of crop production.
2. Longer effective crop growth period.
3. Additional inputs become economically feasible.

And another reason is to leach salts from saline soil & to avoid fro zing in humid and very cold areas.

In order to achieve these objectives, an irrigation system is required to be developed which involves planning, designing; construction, operation& maintenance of various works .i.e. source of water supply, distribution system etc...

2. Need of irrigation

The yield from agricultural land depends up on several factors but the most important factor is that the crop gets adequate water at the various stages of growth of the plants. Plants can get this adequate water naturally from rain & if not artificially from irrigation. The followings are the factors which govern the necessity of irrigation.

- **Insufficient rain fall.** When the rain fall at palace is not adequate to meet the crop requirements, then it is necessary to use irrigation.
- **Uneven distribution of rain fall**. The total rain fall in a region may be adequate but it may be unevenly distributed over time as well as place. With such uneven distribution of rain fall it is necessary to use irrigation. The water may be collected during the period of rain fall& it may be used for irrigation when there is no rain.
- **Growing superior crops.** There are several superior or high-value crops which need frequent application of large quantity of water & for growing such crops irrigation is necessary.

- **Growing a number of crops during a year.** The rain fall in a region may be sufficient to grow only one type of crop in a year for which no irrigation may be required.

However for the same region if more number of crops is to be grown during the same year it would be possible only if irrigation facilities are available. This is only when there is land scarcity and the variation in growing season of each crop. But in some case irrigation is needed to grow only one kind of crop which have much longer period of maturity, for example sugar cane.

3. Total planning concepts of irrigation project.

In order to maximize the benefits from irrigation project it is essential to adopt the various aspects. These are;

- Engineering aspect.
- Agricultural aspect.
- Management aspect.

✓ **Engineering aspect:** the engineering aspect of irrigation project involves the development of a source of water for irrigation & the arrangement for the conveyance from the source right up to the agricultural fields.

✓ **Agricultural aspect:** It involves the timely and systematic application of irrigation water to the agricultural fields by choosing suitable irrigation methods.

  - In addition to the above agricultural aspect also involve the following factors.

❖ Proper leveling and shaping of agricultural fields.

❖ Soil investigation and classification of agricultural land.

❖ Consolidation of the small and scattered holdings of the farmers.

❖ Provision of field channels.

❖ Choosing the proper cropping pattern to suit the local soil and climatic conditions.

❖ Assessment of the water requirement of the crops and distribution of water according to the needs of crops grown.

❖ Conservation of soil against erosion.

❖ Provision of drainage systems to control the water logging on the agricultural land. Reclamation of saline and alkaline land to make it suitable for cultivation.

- ✓ **Management aspect:** It deals with the successful implementation and efficient management of both engineering as well as the agricultural aspect of the project.

4. Benefits of Irrigation

There are several benefits of irrigation which are listed below.

- **Yields of crops can be increased**: In the period of low rain fall or drought, the yield of crop may be increased the irrigation system.
- **Protection from famine:** The food production of a country can be improved by ensuring the growth of crops by availing irrigation facilities. This helps a country to prevent famine situation
- **Improvement of cash crops**: Irrigation helps to improve the cultivation of cash crops like vegetables, fruits, tobacco, and etc.
- **Prosperity of farmers**: When the supply of irrigation water is assured, the farmers can grow two or more crops in a given year on the same land. Thus the farmers may earn more money and improve their living standard.

N.B As per the research data, the following relation is obtained.

The yield vs. applied water (Aw) is described by a quadratic equation.

$Y= -4941 +35.83(Aw) - 0.0195 (Aw) 2$

Where y= yield in kg/ha & Aw= applied water in mm.

5. Demerits of irrigation.

If irrigation water is used judiciously with proper scientific considerations then there would be no ill effect of irrigation. It is only the excess irrigation water that may give rise to the following ill effects.

- **Water logging:** The excess water supplied to the field would percolate in to the soil. Due to constant percolation of large quantity of water, the ground water table would be raised so much that it may completely saturate the root zone of the crops grown. With complete saturation of the soil pores, the normal circulation of air in root zone of the crop is cut off. The agricultural land in this state is called water logged and the phenomena is water logging, which reduce the fertility of soil and if not reclaimed it will make the soil or the land u n productive.
- **Breeding place for mosquitoes:** The excess application of irrigation water may also lead to the formation of significant pools of water in the pits and depressions

existing in the area. These pools of water would be breading place for mosquitoes, which may result in the outbreak of malaria in the area.

- **Unhealthy climate:** Due to intense irrigation the climatic condition of the area become quit cold and damp. This is Unhealthy climate for human being. In such climate the body resistance to disease is decreased.

6. **Classification of irrigation projects**.

Based on the area it covers and the number of peasants associations or water users an irrigation project can be classified as;

- **Small scale:** Are projects for a single peasants association and up to 200 ha in size.
- **Medium scale:** Schemes between 200 and 3000 ha, extending beyond one peasant association, and requiring a greater degree of government assistance.
- **Large scale:** Covering 3000 ha or more.

1.2. **Monitoring crop environment and interpreting the results.**

Monitoring is the process of controlling a given system by continuous inspection or observation and recording the results and reporting the results for concerned body. It is a key factor that determines the success or failure of a given project. Monitoring can involve water users and implementing officials in a participatory learning process. Indicators and methods should be carefully chosen to support the project goals. Monitoring methods should optimize the flow of information. Opportunities lie in encouraging self-assessment by water users associations and strengthening monitoring methods so that government can provide technical assistance when needed on topics such as maintenance, irrigation water supply and implementing irrigation shifts.

Perhaps the most fundamental question concerns what to monitor. The management saying is that "what gets measured is what gets done." If attention is restricted only to targets such as formal registration of water users associations then more important aspects may be neglected. The challenge is to create indicators which are simple and easy to use, but reflect the key goals which the project is intended to accomplish. There is often a tendency for monitoring to be assigned to a separate unit, with little clear understanding of how the results of monitoring will actually be used. Those most directly involved in implementation actually have far more information available, and usually a better understanding than someone from a specialized external unit. Many opportunities exist for enabling farmers and implementing officials to take a more active part in monitoring, analyzing and improving the process of turnover.

Monitoring activities of observation and analysis can occur as part of existing activities such as informal visits and conversation, routine meetings as well as more structured methods including rapid appraisal, sustainability analysis, participatory evaluation and farmer to farmer visits. Experience in the turnover project shows that within a bureaucratic agency such as Public Works sensitive topics can be dealt with much more openly and creatively in the context of informal conversation rather than formal meetings or written materials. Monitoring methods will need to recognize and support such informal mechanisms, rather than simply focusing on drafting forms to be filled in.

... Many opportunities exist for enabling farmers and implementing officials to take a more active part in monitoring, analyzing and improving the process of Irrigation. ...

Monitoring methods need to provide a valid picture of events. Attention has to be paid to making sure that monitoring is not biased by reports from a few unrepresentative model sites. Many other factors besides turnover can influence O&M, agricultural production and farmer welfare. To the extent possible, the impact of turnover has to be disentangled from these other factors. Monitoring methods need to generate information on problems and failures, not just successes.

Many methodologies have been developed to improve the validity of research. These include many different evaluation research methods and also approaches such as rapid appraisal. However most of these have been developed for more academic research. The challenge is to see which of these methods can be adapted for use within the context of participatory monitoring activities intended to accomplish.

In monitoring the crop environment for irrigation requirement the data collected should answer all questions that should be raised in irrigation requirement of the crop and factors that can influence these requirements, but data collection must not be allowed to become an end in itself. For any monitoring activity we have to follow the known steps. These steps are; gathering data; analyzing the data, interpreting the data and taking an action in response to the interpreted data. Focus on readily measurable data/output or soil and environmental conditions which are relevant to the irrigation requirement of the crop and the goals of project and use established method of data collection such as meteorological data if it is available by near. Rank the importance of items to be measured, so that time and budget constraints do not prevent important data from being acquired.

Temperature, wind speed, humidity, rates crop growth, soil moisture content, intensity of sun shine, day time duration and crop signs of stress should be monitored and interpreted. Increase in the above conditions except humidity and soil moisture content will result in increasing the irrigation requirement of the crop.

Monitoring crop environment may involve observations at key sites, regular extension visits and discussion with officials and land users. A check list and periodic meeting in the planning area /project area may serve the purpose. Those responsible for plan implementation should list the tasks need to correct problems as they rise and should also take an action.

Self-Check – 1	Written test

Name…………………………………………… ID………………………… Date…….

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

1. Define irrigation and explain the main objectives of irrigation?
2. What are the major reasons to practice irrigation and when we need irrigation?
3. What are the three aspects of any irrigation project?
4. Write at least four operations that are included in agricultural aspects of an irrigation project.
5. What are the benefits and the demerits of irrigation?
6. What are the three main classifications of irrigation projects and what are the criteria to classify them?
7. What is monitoring and the fundamental question in monitoring?
8. What type of data should be gathered during monitoring?
9. What is the importance of monitoring?
10. Which conditions should be monitored during assessment of crop water requirement?

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

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

Information Sheet 2- Inspecting plant or crop signs

2.1. Introduction

Water is present throughout the plant in all its organs and tissues, the content varying, over 90% of fresh weight of young actively growing plants to 5 % in air dry cells. Life will be impossible in complete absence of water. Reduction in soil water entails in disruption of large number of physic-chemical activities, drastic reductions which leads to death of cells or plants.

Water content in a plant decreases due to soil, plant and environmental factors, the main reason being the extent of transpiration which is controlled by environmental, soil and plant conditions. Transpiration (rate and quantity) depends on leaf size& composition, size & distribution of stomata on leaf, atmospheric humidity, temperature, wind speed and day time length. The amount of water observed depends on length of roots, their volume per volume of soil, water use efficiency and soil moisture content

2.2. Moisture Stress

Moisture stress; is generally applied to conditions of moisture decrease in the plant parts, after sun rise the stomata open and transpiration increases with time until they become closed due to high temperature. As the temperature increases the loss of water from leaf parts extends to the root through xylem. Along the path the water has to confront resistances and the steady state of flow gets imbalanced and transpiration loss cannot be met by absorption. This leads to wilting of leaves of plants. Moisture content decreases either due to increased transpiration or reduction in absorption or both. On an area where the atmosphere is humid and dew the plants may not show wilting sign even if soil moisture content is low. In such case roots are more sensitive to decrease in soil water potential than the leaves. Thus moisture in the plant is governed by soil moisture potential and atmospheric conditions.

Available moisture, concentration of soil solution and root growth determines absorption of water.

In adequate aeration reduces root growth and water absorption of most crops except rice. Soil temperature also affects absorption. It is markedly reduced if soil temperature falls below 20 0 c. fall of temperature reduces absorption due to reduction in root-cell permeability and increase in viscosity of water which increases the resistance to passive movement of water through roots.

2.3. **Effects of moisture stress on crops.**

Through the relationship is complex, reduction of moisture in the soil results in reduction of plant growth through large number of physic-chemical activities. Plants subjected to water stress not only show a general reduction in size but also exhibit characteristic

Self-Check – 2	Written test

conditions in structure, particularly, of leaves. Leaf area, cell size and volume and division are reduced.

Stomata close early and gaseous exchange between plant and atmosphere stops. Photosynthesis decreases earlier than the soil moisture potential reaches permanent wilting point. Reduction in photosynthesis accompanied by increased respiration reduces assimilates in the plants and reduces crop yield. Chemical composition and quality of the crop also affected.

Depending on stage of crop growth, moisture stress has variable effect on protein content in vegetative and /or reproductive parts. In cereals like rice and wheat, moisture stress during ripening reduces grain yield but increases protein content in grains. Levels of rubber, essential oils and fats increase due to moisture stress.

Table.1. Effect of available moisture on quantity and yield of some crops.

Available soil moisture content reduction (0-30 cm)	wheat		barley	Ground nut		mustard		tobacco	
	Yield (kg/ha)	Protein (%)	Grain yield (qu/ha)	Oil content (%)	Yield (qu/ha)	Oil content (%)	Yield (kg/ ha)	Nicotine (%)	Nitrogen (%)
25 %	55.4	12.5	31.15	40.9	5.9	40	1649	1.77	1.65
50%	53.3	14.3	25.75	43.4	7.4	41	1622	2.1	1.67
75%	44.6	15.3	19.15	44.5	2.5	39	1434	4.02	2.4

Name…………………………………………… ID………………………… Date……

Directions: Answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers. (2 points each)

1. How do you inspect plant or crop sign?
2. What is moisture stress?
3. What are the conditions which increase the loss of water from soil or plants?
4. Explain the effect of moisture stress on crops?
5. Discuss the effect of moisture stress on crops.

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

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

Information Sheet 3- Recommending crop signs

3.1. Introduction

As we know that every condition in nature is dynamic /not stable, i.e.it will change from time to time. Likewise the design parameters or factors which influence these parameters like soil and environmental conditions will be changed from time to time or there may be UN usual change on these factors that may cause a failure in our project efficiency or goals.

3.2. Technical recommendation.

Irrigation scheduling/ determining irrigation time is an important activity that should be carried out for success of any irrigation project, but at designing stage it is determined by using some meteorological and soil data of crop environment that is taken from the past records or observations, but these conditions may be changed from time to time or there may occur un even change on these conditions, the condition may be;

- Rise in temperature
- Increase in wind speed
- Increase in sun shine intensity
- Increase in day time duration
- Fall in temperature
- Increase in humidity
- Un usual rain fall etc

Based on the above conditions and stage of crop growth crop water requirements will be changed and we have to recommend irrigation shifts according to environmental conditions and crop water requirements and the conditions should be interpreted according to the project goals. For example our aim is rubber production from a given crop, moisture stress at ripening stage is recommended and we should reduce our irrigation frequency.

Self-Check – 3	Written test

Name…………………………………………… ID………………………… Date…….

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

1. Discuss briefly you professional recommendation when you face crop sign of stress in a given irrigation field? (10 points)

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

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

Information Sheet 4- Factor affecting irrigation requirements

4.1. **The influence of the climate on crop water needs**.

A certain crop grown in a sunny and hot climate needs per day more water than same crop grown in a cloudy and cooler climate. There are, however- apart from sunshine and temperature- other climatic factors which influence the vapour water need. These factors are the humidity and the wind speed (when it is dry, the crop water needs are higher than when it is humid. In windy climates the crops will more water than in calm climates.

The effect of these four climatic factors on the water need of the crop is show in table 1.

Table.2. Effect of major climatic factors on crop water needs.

Climate factor	Crop water need	
	High	Low
Sunshine	Sunny (no clouds)	Cloudy n (no sun)
Temperature	Hot	Cool
Humidity	Low (dry)	High (humid)
Wind speed	Windy	Little wind

The highest crop water needs are thus found in areas which are hot, dry, windy and sunny. The lowest values are found when it is all cool, humid and cloud with little or no wind. From the above it is clear that one crop grown in different climatic Zones will have different water needs. For example, a certain maize variety grown in a cool climate will need less water per day than the same maize variety grown in a hotter climate. It is therefore useful to take a certain standard crop or reference crop and determine how much water this crop needs per day in the various climatic regions. As a standard crop or reference crop grass has been chosen.

4.2. Influence of the crop type on the crop water needs.

The influence of the crop type on the crop water need is important in two ways:

1. The crop type has an influence on the daily water needs of a fully grown crop: i.e. the peak daily water needs: a fully developed crop of onions.
2. The crop type has an influence on the duration of the total growing season of the crop. There are;

- **Short duration crops**, e.g. peas, with a duration of the total growing season of 90-100 days and
- **Longer duration crops**. e.g. melons, with a duration of the total growing season of 120-160 days .

And then there are, of course, the perennial crops that are in the field for many years, such as fruit trees. While, for example, the daily water need of melons may be less than the daily water need of peas, the seasonal water need of melons will be higher than that of beans because the duration of the total following season of melons in much longer.

4.3. Influence of crop type on the daily crop water needs.

In the previous section it has been indicated how the daily water need of standard grass can be estimated. In this section it will be explained how the daily water needs of other crops can be estimated using as a basis the daily water need of the standard grass. It will be easy to understand that a fully grown maize crop- with its large leaf area- will use more water per day than, for example, a fully grown crop of radishes or onions: that is when the two crops are grown in the same area.

When determining the influence e of the crop type on the daily crop water needs, reference is always made to a fully grown crop: the plants have reached their maximum height: they optimally cover the ground; They possibly have started flowering or started grain setting. When the crops are fully grown their water need is the highest. It is the so-called “peak period” of their water needs.

For the various field crops it is possible to determine how much water they need compared to the standard grass .A number of crops need more or less the same amount of water as grass.

Table 3 indicates five groups of crops. The crops in column 1 need 30 percent less water than grass in their peak period. The crops in column 2 need 10 percent less water than grass. The crops in column 3 need the same amount of water and grass. The crops in column 4 and 5 need respectively 10 and 20 percent more water than grass in their peak period.

Table.3. Crop water needs in peak period of various field crops as compared to standard grass

Column 1	Column 2	Column 3	Column 4	Column 5
30%	10%	Same as standard grass	+ 10%	+20%
Citrus olives grapes	Cucumber radishes squash	Carrors Crucitera (Cabbage, caulitliflower, broccoli, etc.) Lettuce Melons Onions Peanuts Peppera Spinach Tea Grass Cacao Coffee Clean cultivated Nuts & fruits trees e.g. apples	Barley Beans Maize Flax Small grains with cover crop cotton Tomato Eggplant Millet Oats Peas Potatoes Safflower Sorghum Soybeans Sugarbeet Sunflower Tobacco wheat	Paddy rice Sugarcane Banana Nuts & fruits trees.

Example

Suppose in a certain area the standard grass crop needs 5.5.mm of water per day. Then, in that same area, maize will need 10% more water. Ten percent of 5.5.mm= 10/ 100x5.5. = 0.55=6.05 or rounded 6.1.mm of water per day.

Question.

Estimate the water needs of citrus, bananas, Onions, cucumber, clean, cultivated apple trees and millet for an area where the water need of standard grass is 6mm/ day.

Solution

Citrus:-30% (compared to grass): thus the water need of citrus is 6.0-30% (6) =6.0-1.8 = 4.2mm/ day.

Bananas: + 20%; thus the water need of bananas is 6.0 +20% (6) = 6.0+1.2= 7.2.mm/ day.

Onions: same as grass: thus the water need of onions is = 6 mm/ day.

Apples: same as grass; thus the water need of clean cultivated apples is 6.0 mm/ day (clean)

If the apples have a cover crop in between the trees, the water need would be 20% higher than grass and thus: 6.0 +20% (6) = 6.0+1.2=7.2mm/ day.

Millet: + 10%; thus the water need of miller is 6.0 +10% (6) = 6.0 +0.6 =6.6mm/ day

4.4. Influence of crop type on the seasonal crop water needs

The crop type not only has an influence on the daily water need of a fully grown crop; i.e. the daily peak water need, but the crop type also has an influence on the duration of the total growing season of the crop, and thus on the seasonal water need.

Data on the duration of the total growing season of the various crops grown in an area can best be obtained locally. These data may be obtained from, for example , the seed suppler, the extension service, the irrigation department or ministry of agriculture.

The duration of the total growing season has an enormous influence on the seasonal crop water need. There are, for example, many rice varieties, some with a short growing cycle (e.g. 90 days) and others with a long following cycle (e.g. 150 days) . This has a strong influence on the seasonal rice water needs: a rice crop which is in the field for 150 days will need in total much more water than a rice crop which is only in the field for 90 days. Of course, for the two rice crops the daily peak water need may still be the same, but the

150 day crop will need this daily amount for a longer period. The time of the year during which crops are grown is also very important.

A certain crop variety grown during the cooler months will need substantially less water than the same crop variety grown during the hotter months.

Table 4 gives some indicative values or approximate values for the duration of the total growing season for the various field crops. It is much better to obtain the values locally.

Table -4 indicative values of the total growing period

Crop	Total growing period (days)	Crop	Total growing period (days)
Alfalfa	100-365	Millet	105-140
Banana	300-365	Onion green	70-95
Barley/Oats. Wheat`	120-150	Onion dry	150-210
Bean, green `	75-90	Peanut/ ground nut	130-140
Dry	95-110	Pea	90-100
Cabbage	120-140	pepper	120-210
Carrot	100-150	Potato	105-145
Citrus	240-365	Radish	35-45
Cotton	180-195	Rice	90-150
Cucumber	105-130	Sorghum	120-130
eggplant	130-140	Soybean	135-150
Flax	150-220	spinach	60-100
Grain/small	150-165	Squash	95-120
Lentil	150-170	Sugar beet	160-230
Lettuce	150-140	Sugarcane	270-365
Maize sweet, Grain Melon	80-110 125-180 120-160	Sunflower Tobacco Tomato	125-130 130-160 135-180

As can be seen from table 4 there is a large average variation of values not only between crops, but also within one crops type. In general it can be assumed that the following period for a certain crops is longer when the climate is cool and shorter when the climate is warm.

4.5. Influence of the growth stage of the crop on crop water needs

A fully grown maize crop will need more water than a maize crop which has just been planted. As has been discussed before, the crop water need or crop evapo-transpiration consists of transpiration by the plant and evaporation from the soil and plant surface. When the plants are very small the evaporation will be more important than the transpiration. When the plants are fully grown the transpiration is more important than the evaporation.

At planting and during the initial stage, the evaporation is more important than the transportation and the evapo-transpiration or crop water need during the initial stage is estimated at 50 percent of the crop water need during the mid- season stage, when the crop is fully developed.

During the so- called crop development staff the crop water need gradually increases from 50 percent of the maximum crop water need to the maximum crop water need. The maximum crop after need is reached at the end of the crop development stage which is the beginning of the mid- season stage. With respect to the late season stage which is the pried during which the crop ripens and is harvested, a distinction can be made between two groups of crops.

- **Fresh harvested crops**: such as lettuce, cabbage, etc. with these crops the crop water need remains the same during the late season stage as it was during the mid- season stage. The crops are harvested fresh and thus need water up to the last moment.
- **Dry harvested crop**: - such as cotton, maize (for grain production), sunflower, etc. During the late season stage these crops are allowed to dry out and sometimes even die. Thus their water needs during the late season stage are minimal: If the crop is indeed allowed to die, the water needs are only some 25 percent of the

crop water need during the mid- season or peak period. Of course, no irrigation is given to these crops during the late season stage.

4.6. Influence of Soil on crop water need.

Water requirement of different soils also vary**.** For example sandy soils require frequent irrigation comparing to clay soil. Soil type must be considered while preparing irrigation scheduling.

Determining when to irrigate a specific crop requires the selection of a Management allowable depletion (MAD) of the available soil water. MAD is defined as the percentage of available soil-water that can be depleted between irrigations without serious plant moisture stress. MAD is expressed as:

- A percentage of the total available water content (AWC) the soil will hold in-the root zone.
- A soil water deficit (SWC) in cm or mm, or
- An allowable soil – water tension level.

Different crops tolerate different soil water depletion levels at different stage of growth without going in to moisture stress. Some crops have critical growth periods during only one stage of growth, while others have critical periods during several stages of growth.

MAD should be evaluated according to crop needs, and, if needed, adjusted during the growing season. Values of MAD, during the growing seasons are typically 25- 40% for high value, shallow rooted crops; 50% for deep rooted crops; and 60-65% for low value deep rooted crops.

Recommended MAD values by soil texture for deep rooted crop are;

Fine texture (Clayey) soils =40%

Medium texture (loam) soils =50%

Coarse texture (sandy soils) =60%

The defence in soil evaporation and crop transpiration between field crops and the reference surface affects the crop coefficient. At full-cover condition, the difference in transpiration and the soil evaporation is relatively small. After rainfall or irrigation, the effect of evaporation from soil is more when crop is small and scarcely shades the ground. At low-cover condition the Kc coefficients is mainly determined at the time when the soil

Self-Check – 4	Written test

surface is watered. If the soil is wet, for most of the time either from irrigation or rain then, the evaporation from the soil surface gets increase and Kc may exceed 1. While, if the soil surface is dry, then evaporation is restricted and Kc gets reduced and drops to as low as 0.1. The difference in the soil evaporation between the field crop and the reference surface can be predicted more precisely by using a dual crop coefficient.

Name…………………………………………… ID………………………… Date……

Directions: Discuss all the questions listed below. Examples may be necessary to aid some explanations/answers. (2 point each)

1. The influence of the climate on crop water needs.
2. The Influence of the crop type on the crop water needs.
3. The Influence of crop type on the daily crop water & seasonal crop water needs.
4. The Influence of the growth stage of the crop on crop water needs
5. The Influence of Soil on crop water need.

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

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

LG #101	LO #2- Check water supply and availability

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics: • Water volume required to meet irrigation needs over specified period is determined. • Water is ordered, if necessary, according to water management authority standards and procedures. • Sufficient notice of water order is given, if necessary, to ensure water is available when required. This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to: • Determine volume Water required to meet irrigation needs over specified period. • Capable of giving order water, according to water management authority standards and procedures, whenever necessary. • Capable of giving sufficient notice of water order and ensure the availability of water when required whenever necessary.
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”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.

4. Accomplish the “Self-checks” which are placed following all information sheets.

5. Ask from your trainer the key to correction (key answers) or you can request your trainer 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

7. Perform “the Learning activity performance test” which is placed following “Operation sheets” ,

8. If your performance is satisfactory proceed to the next learning guide,

9. If your performance is unsatisfactory, see your trainer for further instructions or go back to “Operation sheets”.

Information Sheet 1- Determining water required for irrigation.

1.1. Introduction

Importance of irrigation depends on the quantity, quality and intensity of water supply from a given source. In absence of rain fall as in dry season the crop requirement is entirely met from irrigation and is equivalent to gross irrigation requirement.

Therefore, before starting or planning an irrigation work we have to check water supply and availability. This may include economic, social, environmental and political considerations.

- **Economic considerations:** the source should be near from the field that is going to be irrigated and should be at higher elevation than the field to reduce any additional cost for pumping and unless there are no other options, it is not recommended to use ground water by pumping. So, we have to do cost benefit analysis.
- **Social considerations:** as we know that water is the most important thing for the sustenance of animals and plants. As its importance increase the competition from different sectors and groups will raise, so every irrigation project at upper stream will affect the society of the downstream, so we have to try to come up with an agreement which benefits both sides(upstream downstream)
- **Environmental considerations:** the water source from which we divert water for irrigation can be used; for recreational purpose, as home for various in land animals or it may be salty and so on. Therefore, using water from such sources can result in negative environmental impact
- **Political considerations**; the source could be from different regional state or in between two or more states.

1.2. Understanding crop water requirements

- **Water requirement** may be defined as the quantity of water, regardless of its source, required by a crop or diversified pattern of crops in a given period of time of its normal growth under field conditions at a given place. Water requirement is usually equal to evapo-transpiration. In addition to evapo-transpiration demands, water requirement also includes losses during the application of irrigation water and the quantity of water required for special operations such as land preparation, transplanting, leaching etc. **WR = Evapotranspiration + Application losses + Special needs.**

Water requirement (WR) is therefore, the 'demand' and 'supply' that would consist of contributions from irrigation water (IR), effective rainfall (ER) and soil profile contributions (S). Therefore water requirement can also be expressed as

- **WR = IR + ER + S.**

- **Evaporation:** It is the process by which water, in the form of water vapour, enters the atmosphere from open water surfaces such as the seas, lakes, ponds, rivers or from wetland surfaces. Evaporation measurements may be made by the pitch evaporimeter or most commonly by the open pan evaporimeter. It is the amount of water loss (in depth) from the pan filled with water per unit of time, usually per 24 hours and measured in mm/day.
- **Transpiration:** It is the process by which water vapour leaves the living plant body and enters the atmosphere. The climate, the soil and the plant factors influence the transpiration.
- **Evapo-Transpiration:** It is the total water loss due to transpiration from a crop and evaporation from the soil for a particular area during a specified time. Evapotranspiration denoted as ETo (reference evapotranspiration), is a factor of mainly the climate (temperature, wind speed, relative humidity, and sunshine hour) of that particular area. ETo can directly be estimated from a pan evaporation data as: **ETo = Epan x Kpan**

Where ETo = reference evapotranspiration in mm/day

- Epan = evaporation from the pan in mm/day
- Kpan = pan coefficient, which varies between 0.35 and 0.85 or average of 0.7

ETo can also be estimated indirectly from various empirical formulas such as the Blaney-Criddle, Penman-Montheith, or Thontweit formulas, which involve mainly of climatic factors.

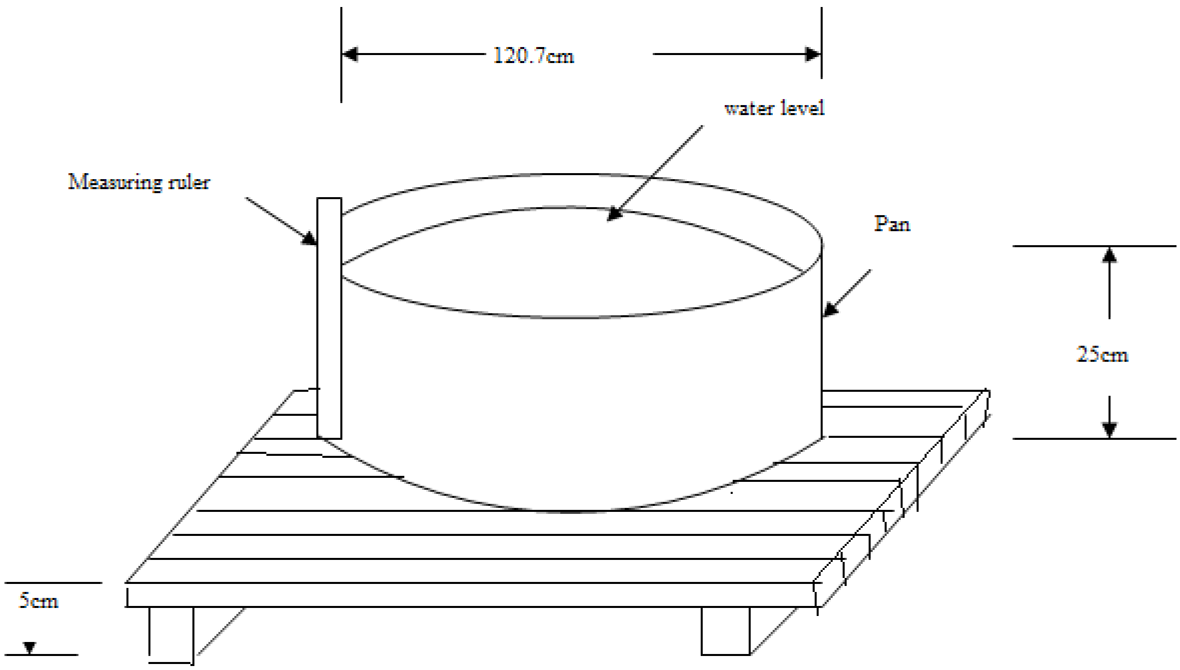


Fig.1. Open pan evaporimeter

- **Crop water need:** It is the amount of water needed by the crop to replace the transpiration and evaporation losses. It tells how much water is required for the crop`s daily or seasonal consumption and is usually expressed in mm/day, mm/month, or mm/season.

The water demand of a certain crop type on a particular area (denoted as ETc) mainly depends on:

- ✓ **The climate** (crops need more water in a windy, sunny, dry, and hot climate, but less water in less wind condition, cloudy, wet, and cool climate.)
- ✓ **The crop type** (crops like rice and sugarcane require more water than crops like beans, wheat, etc.)
- ✓ **The** crop growth stage (less water is needed at initial growth stage, increases at crop development, and highest demand at mid season stage, but reduces at late season or harvest time.)

Therefore, the crop water demand or crop evapotranspiration, (ETc) is calculated as:

ETc = ETo x Kc

where, ETc = crop evapotranspiration in mm/day

ETo = reference evapotranspiration in mm/day

Kc = the crop factor (crop coefficient), ranging between

0.35 to 0.50 at initial growth stage

0.60 to 0.80 at development stage

0.90 to 1.15 at mid season stage

0.30 to 1.0 at late season stage

- Crop coefficient is the ratio of crop evapo-transpiration to the reference crop evappo-transpiration

1.3. Data collection and collate

Data to be collected and collated to determine reference evapotranspiration (Eto)

- From pan evapormeter
  - Epa
  - Kpan
- From weather data

✓ Using Blaney_Criddle method

- Mean daily temperature
- Mean daily percentage of annual daylight hour

✓ Using Pennaman_Monteith method

1. **Location:** The altitude above sea level (m) and latitude (degrees north or south) of the location are specified.
2. **Temperature:** The average daily maximum and minimum air temperature in degree celicius (^{0}c).
3. **Humidity:** the average daily vapor pressure, e_a (KPa) is required. However, if the actual vapor pressure is not available, that can be computed by using the maximum and minimum relative temperature (0c).
4. **Radiation:** The average daily net radiation (MJm-2day-1) is required. If this is not available then it can be determined from the average short wave radiation measured with pyranometer or from the average daily actual duration of bright sunshine (hrs per day) measured with sunshine recorder.
5. **Wind speed:** The average daily wind speed (ms-1) at 2m height above the ground level is required.

1.4. Data to be collected and collated to determine crop evapotranspiration (ETc)

- Reference crop evapotranspiration (Eto); calculated from the above sources.
- Crop coefficient (Kc) of crop can calculate based on crop growing stage.

1.5. Data to be collected and collated to determine irrigation scheduling.

Total available water (TAW): Which is calculated based on the data of field capacity, permanent wilting point and depth of root zone.

Readily available soil water (RAW): Which is calculated based on total available water and maximum allowable deficit.

ETc, Net irrigation requirement (NIR), Gross irrigation requirement (GIR), Irrigation efficiency, discharge of the stream or the channel, dry bulk density and command area of irrigation is require

1.6. Data Analysis and crop Water Requirement determination

1.6.1. Determine of crop water needs

1. **Approximate values of seasonal crop water need**

It is often possible to obtain data on crop water needs locally and it is thus not necessary to calculate them. However, to give the reader some idea on values of seasonal water needs for the most important field crops, Table 5 can be used as a guide.

Table 5. Approximate values of seasonal crop water needs.

Crop	Crop water need (mm/ total growing period)
Alfalfa	800- 1600
Banana	1200- 2200
Barley/ Oats/ wheat	450-650
Bean	300-500
Cabbage	350-500
Citrus	900 -1200
Cotton	700 – 1300
Maize	500- 800
Melon	400-600

Onion	350-550
Peanut	500-700
Pea	350-500
Pepper	600-900
Potato	500-700
Rice (paddy)	450-700
Sorghum/ millet	550-650
Soybean	450-700
Sugar beet	500-750
Sugar cane	1500-2500
Sun flower	600-1000
Tomato	400-800

1.7. Methods of computing reference crop evapotranspiration (ETo) for calculating ET_C

In order to get the actual evapotranspiration, first it is important to determine the reference evapotranspiration. This can be done by using the following method.

1.7.1. ET_O estimated from pan evaporation

ET_o can be determined by the help of several methods But the simplest, reasonably accurate and most commonly used is the pan evaporation method. The evaporation rate from pans filled with water is easily obtained. In the absence of rain, the amount of water evaporated during a period (mm/day) corresponds with the decrease in water depth in that period. Pans evaporation provides a measurement of the integrated effect of radiation, wind, temperature and humidity on evaporation from a specific open water surface. The commonly used standard pan is the U.S class A pan. U.S class A pan has a standard size of 120cm diameter, and 25cm depth. It is made of galvanized iron. For measurement of evaporation, the pan should be properly sat on a wooden open frame with its bottom 15cm above the ground level.

1. Pan Evaporation Method

Evaporation pans provide a measurement of the combined effect of temperature , humidity, wind speed an sunshine on the reference crop evaporation.

Many different types of evaporation pans are being used. The best know pans are the class A evaporation pan (circular pan) and the sunken Colorado pan (square pan)

Eto reference crop evaporation, Kpan=pan coefficient, Epan = Pan evaporation

If the water depth in the pan drops too much (due to lack of rain), water is added and the water depth is measured before and after the water is added. If the water level rises too much (due to rain) water is taken out of the pan and the water depths before and after is measured. Add water when the water depth in the pan drops too much.

Determination of K pan

When using the evaporation pan to estimate the ETO, in fact a comparison is made between the evaporation from the water surface in the plan and the evaporation of the standard grass. Of course the water in the pan and the grass do not react in exactly the same way to the climate. Therefore a special coefficient is used (K pan) to relate one to the other.

The pan coefficient, K pan, depends on:

- The type of pan used
- The pan environment: if the pan is placed in a fallow or cropped area.
- The climate: the humidity and wind speed.

For the class A evaporation pan, the k pan varies between 0.35 and 0.85 average k pan = 0.70 For the sunken Clorado pan, the k varies between 0.45 and 1.10. average k- pan = 0.80

The k pan is high if;

- The pan is place in a fallow area
- The humidity is high (i.e humid)
- The wind speed is low

The k pan is low if:

*. The pan is placed in a cropped area
*. The humidity is low (i.e dry)
*, the wind speed is high

Details of the pan coefficient are usually provided by the supplier of the pan. If the pan factor is not known the average value could be used (see box). If more accuracy is required. The pan factors given in annex 1 should be applied . These values, however, only refer to the class A evaporation pan and the sunken Colorado pan.

Some examples

1) Type of pan; class A evaporation pan

Water depth in pan on day 1= 15mm (

Water depth in pan on day 2=144 mm (after 24 hours ;

Rainfall (during 24 hours) = 0 mm

K pan = 0.75

Formula : ETO = K pan E pan

Calculation: E pan = 150-144= 6 mm/ day

ETO = 0.75 x6 = 4.5 mm/ day

2) Type of pan; Sunken Colorado pan

Calculation: E pan = 411- 409 + 9 mm/ day

ETO = 0.90 x 9 = 8.1 mm/ day

- Measuring devices are usually more accurate then the ruler indicated and thus allow for more accurate readings.

1.7.1. Blaney – criddle method

If no measured data on pan evaporation are available locally, a theoretical method (e.g the blaney- criddle method) to calculate the reference crop evaporation ETO has to be used. There are a large number of theoretical methods to determine the ETO. Many of them have been determined and tested locally. If such local formula is available they should be used. If such local formula are not available one of the general theoretical methods has to be used.

The Blaney- criddle method is simple, using measured data on temperature only it should be noted, however, that this method is not very accurate; it should be noted, however, that this method is not very accurate; it provides a rough estimate or " order of magnitude " only. Especially under "extreme" climatic conditions the Blaney- Criddle method is inaccurate in windy. Dry, sunny areas, the ETO is underestimated (up to some 60 percent). While in calm, humid, coluded areas, the ETO is overestimated Up to some 40 percent).

The Blaney- Criddle forumula : ETO P= (o.46 T mean + 8)

ETO= Reference Crop evaporation (mm/ day) as an average for a period of 1 month.

T= Mean= mean daily temperature (^{0} C)

P= mean daily percentage of annual daytime hours.

The use of the blaney – Criddle formula

<u>Step</u> 1 Determination of the mean dialy temperatue : T mean the blaney- Criddle method always refers to mean monthly values, both for the temperature and the ETO. If , for example, it is found that T mean in march is 28 ^{0}c, it means that during the whole month of march the mean daily temperature is 28^{0}C .

If in a local meteorological station the daily minimum and maximum temperatures are measured, the mean daily temperature is calculated as follows.

$$T\ max = \frac{\text{Sum of all T max values during the month}}{\text{Number of days of the month}}$$

$$T\ min = \frac{\text{sum of all T min values during the month}}{\text{Number of days of the month}}$$

$$T\ mean = \frac{T\ max + T\ min}{2}$$

Step 2: Determination of the mean daily percentage of annual day time

To determine the value of P, Table 4 is used. To be able to determine the P value it is essential to know the approximate latitude of the area: the number of degrees north or south of the evaporation

Suppose the P value for the month march has to be determined for an area with latitude of 45^0 south. From Table 4 it can be seen that the P value during March = 0.28.

Table 5 Mean daily percentage (P) of Annual Daytime Hours for different Latitudes.

Latitude	North South	Jan July	Feb Aug	Mar Sept	Apr Oct	May Nov	June Dec	July Jan	Aug Feb	Sep Mar	Oct Apr	Nov May	Dec June
60^0		.15	.20	.26	.32	.38	.41	.40	.34	.28	.22	.17	.13
55		.17	.21	.26	.32	.36	.39	.38	.33	.28	.23	.18	.16
50		.19	.23	.27	.31	.34	.36	.35	.32	.28	.24	.20	.18
45		.20	.23	.27	.30	.34	.35	.35	.32	.28	.24	.20	.18
40		.22	.24	.27	.30	.32	.34	.34	.31	.28	.24	.20	.18
35		.23	.25	.27	.29	.32	.32	.33	.30	.28	.25	.22	.21
30		.24	.25	.27	.29	.31	.32	.32	.30	.28	.25	.23	.22
25		.24	.26	.27	.29	.30	.31	.31	.29	.28	.26	.24	.23
20		.25	.26	.27	.29	.29	.30	.31	.29	.28	.26	.25	.24
15		.26	.26	.27	.28	.29	.29	.30	.28	.28	.27	.26	.25
10		.26	.27	.27	.28	.28	.29	.29	.28	.28	.27	.26	.26
5		.27	.27	.27	.28	.28	.28	.29	.28	.28	.27	.27	.27
0		.27	.27	.27	.27	.27	.27	.28	.27	.27	.27	.27	.27

Step 3: Calculate ETO, Using the formul;a ;**ETO= P (0.46 T mean +8) f**or example , when P=0.29 and T mean = 21.5^{0}c the ETO is calculated as follows.

ETO- 0.29 (0.46 x21.5+8) = 0.29 (9.89+8) = 0.29 x17.89 = 5.2 mm/day.

Calcuation example Blaney- Criddle

Given Latitude = 35^0 Notth Mean T max in April = 29.5^{0}c Mean T min in April = 19 4^{0}c

Question

Determine four the month pair the mean the mean ETO in mm/ day using the Blaney criddel method.

Solution Formula: ETO = P (0.46 T mean +8) $\frac{T\ max + T\ min}{2} = \frac{29.5 + 19.4}{2} = 24.5^0$c

Step 1: determine T mean :T mean

Step 2; determine P; Latitude : 35^0 North

Month : April

Form Table 4: P= 0.29

Step 3: Calculate ETO ; ETO = 0.29 (0.46 x 24.5 +8) = 5.6 mm/ day

Thus he mean reference crop evaporttransipration ETO = 5.6mm/ day during the whole month of April.

Data Sheet 2

Calculation of the mean Monthly temperature: T max and T min

Location: Example Date 7/5/2013 E.C

Month : January

Number of days in the month 30

Table 7 Sample example to record tempratue

Day	T max (^{0}c)	T min(^{0}c)	Day	T max (^{0}c)	T Min (^{0}C)
1	34.6	23.2	16	37.5	25.8
2	35.6	24.1	17	37.7	25.8
3	35.9	24.6	18	37.1	25.5
4	36.5	24.9	19	36.9	25.6
5	37.1	25.4	20	36.5	25.4
6	37.0	25.3	21	36.0	24.8
7	37.6	26.0	22	35.1	24.0
8	37.3	25.5	23	35.5	24.1
9	37.1	25.3	24	35.9	24.4
10	36.0	24.5	25	36.1	24.4
11	35.9	24.3	26	36.5	25.0
12	35.5	23.9	27	37.0	25.5
13	36.6	25.1	28	37.1	25.6
14	37.4	25.5	29	37.5	25.8
15	37.6	26.0	30	37.1	25.5

Calculate: Sum T: max = 1097.2

Sum T min = 750.8

Mean T max = sum T max / Number of days in month = 1097.2 / 30 = 36.6^{0}c

Mean T min = sum T min / Number of days in month = 750.8 / 30 = 25 .0^{0}c

Data Sheet -3

Determination ETO: Blaney- criddle Method

Location: HOLETA Date 7/5/2013E.C

Latitude 13 North Longitude ________________

Month	T min (^{O}c)	T max (^{O}c)	T mean (^{0}c)	P Table 4	ETO mm/ day
Jan	15.5	32.1	23.8	0.26	4.9
Feb	18.8	35.8	27.3	0.26	5.3
Mar	21.8	38.0	29.9	0.27	5.9
Apr	24.5	38.7	31.6	0.28	6.3
May	26.0	39.0	32.5	0.29	6.7
Jun	25.0	36.6	30.8	0.29	6.4
Jul	22.7	32.6	27.6	0.29	6.0
Aug	22.0	30.8	26.4	0.28	5.6
Sep	23.0	31.8	27.4	0.28	5.8
Oct	21.3	34.8	28.0	0.27	5.6
Dec	16.6	32.0	24.3	0.25	4.8

Note :T mean = $\frac{T\ max + T\ min}{2}$

ETO = P (o.46 T mean + 8)

Indicative values of ETO

If only a rough estimate of the ETO value is required, Table 5 can be used.

Table 6 Indicative values of ETO (mm/ day)

Climatic Zone	Low (Less than 15^0c)	Mean daily temperature (15-25^0c)	High (more than 25^0c)
Desert / arid	4 - 5	7- 8	9 - 10
Semi arid	4-5	6 - 7	8 – 9
(Moist) sub- humid	3-4	5 -6	7- 8
Humid	1-2	3- 4	5 - 6

1.7.2. Supplementary information for determination of crop water Needs

The relationship between the reference grass crop and the crop actually grown is given by the crop factor, KC, as shown in the following formula :

ETO x Kc = ET Crop

With ET crop = crop evapotranspiration or crop water and mm/ days)

KC = Crop factor

ETO = reference evapotranspiration (mm/ day)

Both ET crop and ETO are expressed in the same unit

Usually in mm/ day (as an average for a period of one month) or in mm/ month.

The crop factor , Kc mainly depend on

- The type of crop
- The growth stage of the crop
- The climate

Kc and the type of crop

Fully developed maize, with its large leaf area will be able to transpire, and thus use, mote water than the reference grass crop : Kc maize is higher than 1 cucumbre, also fully developed, will use less water than the reference grass crop; Kc cucumber is less than 1.

Kc and the growth stage of the crop

A creation crop will use more water once it is fully developed, compared to a crop which has just recently been planted.

Kc and the climate

The climate influences the duration of the total growing period and the various growth stages. In a cool climate a certain crop will grow slower than in a warm climate. Thus., to determine the crop factor Kc, it is necessary, for each crop, to know the total length of the growing season and the lengths of the various growth stages.

The determination of the Kc values for the various growth stages of the crops involves several stapes.

Step -1 Determination of the total growing period of each crop

Step -2 Determinations of the various growth stages of each crop

Step -3 Determinations of the Kc values for each crop for each of the growth stages.

Determination of the total growing period

The total growing period (in days) is the period from sowing or transplanting to the last day of the harvest.. It is mainly dependent on :

- The type of crop and the variety
- The climate
- The planting date

As the growing period heavily depends on local circumstances (e.g local crop varieties) it is always best to obtain these data locally. Only if no data are available locally should table 8 be used.

As can be seen from table 8 there is a large variation of values not only between crops but also within one crop type. In general it can be assumed that the growing period for a certain crop is longer when the climate is cool and shorter when the climate is warm.

Table 8 Indicative values of the Total growing period

Crop	Total Growing Period (days)`	Crop	Total growing period (days
Alfalfa	100-365	Miller	105-140
Banana	300- 365	Onion, free	70-95
Barley. Oats. Wheat	120-150	Dry	150-210
Bean, green	75-90	Peanut/ Ground nut	130-140
Dry	95-100	Pea	90-100
Cabbage	120-140	pepper	120-210
Carrot	100-150	Potato	105-145
Citrus	240 -365	Radish	35-45
Cotton	180-195	Rice	90-150
Cucumber	105 -130	Sorghum	120-130
Egg plant	130-140	Soybean	135-150
Flax	150-220	Spinach	60-100
Grain/small	150-165	Squash	95-100
Lentil	150-170	Sugar beer	160 -230
Lettuce	75-140	Sugarcane	270 -365
Maize, Sweet	80-110	Sunflower	125 -130
Grain	125-180	Tobacco	130- 160
Melon	120-160	Tomato	135-180

1.7.3. Determine of the growth stages

Once the total growing period is know, the duration (in days) of the various growth stages has to be determined. The total growing period is divided in to 4 growth stages.

1. **The initial stage**:" this is the period from sowing or transplanting until the crop covers about 10% of the ground.

2. **The crop development stage** : this period starts at the end of the initial stage and lasts until the full ground cover has been reached (ground cover 70-80) ; it does not necessarily mean that the crop is at its maximum height.

3. **The min-d season stage** : this period starts at the end of the crop development stage lasts until maturity; it includes flowering and grain- setting.

4. **The late season stage** : this period starts at the end of mid season stage and lasts until the last day of the harvest, it includes ripening.

Table -9 approximate duration of Growth stages for various field crops

	Total	Initial stage	Crop development	Mid season stage	Late season stage
Barley	120	15	25	50	30
oats	150	15	30	65	40
Wheat	75	15	25	25	10
Bean/green	90	20	30	30	10
Bean /dry	95	15	25	35	20
Cabbage	110	20	30	40	20
Carrot	120	20	25	60	15
Cotton	180	30	50	55	45
flax	195	30	50	65	50
Cucumber	105	20	30	40	15
Egg plan	130	30	40	40	20
Grain/ small	150	20	30	60	40
Lentil	150	20	30	60	40
Lettuce	75	20	30	15	10
Maize	140	35	50	45	10
sweet	110	20	30	50	10
Maize grain	125	20	35	40	30
Melon	120	25	35	40	20
Millet	105	15	25	40	25

Onion green	95	25	40	20	10
Onion dry	150	15	25	70	40
Peanut	130	25	35	45	25
Ground nut	140	30	40	45	25
Pea	90	15	25	35	15
Pepper	120	25	35	40	20
Potato	105	25	30	30	20
Radish	40	10	10	15	5
Sorghum	120	20	30	40	30
Soybean	135	20	30	60	25
Spinach	100	20	30	40	10
Squash	120	25	35	35	25
Sugarbeet	160	25	35	60	40
Sunflower	125	20	35	45	25
Tomato	135	30	40	40	25

Example

Carrots: the "minimum "growing period is 100 days. This growing period corresponds with the following duration of growth stages.

Initial stage :20 days

Crop development stage : 30 days

Mid- season's stage : 30 days

Late season stage: 20 days Total: 100 days

The Kc value of the crop is 0.45, 0.75, 1.15, 0.85 respectively. Planting October 01. Epan for October, November, December and January respectively are 0.8, 4.1, 4.3 and 4. Kpan=0.7

a) Calculate the crop water requirement the whole growing season of the crop.

Solution

i) CWR for initial stage (20days)

October 01 to October 20= 20 days

CWR initial (mm)= Kpan * Epan * Kc * No. of days

= 0.7* 0.8* 0.45 * 20 = 5.04 mm

ii) CWR for development stage (30 days)

CWR1 from October 21 to October 30

CWR 1 = Kpan * Epan * Kc * No. of days

= 0.7 * 0.8 * 0.75 * 10= 4.2mm

CWR 2 from November 01 to November 20

CWR 2= Kpan * Epan * Kc * No. of days

= 0.7 *4.1 * 0.75 * 20= 43.05mm

Therefore CWR for development stage = CWR1 + CWR2 = 4.2mm + 43.05=47.25mm

iii) CWR for mid stage (30 days)

CWR1 from November 21 to November 30

CWR 1 = Kpan * Epan * Kc * No. of days

= 0.7 *4.1 * 1.15* 10= 33.005mm

CWR 2 from December 01 to December 20

CWR 2= Kpan * Epan * Kc * No. of days

= 0.7 *4.3* 1.15 * 20= 69.23mm

Therefore CWR for development stage = CWR1 + CWR2 = 33.005mm+ 69.23mm =102.235mm

iv) CWR for late stage (20 days)

CWR1 from December 21 to December 30

CWR 1 = Kpan * Epan * Kc * No. of days

= 0.7 *4.3 * 0.85* 10= 25.585

CWR 2 from January 01 to January 10

CWR 2= Kpan * Epan * Kc * No. of days

= 0.7 *4* 0.85* 10= 23.53mm

Therefore CWR for development stage = CWR1 + CWR2 = 25.585+ 23.53 =49.115mm

Thus, the CWRfor the whole growing period would be,

CWR total= CWR initial + CWR development + CWR mid + CWR late

= 5.04mm + 47.5mm + 102.235mm + 49.115mm

= 204.18mm

Self-Check – 1	Written test

Name………………………………………… ID………………………… Date…….

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

Test I: Short Answer Questions

1. **Define the following terms**

a) Evaporation

b) Transpiration:

c) Evapo-Transpiration

d) crop water requirement

e) Temperature

f) Humidity:

g) Radiation

h) Wind speed

i) Total available water

j) Readily available soil water

2. Explain briefly the methods of determining reference crop evaporation (Eto)
3. Write and explain the variables that influencing crop water requirement (CWR)
4. **Given** Latitude = 50^0 North

Mean T max in April = 31^0c

Mean T min in April = 21^0c

Question

a) Determine for the month April the mean ETO in mm/ day using the Blaney criddel method.

b) If the Crope factor (Kc) value is 0.85, determine the CWR

5. Type of pan; class A evaporation pan

Water depth in pan on day 1= 200mm Water depth in pan on day 2=140 mm (after 24 hours

Rainfall (during 24 hours) = 0 mm K pan = 0.75

c) Calculate E pan and Eto

d) If the Crope factor (Kc) value is 0.9, determine the CWR

6. Type of pan; class A evaporation pan

Water depth in pan on day 1= 150mm, Water depth in pan on day 28=80 mm (after 24 hours Rainfall (during 24 hours) = 30mm K pan = 0.75

a) Calculate E pan and Eto

b) If the Crope factor (Kc) value is 0.9, determine the CWR

7. What is the crop water requirement of Maize that was planted on 01 July and has the “minimum “growing period of 130 days. This growing period corresponds with the following duration of growth stages and their corresponding Kc factor values.

Growing Stage	Length of growing days	Crope factor (Kc)
Initial season	20	0.4
Crop development season	35	0.8
Mid season	45	1.15
Late season	30	0.7

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

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

Information Sheet 2- Ordering water allocation

2.1.Water allocation

One of the more evident problems in the future is the growth of alternative demands for water such as urban and industrial needs. These uses place a higher value in on water resources and therefore it tend to focus attention on wasteful practices. Irrigation science in the future will undoubtedly face the problem of maximizing efficiency and good management system. It is important that the scope of irrigation science not be limited to diversion and conveyance systems nor solely to the irrigated field nor only to the drainage path ways, but irrigation is a system extending across many technical non-technical disciplines. It only works effectively and continually when all the components are integrated smoothly. These components can be;

Water management authorities

Farmers/ individual farmers

Scheme operators

Other sectors using water in a high quantity

Water management authorities, it is a body which has a full authority to control, order, schedule and obtain a payment from different customers that uses a given water source. An irrigation scheme is more difficult to manage, because;

- **It often involves two different organizations**; an irrigation scheme often supplies water to a group of farmers, who then have to distribute the water to individual members of the group. This means managing an irrigation scheme may involve two different organizations; one for managing the supply of water to the groups, and the other for distributing water within each group.
- **It involves more complicated operations;** it should be applied in accordance with the requirements of the crops. The managers of an irrigation scheme/ water management authority , firs have to obtain information on the farmers water requirement, then draw up a delivery schedule, adjust the gate settings throughout the scheme, make the deliveries and then start all over again for the next round of application.

- **There is more likelihood of conflicts,** these conflicts can be;
  - ✓ Conflict among farmers within a group of water user
  - ✓ Conflict among groups of water users
  - ✓ Conflicts among the groups and managers of the main system

Such conflicts are more difficult to solve, if the farmers are not satisfied with the services of a particular supplier and they can go to another supplier.

- **Obtaining payment from the farmers is more difficult** it is much more difficult to stop water deliveries to one farmer when water is delivered to a group. While it is technically possible to classify a whole group, this is not attractive for the irrigation scheme managers. They cannot sell their supplies to other customers outside the irrigation scheme.
- **Irrigation demand may exceed supply,** in an irrigation scheme, the maximum supply is limited by water availability and canal capacity, and this is another source of conflict. In irrigation shame, the organization that distributes the water is often of a public nature, while the group of farmers receiving the water is often a gain a private institutions, this mix of public and private institutions that all have their own rules that makes irrigation management especially difficult.

Not all irrigation schemes have this mixed type of management. Two other types are;

1. Public –managed schemes
2. Farmer-managed schemes

1. public managed schemes, a single government agency is responsible for water and agricultural managements. As all decision about cropping schedule and water deliveries are made by the same agency, they are fewer conflicts, the disadvantages is that any management mistake will also lead to failure on a large scale. The position of farmers in a public managed scheme is more similar to that of workers in factory.
2. farmers managed scheme all decisions on irrigation and agricultural issue are made by farmers. The irrigation issues above the farm level, such as main system operation and maintenance are performed by farmers operating as group.

Self-Check – 2	Written test

Irrigation and agricultural issues at the farm are decided by individual farmer.

N.B in order to avoid the above difficulties and conflicts the water management authority should have its own standards and procedures which every customers / water users should follow and respect it and the water authority should use this standards and procedures when ordering the water for customers.

Name…………………………………………… ID……………………….. Date……

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers. (2 points each)

1. Explain the components of water allocation
2. Mention the likelihood of conflicts in ordering water allocation of irrigation
3. What can you do if Irrigation demand may exceed supply

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

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

Information Sheet 3- Giving sufficient water order

3.1. Water order

we know that water is one of the most important constituent of life, due to its importance competition for it will rise from different sectors, like; industries, hydropower stations, irrigation projects and municipal water supplies. As the water demand of these sectors, increase the water management authority may not supply enough water for its customers as they want, in order to satisfy the needs of customers, the water management authority will have its own principles and procedures when, supplying water for its customers and the commitment of a water management authority for any customer depends on the; available water, water demands of the customers, the necessity of the sector societies well-being.

Based on these criteria water management authority may change the water orders from time to time, in response of changes in climatic conditions, siltation of reservoirs, maintenance of structures, or an increase in water demand for one sector will affect the water supply. For example, an increase in water demands of municipal water supply during holidays. In such cases, the water management authority should give sufficient notice of water orders for its customers before implementing the new schedule. In small scale irrigation projects it is the responsibility of extension workers to give notice of water orders for farmers. This can be through local representatives, or on a time when the given water users meet for different purposes, like, religious activities, idir and iqub.

Self-Check – 3	**Written test**

Name…………………………………………… ID………………………… Date……

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

1. Discuss briefly about Giving sufficient water order in irrigation scheme (6 points)

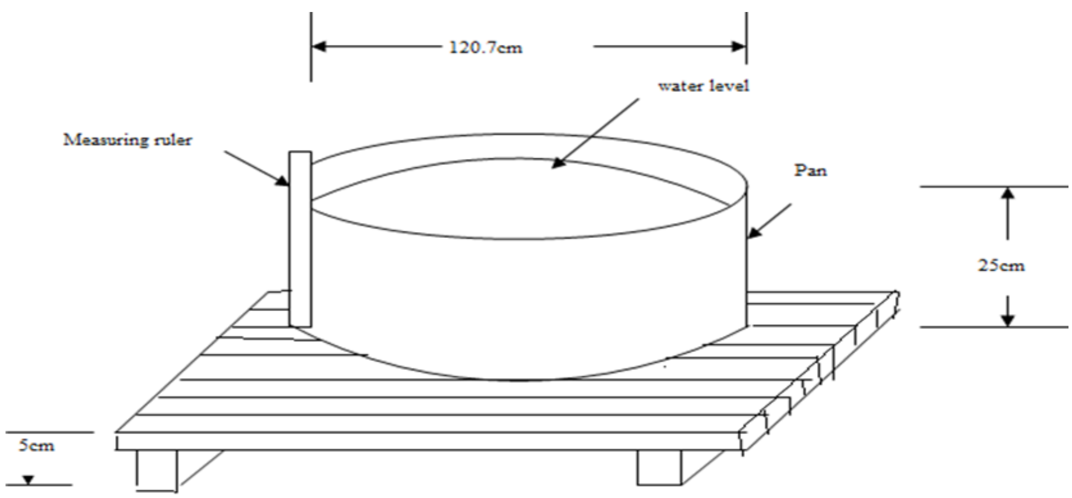
Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

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

Operation Sheet 1- Understanding crop water requirements

ROCEDURE

1. The pan is installed in the field
2. The pan is filled with a known quantity of water (the surface area of the pan is known and the water depth is measured)
3. The water is allowed to evaporate during a certain period of time (usually 24 hours). For example, each morning is 7 o'clock a measurement is taken. The rainfall, if any is measured simultaneously.
4. After 24 hours, the remaining quantity of water (i.e water depth is measured.
5. The amount of evaporation per time unit (the difference between the two measured water depths) is calculated, this is the pan evaporation: E pan (in mm/ 24 hours).
6. The E pan is multiplied by a pen coefficient, K pan (use 0.7 for US Class pan), to obtain the ETO. See the figure below



Observations

Record the following datas

No. of days	Water depth in the pan (mm)	Amount of rainfall (mm)	Pan coefficient	Balance (subtract the amount of rainfall from water depth in the pan, if it rains)
1				
2				
3				
.				
.				
.				
29				
30				

Operation Sheet 2- Determination crop water requirements using B.Criddle

PROCEDURE:

1. Determination of the mean dialy temperatue
2. Determination of the mean daily percentage of annual day time
3. Calculate ETO
4. Calculate CWR

Data Sheet -3

Determination ETO: Blaney- criddle Method

Location: ______________________ Date______________________ Altitude____________________

Latitude _______________________ Longitude _________________

Month	T min (^{O}C)	T max (^{O}C)	T mean (^{0}c)	P Table 5 (*)	ETO mm/ day
Jan					
Feb					
Mar					
Apr					
May					
Jun					
Jul					
Aug					
Sep					

Name………………………………… ID……………………………..

LAP TEST	Performance Test

Date……………………………………

Time started: ________________________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within **3** hour. The project is expected from each student to do it.

Task-1 Collect and Collet the necessary data from nearby metrological station and calculate CWR using Blanny Criddle Method

Task-2 Collect and Collet the necessary data from nearby metrological station and calculate CWR using Pan evaporometer Method

LG #102	LO #3- Implement irrigation shifts

Instruction sheet

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

- Resources are coordinated and personnel briefed to deliver requirements.
- Agreed irrigation schedule is implemented.

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, **upon completion of this learning guide, you will be able to**:

- Coordinate Resources and have personnel brief to deliver requirements.
- Implement the agreed irrigation schedule.

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”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks” which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer 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
7. Perform “the Learning activity performance test” which is placed following “Operation sheets” ,
8. If your performance is satisfactory proceed to the next learning guide,
9. If your performance is unsatisfactory, see your trainer for further instructions or go back to “Operation sheets”.

Information Sheet 1- Coordinating resource and briefing personnel

1.1. Coordinating resource

As we know the basic objective of irrigation is to supplement moisture for a given crop, to get optimum yield. But achieving this objective is not a simple task since irrigation is a system extending across different technical and non-technical disciplines, that require many professionals and it may have so many components like; water management authority, scheme operators, extension workers, farmers and other sectors. Therefore, in order to achieve the objective, all the above components should integrate smoothly and there should be coordination between them.

1.2. Briefing personnel

Irrigation is also an alteration in nature, therefore it has its own negative impact on; soil, weather conditions and human health. So to avoid or minimize such negative impacts the obvious choice is coordination between components and training the farmers.
Personnel briefing, is proper utilization of skilled man power.

Comparative analysis of efforts to improve local participation in irrigation offers a basis for examining achievements, problems and opportunities for the future. While many alternatives seem to exist for who can carry out the role of organizer more attention should be directed to the problems of training and supervising organizers. Farmers demonstrably can improve the construction of structures but design innovation is still scarce. Requirements for local contributions are more feasible if built into projects from the beginning.

Further progress in participation requires going beyond reforming centralized agencies to create additional means for enabling greater democracy, diversity and self-reliance.

Improving local participation continues to be been seen as one of the most promising ways to make irrigation schemes perform better

Self-Check – 1	**Written test**

Name…………………………………………… ID……………………….. Date…….

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

1. Briefly Discuss How you Coordinate resource and briefing personnel in a given irrigation scheme (6 point)

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

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

2.1. Soil water balance

Evapo-transpiration can also be determined by measuring the various components of the soil water balance. The method consists of assessing the incoming and outgoing water change into the crop root zone over some time period. Irrigation (I) and rainfall (P) add water to the root zone. Part of I and P might be lost by surface runoff (RO) and by deep percolation (DP) that will eventually recharge the water table. If all change other than evapotranspiration (ET) can be assessed, the evapotranspiration can be obtained from the change in soil water content over the time period: that is,

$$ET = I + P - RO - DP$$

Some change such as subsurface flow, and deep percolation are difficult to assess in short time periods. The soil water balance method can usually only give ET estimates over long time periods of the order of week-long or ten-day periods.

Irrigation Water Requirement

The irrigation water requirement basically represents the difference between the crop water requirement and effective precipitation (effective rainfall). The irrigation water requirement also includes additional water for leaching of salts and to compensate for non-uniformity of water application

2.2. Effective rainfall

It is a part of annual or seasonal RF which can be stored inthe root zone and utilized by the crop. All amount of rainfall are not useful due to evaporation, percolation, and runoff losses

Factors affecting effective rainfall

Rainfall characteristics: rainfall characteristics such as intensity, distribution affect the effective rainfall.

- **Land slope**: it affects the opportunity time of rainfall for uniform infiltration.
- **Soil characteristics**: the soil properties such as infiltration and water holding capacity influence the degree of effective rainfall. As the water holding capacity increases, effective rainfall also increases. Low infiltration resulted to high runoff which reduces the effective rain fall.

- **Crop characteristics**: effective rainfall is directly proportional to the rate of water up take by the crop. The rate of water up take by the crop is affected by degree of ground water, rooting depth, stage of crop.

2.3.1. Determination of effective rainfall

In many countries different formula have been developed to determine effective rainfall. Such formula takes in to account factors like rainfall reliability, topography, soil type. According to ecological zone of Ethiopia it is determined as follows.

$P_e = 0.6 * P_{total} - 10$, for P_{total} < or = 60 mm /month

$P_e = 0.8 * P_{total} - 24$, for $P_{total} > 60$mm/month

Where, Pe is effective rainfall

P_{total} is total precipitation

2.3.2. Net irrigation water requirement (NIWR):

It is the amount of water required to bring the soil moisture level held in the root zone to field capacity. OR It is the depth of moisture that must be supplied by irrigation to satisfy evapo-transpiration need of the crop minus effective precipitation.

$$NIWR = CWR(ET_C) - P_e$$

Where: NIWR is the net irrigation requirement;

ET_C is evapo-transpiration,

Pe is effective precipitation

Gross irrigation water requirement (GIWR): is the total amount of water required to be diverted from the source or it is NIWR + Loss of Water.

$$GIWR = \frac{NIWR}{E_I}$$ where $0 < E_I < 1$

E_I – irrigation efficiency

It can be express in terms of

- Application depth(mm/day) or
- Flow rate over a hectare of land(mm/hr)

Example: Calculate monthly and total NIWR& GIWR of the following data with irrigation efficiency $E_I = 0.6$

month	Feb	Mar	April	May	June
CWR(mm)	69	123	180	234	180
P_t(mm)	20	38	40	80	16

Solution

Month	CWR (mm)	Pt (mm/month)	Pe *(mm/month)	NIR **(mm/month)	GIR ***(mm/month)
Feb	69	20	2	67	111.67
Mar	123	38	12.8	110.2	183.67
Apr	180	40	14	166	276.67
May	234	80	40	194	323.33
Jun	180	16	0	180	300

*Pe =0.6 * Pt -10, for pt $\leq$ 60mm/month

Pe = 0.8 * pt -24, for Pt > 60mm/month

** NIR = CWR –Pe

*** GIR =NIR/Ef = NIR/0.6

Example: Based on the following information determine the net irrigation water requirement and the gross irrigation water requirement of the crop.

Month	ETc(mm)	Pe(mm)
October(15day)	37	30.8
November(30day)	84.2	20.4
December(30day)	154.9	6.7
January(30day)	188.1	2.4
February(1 day)	13.3	1.0

E_{I} = 85.4%

Month	ETC 8mm)	Pe (mm9	NIR *(mm)	GIR **(mm)	NIR***(mm/day)	GIR****(mm/day)
October(15day)	37	30.8	6.2	7.6	0.41	0.48
November(30day)	84.2	20.4	63.8	74.7	2.13	2.49
December(30day)	154.9	6.7	148.2	173.54	4.94	5.78
January(30day)	188.1	2.4	185.7	217.45	6.19	7.25
February(1 day)	13.3	1.0	12.3	14.4	12.3	14.4

NIR *(mm) = NIR = CWR-Pe

GIR **(mm) = NIR/Ef =NIR/0.854

NIR***(mm/day) =CWR-Pe/(No. of days in month)

GIR****(mm/day) = NIR(mm/day)/(Ef)

= NIR(mm/day)/(0.854)

2.4. Economics of irrigation and Matching Supply and Demand

2.4.1. Economics of irrigation

Since irrigation costs money, it must be economically efficient. We therefore need tools to analyze and measure efficiency. For this purpose we use yield or productivity.

- **Return and productivity**

  It is the relation between the amount produced and the sum of production factor used to produce it. Example, if you produce 900kg of sorghum,

  return from the land =900kg ⁄ 1.2ha ⟹ 750kg/ha

- **Return from Water**

It is calculated in the some way of the previous one. If 800mm or 8000m3/ha of rain fall occurs during the season then the return from rain in the season will be 750kg/8000m3 ⟹ 0.094kg/m3 in rain feed agriculture this way of expressing return from water never used. Because it costs nothing, but this expression worth important for irrigated farm.

- **Optimal water application in economics term**

The optimal application is the one, which gives the highest income or yield. To determine the optimal application of water, the irrigator should conduct experiment. You can look up the following example how to precede the experiment. Here five plots are shown side by side in exactly in the same way. i.e. the same Varity, the same sowing density, and the same growing method. Each method receives the same water application (row A). Knowing the water cost (row B),it is possible to calculate the total cost of water(C).row D gives the income obtained after subtracting all the other expenses(cost of seed, labor, harvesting, and fertilizer) except the water expenses. If we divide this gross income by total water supply we obtained the income per m^3 of water.

Plots	P	Q	R	S	T
A. water application	50	75	100	125	150
B. Cost of water (birr/m3)	12	12	12	12	12
C. total cost of water (birr)	600	900	1200	1500	1800
D. Gross income per area (after deducting expenses except water expenses) (birr)	1440	3000	4445	4980	4760

E. Gross income per cubic meter (birr)	28.8	41.3	44.4	39.8	31.7

Conclusion from the Table

The highest average income is obtained with application of 100m3water per The highest total income is obtained with an application of 125m3 (plot s) area (plot R).

2.4.2. Matching Supply & Demand of Irrigation water

I. Methods of matching Supply & Demand of Irrigation water

Ideally the supply of irrigation water should be equal to the demand to cover the full crop needs but commonly, there is a shortage of water. When this happens, it is advisable to manage with available water through the following methods.

1. Reducing the area to be irrigated

Growing crops only some portion (mostly 25-30%) of the farm area during the dry season or when water supply decreases so that on the remaining area the plants receive adequate amount of water they need.

2. Changing Crop types

- If there is water shortage, a possible irrigation strategy can be adopted that is reducing the number of water application, which some crop types can adapt.
- Plants adapting to an irrigation strategy of reducing water application: Cabbage, lettuce, tobacco, cowpea, cotton, sorghum, sugarcane, groundnut, etc
- Plants which are not adapting irrigation strategy of reducing water application: Beans, maize, peas, potato, tomato, watermelon, cucumber, chillies, etc.

3. Changing water management practice

Decrease the amount of water being applied per irrigation (i.e. deficit irrigation) Reducing evaporation by practice like shading nurseries, mulching, setting up wind break, etc.

II. When and how much to irrigate (Irrigation Scheduling)

Irrigation scheduling determines how often a crop should be irrigated in its whole growing season in order to meet its daily, monthly as well as seasonal water requirement. Irrigation is normally scheduled to maintain readily available water (RAW) so that plants can potentially satisfy their ET demand. Irrigation scheduling may be affected by different factor as mentioned below.

2.4.3. Factors Affecting Irrigation Scheduling

1. **Type of Crop:** Different crops require different water requirements. So, the type of the crop also determines irrigation scheduling. The crop rooting depth and growing stage influence the scheduling of irrigation.

2. **Soil:** Water requirement of different soils also vary**.** For example sandy soils require frequent irrigation comparing to clay soil. Soil type must be considered while preparing irrigation scheduling.

3. **Climate**: Climate and season also pays key role in water requirement of crops, because climate influences rate of evaporation. Climate should be taken into account when we prepare irrigation schedule for particular crops.

Irrigation scheduling enables the farmer to apply the correct quantity of water during each application at the right application time. So the farmer should be able to predict when his crops need irrigation. This can be done by the following irrigation scheduling method:

2.4.4.Irrigation scheduling method

a) Observing Plants

- This is a direct way of knowing when the crops need water.
- The farmer observes the plants for any signs of wilting or change in *leaf colour* or *growth rate*.
- The method is *simple* but its major disadvantage is that the signs of shortage appear after the optimum allowable depletion has already been exceeded. In other words this may occur after the crop faced water stress which leads the reduction of yield.

b) Keeping a water balance sheet (simple calculation)

- This approach works on the principle that the change in water content of the soil is represented by the difference between water added by irrigation (or rainfall) and the amount lost by evapo-transpiration. So it tells us to apply water in order to substitute the loss through evapo-transpiration.
- The records are kept for each farm and crops (see the table below).
- The method requires no equipment and is easy to operate.
- It can be operated on a daily or weekly or 10 day basis.

Table 11: Example of Irrigation Plan: Water Balance Sheet

Apply 30mm of water at 30 mm .deficit

Date	Estimated ET (mm)	Rainfall (mm)	Accumulated Deficit (mm)	Irrigation(mm)
5.1.09	4.2	-	4.2	
6.1.09	3.5	-	7.7	
7.1.09	3.8	-	11.5	
8.1.09	4.5	-	16.0	
9.1.09	5.2	-	21.2	
10.1.09	5.1	2.0	24.3	
11.1.09	5.5	-	29.8	
12.1.09	5.1	-	4.9 (34.9)	30
13.1.09	4.9	-	9.8	

c) Measuring Soil Moisture

- This is the best scheduling and the most widely used. Soil moisture can be indirectly measured using devices and instruments eg. tensiometers, resistance blocks or neutron probes.
- Direct measurement of soil moisture can be by weighing or the gravimetric method.
- These methods are either too expensive or complicated.
- The simplest and most practical method is to estimate the moisture content by the 'feel and appearance' of the soil.
- Soil is collected at the root zone and checked to guess the right time to irrigate.

Irrigation scheduling should answer how much water to apply (irrigation depth), when to apply(irrigation frequency) and in what pattern to apply(irrigation period). Those terms are elaborated as follows.

3. How much water to Apply?(Irrigation depth)

Irrigation is normally required to keep the soil water content between FC and θc. This range is called RAW. In irrigation system design, net irrigation requirement is interchangeably used with RAW. It is calculated as:

NIR = RAW = (FC – θc).Dz

= MAD. TAW

= MAD* (FC – PWP)*Dz*bulk density

MAD = maximum allowable depletion = 0.50 for most crops. However, irrigation amount should account unavoidable water losses in application such as runoff and deep percolation. Thus, the NIR needs to be increased by an overall irrigation efficiency of the system, E. Therefore, the actual irrigation amount to be applied is called Gross Water Requirement which is given by:

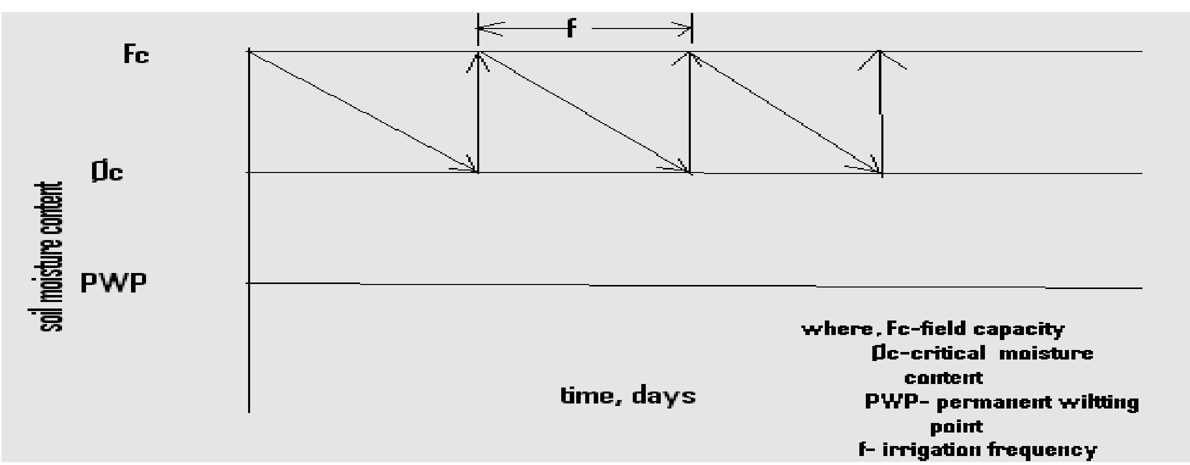
GIR = NIR/Ea

4. **When to Apply? (Frequency of irrigation)**

This refers to the irrigation interval which is the number of days between two successive irrigation applications. It is given by:

f = NIR/ETc

- Irrigation frequency therefore depends upon both soil and crop properties.
  - For shallow soil having shallow rooted crops, irrigation frequency will be small and water will need be applied more often
  - During germination and flowering stage, crop must be irrigated frequently as permissible depletion would be small.



Example 1

How much water must be added to a field of area 3 ha to increase the volumetric water content of the top 40cm from 16% to 28%? Assume all water added to the field stays in the top 40cm.

Solution

Volume = A*dw

dw= (PWP-FC)*di

(28%-16%)*0.4 = 0.048m

Volume =A*dw

= 30,000m^2 * =.048m

= 1440m^3

Example 2.

Compute the depth and frequency of irrigation required for a certain crop with data given below.

Crop: wheat, Average daily CU: 1.2cm D rz: 1.20m, Application efficiency: 75%

FC: 17%, PWP: 5%, Bulk density: 1.72 gm/cm^3, ***Answer: d = 24.77cm; f = 10days***

a. NIR = (Fc-PWP) * Dr * ρb * MAD

(17%-5%) * 120cm * 1.72 * 0.5 = 12.384cm

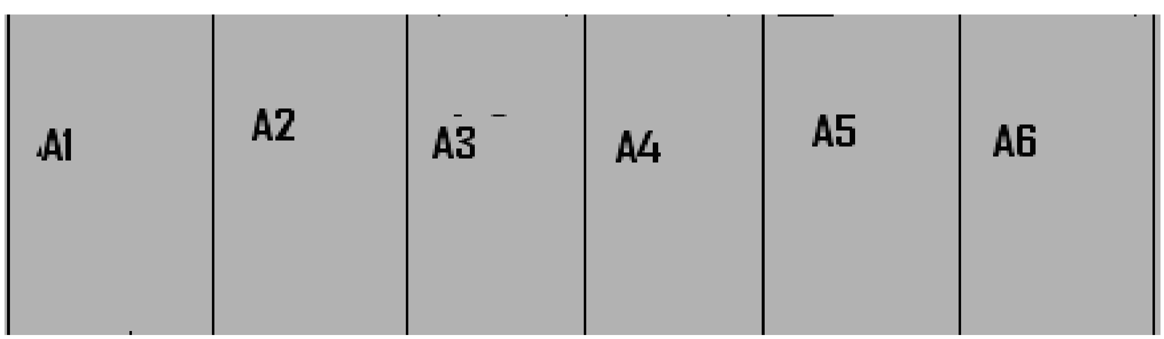
Cu = 1.2cm/day

Frequency, f , = NIR/Cu = 12.384cm/1.2cm/day = 10 days

5. Irrigation Period

- It is the number of days allowed to complete one irrigation cycle in a given area.
- Irrigation period can not be greater than the irrigation interval.

Example: if the calculated irrigation interval is 7 days and if an irrigated area is divided into 6 sub-areas to be irrigated in shift. The irrigation period is 6 days.



And it can be calculated by:

$$IP = \frac{f * GIWR * A}{0.36Qm}$$

Where: IP- irrigation period in hour

f- Irrigation interval in day

GIWR- gross irrigation requirement of the plant in mm/day

A - Area of irrigated farm in hectare

Q_m - manageable discharge in liter/sec.

Exercise:

Calculate irrigation interval (f) & Irrigation period (IP) under the following condition. CWR (ET_C) =10mm/day, root depth=1m, FC=24%, PWP=8%,

Q_M =150L/Se, A=0.5ha, GIWR = 70% and Depletion=50% , Bulk Density 1.5g/cm3

Solution

ETc= 10mm/day Dr= 1m =100cm FC = 24% PWP = 8%

Q = 150 lt /sec = 150m3/1000 sec = 0.15 m3/sec

Irrigation efficiency = η = 70% MAD = 50% ρ_b= 1.5 gm/cm^3

a) Frequency of irrigation

$$F = \frac{NIR}{ETc}$$

But, NIR = di * MAD

$$di = \left(\frac{FC-PWP}{100}\right) * Dr_8 * \rho_b$$

di =
$$di = \left(\frac{24-8}{100}\right) * 100 * 1.5$$

di= 24cm

NIR = di * MAD = 24cm * 50/100= 12cm

Therefore $$F = \frac{NIR}{ETc}$$

$$= \frac{12cm}{10mm/day}$$

$$= \frac{120mm}{10mm/day}$$, F= 12 days

c) Time of irrigation, t

$Q * t = A * GIWR$

$$t\ (sec) = \frac{A * GIWR}{Q}$$

$A = 5000m^2$, $Q = 0.15\ m^3/sec$

$$GIWR = \frac{NIR}{\eta} = 12\ CM/0.7 = 17.143\ CM$$

$GIWR = 0.17143m$

$$t\ (sec) = \frac{A * GIWR}{Q} = t\ (sec) = \frac{50000m^2 * 0.17143m}{15m^3/sec}$$

t= 5714.333 sec = 1.59 hr = 1.6 hr

2.5. Forming Water Users Association (WUA)

The establishment of WUA is essential for successful irrigation. The farmers on given scheme (Irrigation Project) may have their own ideas about how they should organize themselves for management. These ideas must be respected. Some suggestions for organization of WUA are outlined as follows:

I. All farmers should be member of WUA.

II. The farmers should elect a board and a chairman for a limited term.

III. The first few meeting of the WUA should formulate the rule and regulation for the WUA. It should have detail of the duties & responsibilities of the WUA committee member and individual member of the WUA.

IV. The WUA should consider the appointment of one respected farmer to act as the water manager. The water manager should be responsible to the WUA board and members for the allocation and distribution of water & maintenance of the irrigation and drainage system. The water manager would be paid for this job, either with produce or with the allocation a plot of land to cultivate. The post of water manager would be for a limited term and subjected to election by the members.

V. The WUA should formulate guideline for the resolution of conflict between members over water related issues

VI. The WUA should formulate Realistic and implemental penalties for the infringement of the association rule and regulation

2.6. Methods of organizing water distribution

1. Continuous Flow Method

-same discharge flows continuously throughout the irrigation season**.**

-simplest but least efficient

-general limited to main canals serving 50ha or more.

2. Rotational (turn) flow

Water is applied on rotation for a fixed time on fixed day .The water may be distributed by turns.

- Having equal duration throughout the irrigation season
- Having different duration, longer at the beginning and end of the irrigation season and shorter in the middle , according to the crop demand .

In this system, the farmer is relived of the strain of constant irrigation. During the time that the stream s at the farmers disposal, he can give himself wholly ton the work of irrigation; when that work is done, he may turn to some other farm operation.

3. on-Demand Flow Method

- Water is released to a farmer at the request of the farmer.

- Most difficult to organize properly because if there is water scarcity or if the farmers at the top over utilizes the water, the farmers at the down slope will get very little or no water. There is also water scarcity problem with peak season flow requirement.

- This system is most appropriate to closed conduit pressure systems such as sprinkler irrigation or small projects (smaller than 50ha.), with adequate control of water source such as pump irrigation.

4. Reservoir (Storage Pond) Method

-Combines the operation of continuous or rotational flow method with on-demand method.

-Reservoirs are built along each distributor canal.

N.B the method chosen for the distribution of water may affect greatly the duty of water under the system for it may determine the crops to be grown and the areas to be devoted to each.

Self-Check – 2	Written test

Name…………………………………………… ID………………………… Date……

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

1. Define the following terms
a) Effective rainfall
b) Net irrigation water requirement
c) Gross irrigation water requirement
2. write the factors affecting effective rainfall
1. Irrigation Plan: Water Balance Sheet. Apply 25mm of water at 25 mm .deficit and fill in the blank under the column of accumulated deficient below in the table.

Date	Estimated ET (mm)	Rainfall (mm)	Accumulated Deficit (mm)	Irrigation(mm
5.1.13	4	-		
6.1.13	3	3		
7.1.13	3.8	-		
8.1.13	4.5	1.5		
9.1.13	5	-		
10.1.13	6	2.0		
11.1.13	3	-		
12.1.13	4	-		
13.1.13	5	-		

3. How much water must be added to a field of area 5ha to increase the volumetric water content of the top 50cm from 16% to 28%? Assume all water added to the field stays in the top 50cm.

4. Compute the depth and frequency of irrigation required for a certain crop with data given below.

Crop: wheat, Average daily CU: 1.5cm D rz: 1.40m, Application efficiency: 70%

FC: 17%, PWP: 5%, Bulk density: 1.72 gm/cm^3

5. Calculate irrigation interval (f) & Irrigation period (IP) under the following condition. CWR (ET_C) =12mm/day, root depth=1.5m, FC=24%, PWP=8%, Q_M =0.03m^3/s, A=1.5ha, GIWR = 70% and Depletion=50%

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

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

Operation Sheet 1-Implementing Irrigation schedule

PROCEDURE:

1. Wear safety cloths
2. Collect all tools, materials and equipment.
3. preparing to use a level the instrument
4. To fix the instrument on the tripod, release the clamp screw of the instrument
5. Hold the instrument in the right hand and fix it on the tripod by turning round only the lower part with the left hand.
6. Screw the instrument firmly.
7. Place the instrument in a desired position at a convenient height for sighting with the tripod legs spread well apart
8. Bring all the foot screws in the center of their run.

9. Fix any two legs firmly into the ground by pressing them with the hand
10. Move the third leg to the right, or left until main bubble is approximately in the center.
11. Place the telescope parallel to a pair of foot screws and bring the bubble to the center of its run by turning these screws equally
12. Turn the telescope through 90 degree so that it lies over the third foot screw, and center the bubble by turning this screw.
13. Again bring the bubble to the center of its run, and repeat these operations until the bubble remains in the center of its run in both positions, which are at right angles to each other.
14. If the instrument is in adjustment, the bubble will traverse (i.e. remain central) for all directions of the telescope.

LAP TEST	Performance Test

Name………………………………. ID……………………………..

Date…………………………………….

Time started: ________________________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within **3** hour. The project is expected from each student to do it.

Task-1 Collect and collect data from nearby irrigation of your college and conduct irrigation scheduling using different methods.

LG#103	LO-4 Monitor and evaluate irrigation system process

Instruction sheet

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

- Plant or crop environment is monitored according to enterprise policy and procedures.
- Frequency of irrigation is recorded.
- Water usage is measured and recorded and does not exceed water allocation for a given period.
- Differences between estimated water use and actual water used are calculated.
- Water quality is measured according to enterprise OHS policy and procedures.
- Plant or crop growth and water use efficiency is assessed.
- Soil chemical characteristics are measured and soil moisture is assessed.
- Labor performance is measured.
- Climate and weather conditions are recorded.

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Monitor Plant or crop environment, according to enterprise policy and procedures.
- Record Frequency of irrigation.
- Measure and record Water usage and control water not to exceed than the water allocation for a given period.
- Calculate the differences between the estimated water use and the actual water used.
- Measure Water quality, according to enterprise OHS policy and procedures.
- Assess Plant or crop growth and water use efficiency.
- Measure Soil chemical characteristics and assess soil moisture..

- Measure Labour performance.
- Record Climate and weather conditions.

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". Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them. 4. Accomplish the "Self-checks" which are placed following all information sheets. 5. Ask from your trainer the key to correction (key answers) or you can request your trainer 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 7.Perform "the Learning activity performance test" which is placed following "Operation sheets" , 8.If your performance is satisfactory proceed to the next learning guide, 9.If your performance is unsatisfactory, see your trainer for further instructions or go back to "Operation sheets".

Information sheet: 1- Monitoring plant or crop irrigation

1.1. Moisture deficit /stress

Crop stage is directly dependent on water balance in its body. Water deficit affects all physiological processes and reduces growth and development. It is not easy to know when and to what extent water deficit has developed in the plant. Some plants (maize, sun flower) show the symptoms of deficit quickly and easily where as others (cacti) do not, at the time crops exhibits stress symptoms, a lot of irreparable damage has already been done to it.

Measurement of plant water status provides fundamental approach for the problem but none of the techniques developed so far is full proof and applicable to field conditions directly. The techniques used to know as the plant is under **moisture deficit /stress i**s;

- **Visual indications**:-color, drooping of leaves, wilting sing.
- **Movement**:-leaf angle, Dendron meter reading for shrinkage of girth.
- **Growth indices**:-size of leaf, fruit shedding.
- **Plant water content**: - relative turgidity, relative moisture deficit etc.

And there are some sophisticated methods like reflectance (infrared photograph) such methods are generally limited to measurement of individual plant parts such as leaves and petioles.

Critical growth stage concept is found to be more practical than other methods. In crop life, certain stage/s is / are more important than other with respect to susceptibility to moisture stress affecting growth and development. The crop is to be irrigation at such critical stage (s) to guard against reduction in yield. Critical stages of growth of deferent crops have been given elsewhere in irrigation and agronomy books (example irrigation and drainage by D.LENKA 3rd edition page 103)

Self-Check – 1	Written test

Name…………………………………………… ID……………………….. Date…….

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

1.Discuss briefly the methods of monitoring plant or crop irrigation. (6 points)

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

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

Information sheet: 2- Recording irrigation frequency

2.1. Irrigation frequency

Irrigation interval or frequency of irrigation is the number of days between irrigation during periods without rain fall.

It depends on the consumptive use rate of a crop and on the amount of available moisture in the crop root zone.

$$\text{Irrigation frequency} = \frac{\text{available water to be used by the crop}}{\text{Crop water requirement}}$$

$$\text{II} = \frac{(\text{Fc} - \text{pwp})\text{x Rz x D}}{CWR}$$

Where II=Irrigation interval

Z=depth of root zone (mm)

D=depletion factor /depletion of moisture (%)

Fe=volumetric field capacity

Pwp= volumetric permanent wilting point

CwR= crop water requirement (mm/day)

Irrigation period /time of application

Irrigation period is the time that can be allowed for applying one irrigation to a given design area

$$\text{Ip} = \frac{\text{IIxIqxA}}{0.36*Qm}$$

Where, Ip=irrigation period in hour

II=irrigation interval in day

Ig=cross irrigation requirement of plant in mm/day

A=Area of irrigated farm in hectare

Qm=manageable discharge in liter /see

After we have calculated this irrigation frequency, we must follow the schedule and record irrigation frequency, but irrigation frequency should not be greater than irrigation period.

- ***N.B*** when we record irrigation frequency, we have to look for crop environment and the resulting change as irrigation frequency changed in some moments.

Self-Check – 2	**Written test**

Name…………………………………………… ID……………………….. Date……

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers (2 point each)

.

1. How do you determine frequency of irrigation

2. What parameters are recorded in frequency of irrigation

3. How do you calculate irrigation period

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

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

3.1. Measuring water usage

Water is the most valuable asset of irrigated agriculture. Accurate measurement of irrigation water permits more intelligent use of this valuable natural resource. Such measurement reduces excessive waste and allows the water to be distributed among users according to their need and right. In every irrigation project water is supplied from the reservoir to the field through a well-planned network of main canals, distributaries, branch canals, sub canals and water courses. Water supply needs to be qualified at each point of supply for its efficient use.

Irrigation water is measured at various points at the source, in the conveyance channels and at the field intakes.

At the source: - water is measured at this point in order to know the water supply or water availability from the source. This is important to decide direct withdrawal if supply is greater than demand or construction of water reservoirs and dams if the supply is less than the demand.

In the conveyance channels: - water is measured at this point for proper distribution of the required amount of water.

Methods used to measure water can be grouped in to;

1. Direct method /volume method
2. Velocity area method
3. Use of weirs and orifices

1. Direct method, in this method the flower is collected in a container of known volume for a definite period of time. Only a bucket of known volume and a stop watch are required.

$$\text{Discharge} = \frac{\text{volume of bucket (liters}}{\textit{time required to fill up the bucket}(\text{sec}\quad)}$$

2. **Velocity area method**: - the rate of flow passing a point in a pipe, ad itch or channel can be determined by multiplying the cross sectional area of water flow section at right angle to the direction of flow by the average velocity of water.

Q= A.V

When Q= discharge (M3 /sec)

A= cross sectional area (m3)

V=velocity

Area determination

- ❖ In a wide and irregular channel section, the area is determined by first dividing the cross-section in to segments of equal distance apart. Then

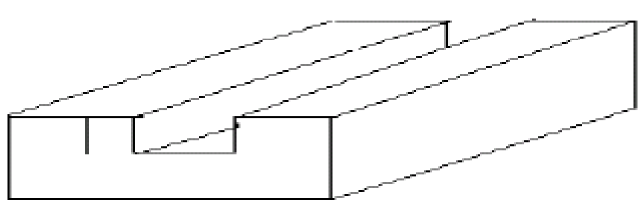
$$A= \frac{x1(Yo+Y1) + x2(Y1+Y2) + \cdots .. xn\ (yn-1+yn)}{2}$$

But yo = yn = o, if x1 = x2=….xn = x

A = x (y1+y2+y3+…yn−12)

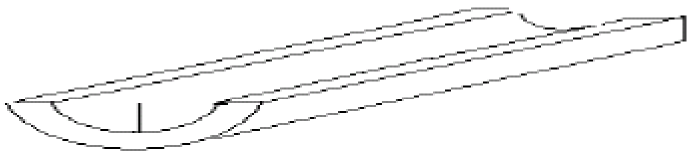
in a rectangular channel section, the area is determined as follows

Area = bed widths x depth of the channel. I.e. A = w * D



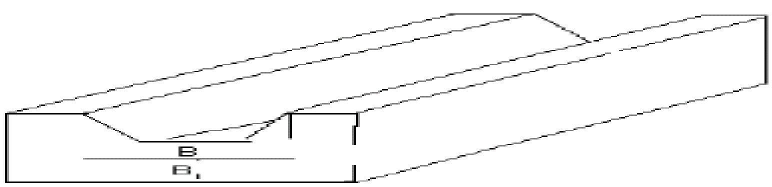
- In semi-circular channel section

$Area = \pi r2/2$



- In trapezoidal cross sectional channel

Area =1/2 h (A+B)



II. Velocity determination

Velocity can be measured by float, current meter or tracer method.

Float method: - this method gives an approximate flow rate. When water is flowing in a uniform sized channel the cross sectional area is determined at different points of the channel. The channel should be fairly long (25-30m long, 0.5-0.7 wide). Small float (a wooden piece, heavy cork with a nail at center e.t.c. that will float partially and move uniformly in the direction of flow) is placed a few meters up stream and the time that a float takes to reach a certain distance is recorded. Several observations should be taken to reach at a good average velocity.

Then, discharge is calculated as Q=o.85 A.V

Where, Q = discharge in L/sec or m3/sec

A = cross sectional area of the channel in m2

V = Flow velocity in m/sec

III. Current meter method

- **Current meter** is small instrument containing a revolving wheel or vane that turns by the movement of water/ flowing water
- It is used for accurate determination of velocity
- In deep streams it is suspended by a cable and in shallow streams it is attached to a rod.
- Before using current meter it is necessary to calibrate it with respect to rotation of the vane and velocity of water.
- The number of revolution is recorded repeatedly and we have to take the average of observation.

$$Vav= \frac{v0.2+v0.8}{2} \quad \text{if depth} \geq 3\text{m or}$$

Vav= V0.6 if depth is<3m, 0.2, 0.6, 0.8 depth in m.

- It may be of two types

A. Cup type: - it can measure flow velocity of 300-450cm/sec

-It has larger size -Used in experimental fields

B. Properly type:-it can measure flow velocity of 600-700cm/sec

- Smaller size - Used in pipes and laboratories

Tracer method:-this method consists of injecting certain dyes in to a stream at a given point and detecting it down stream. The velocity is calculated from the time the tracer travels a known distance. To get a good average of velocity the time that the first and last portions of tracer dye arrive at the fixed point should be determined. Fluorescein and potassium permanganate are suitable dyes for such studies. Since tracer is a liquid it gets diluted and its time to reach cannot be judged correctly. i.e. Calculation of velocity gets vitiated.

1. **Use of weirs and orifices**

Weirs: - are sharp crested over flow structures that are installed or built across open canals. It consists of a balk head of timber, concrete or metal across the channel, having in its top edge an opening through which the stream flows this opening is called the weir notch, its bottom edge is the crest and the depth of water passing over the crest as measured at a definite point upstream from the balk head is the head, H

The three well known types of weirs are;

A. rectangular weir: - it has rectangular opening or notch i.e. it has horizontal crest and vertical sides and commonly used to measure large discharge.

- It may be contracted or suppressed type

I. Contracted type: - when the crest length is or width of the notch is less than the channel width.

The discharge Q.is given by Q=0.0184 (L1-0.1H) H3/2 if one end contracted.

Q= 0.0184(L1-0.2H) H3/2 if both ends are contracted.

II. Suppressed type: - when a crest extending across the full width of the channel and no contractions are produced.

Q=0.0184LH3/2

Where, Q= discharge in L/sec,

H=height above the crest (cm)

L=effective length of weir

L1 = weir crest length (cm)

B. Trapezoidal weir:-it is an improved form of rectangular weir, with a slightly higher capacity for the same crest length. Here the notch is trapezoidal in shape with the sides' inclined at a slope of 1:4; i.e. Horizontal to vertical.

Q= 0186LH3/2, L/sec

C. 900 v-notch weir:-it has triangular opening, and is well suited for measuring small flows with high accuracy. The crest of the weir is consists a V-notch, each side being inclined at 450 from the vertical.

Q can be computed as Q=0.138H5/2

N.B after we compute discharge we have to check it, if it is greater than or less than the water allocated for a given period.

3.2. Recording water usage

On whatever method we use in measuring water it should be recorded on the recording format of the supply side of water for irrigation

Self-Check – 3	Written test

Name………………………………………… ID……………………… Date…….

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers. (3 point each)

1. Discuss briefly about how Irrigation water is measured at various points at the source, in the conveyance channels and at the field intakes.
2. Elaborate the following Methods which are used to measure water :

a) Direct method /volume method

b) b) Velocity area method

c) c) Use of weirs and orifices

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

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

Information sheet: 4- Estimating water usage

4.1.Methods of estimation of water usage

A certain crop grown in a sunny and hot climate needs per day more water than same crop grown in a cloudy and cooler climate. There are, however- apart from sunshine and temperature- other climatic factors which influence the vapor water need. These factors are the humidity and the wind speed (when it is dry, the crop water needs are higher than when it is humid. In windy climates the crops will more water than in calm climates.

The effect of these four climatic factors on the water need of the crop is show in table 1.

Table 1. Effect of major climatic factors on crop water needs.

Climate factor	Crop water need	
	High	Low
Sunshine	Sunny (no clouds)	Cloudy n (no sun)
Temperature	Hot	Cool
Humidity	Low (dry)	High (humid)
Wind speed	Windy	Little wind

The highest crop water needs are thus found in areas which are hot, dry, windy and sunny. The lowest values are found when it is all cool, humid and cloud with little or no wind. From the above it is clear that one crop grown in different climatic Zones will have different water needs. For example, a certain maize variety grown in a cool climate will need less water per day than the same maize variety grown in a hotter climate. It is therefore useful to take a certain standard crop or reference crop and determine how much water this crop needs per day in the various climatic regions. As a standard crop or reference crop grass has been chosen.

Table -2 indicates the average daily water needs of this reference grass crop. The daily water needs of the grass depend on the climatic Zone (rainfall regime) and daily temperatures

Table 2. Average daily water need (mm/day) of standard grass during irrigation season.

Climatic Zone	Mean daily temperature		
	Low (less than 15^0c)	Medium (15-25^0C)	high (more than 25^0C)
Desert / arid	4 - 6	7- 8	9- 10
Semi arid	4 - 5	6 - 7	8 - 9
Sub- humid	3- 4	5 - 6	7 - 8
Humid	1 – 2	3 - 4	5- 6

For example the standard grass crop grown in a semi- arid climate with a mean temperature of 20^0C needs approximately 6.5 mm of water per day. The same grass crop grown in a sub- humid climate with a mean temperature of 30^0c needs some 7.5 mm of water per day. This daily water need of the standard grass crop is also called “reference crop evapotranspiration e crop water requirement is also termed as consumptive use of the crop.

Self-Check – 4	Written test

Name………………………………………… ID……………………… Date…….

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

1. Based Up on the above Estimate the water needs of the following

a. Potatoes

b. Sorghum

c. Soybeans

d. Sugar beet

e. Sunflower

f. Wheat

For an area where the water need of standard grass is 6mm/ day.

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

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

Information sheet: 5-Measuring water quality

5.1. Water quality

A major concern with water used for irrigation is decreased crop yields and land degradation as a result of excess salts being present in water and in soils. Salinity means the presence of soluble salts in or on soils, or in water.

5.2. Assessing irrigation salinity

For salinity management purposes, to assess the suitability of water and soil for irrigation, the following must be considered:

- Quality of the irrigation water
- Characteristics of the soil to be irrigated
- Salt tolerance of the crop to be grown.

Climate, soil management and water management practices can also impact on salinity.

5.3. Measuring water quality

.

Irrigation water must be analyzed for:

- Electrical conductivity (ECi), which is a measure of the total soluble salts in the water. ECi may be measured and reported in deciSiemens per metre (dS/m) or micro Siemens per centimeter (µS/cm). A value in µS/cm can be converted to dS/m by dividing by 1000
- The level of sodium (Na^+), calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions present.

General salinity ratings for water are shown in Table 1.

These ECi values can then be used to determine the suitability of water and soil for a particular irrigation situation as outlined below.

Table 9—Salinity ratings for water

EC_i dS/m	**Water salinity rating** (levels of soluble salts)
< 0.65	low
0.65–1.3	moderate
1.3–2.9	high
2.9–5.2	very high
> 5.2	extremely high

5.4. Soil structure stability

The ECi value can be used to predict soil structure stability in relation to irrigation water quality and the sodium adsorption ratio (SAR). The SAR value is a measure of the relative concentration of sodium to calcium and magnesium. SAR can be calculated from the following equation:

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$

Where Na, Ca and Mg are expressed in milliequivalents per litre (meq/L). A SAR value is provided in the water analysis report provided by the laboratory analyzing the water sample.

High concentrations of sodium in irrigation water can result in the degradation of soil structure. This will reduce water infiltration into the soil surface and down the profile, and limit aeration, leading to reduced crop growth.

The potential impact of irrigation water quality on soil structure can be evaluated using ECi and SAR values, as shown in Figure 1.

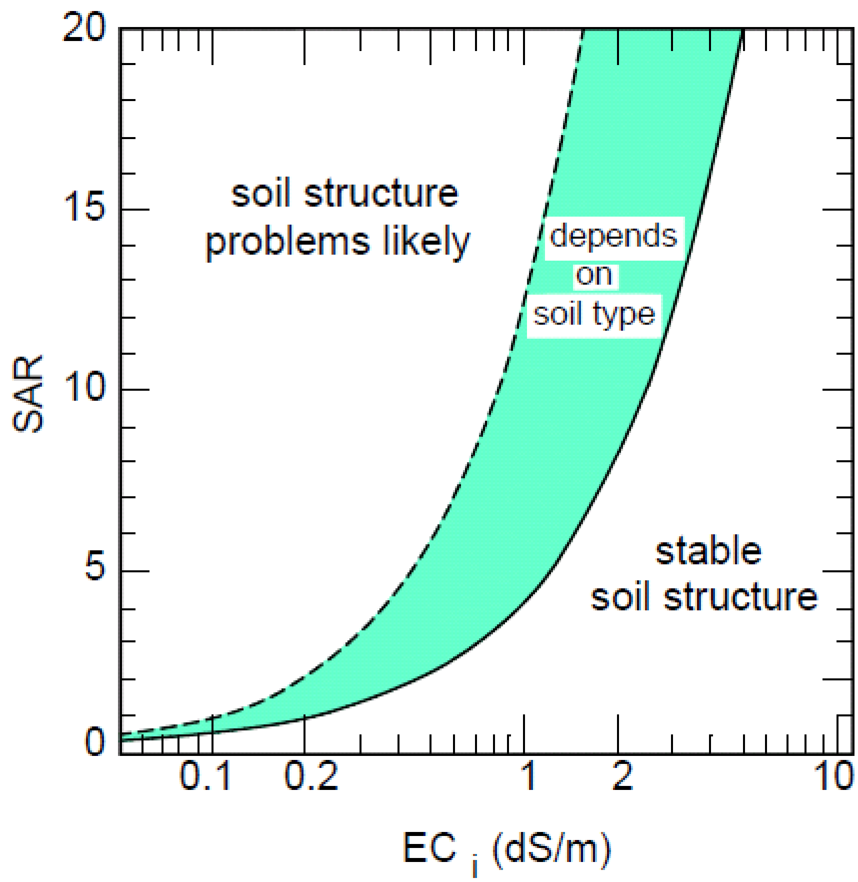


Figure 1—Relationship between SAR and ECi of irrigation water for prediction of soil structure stability

5.5. Crop salt tolerance

Crop salt tolerance also needs to be taken into account when assessing the suitability of water and soil for irrigation.

The salt content of the soil water in the crop's root zone—referred to as the average root zone salinity (ECse)—is important in assessing which crops are
suitable for growing in particular soils. The average ECse can be calculated using the measured ECi of the irrigation water. This requires estimation of the average root zone leaching fraction (LF) of the soil under irrigation, i.e. the proportion of applied water moving below the root zone. This is shown in Figure 2.

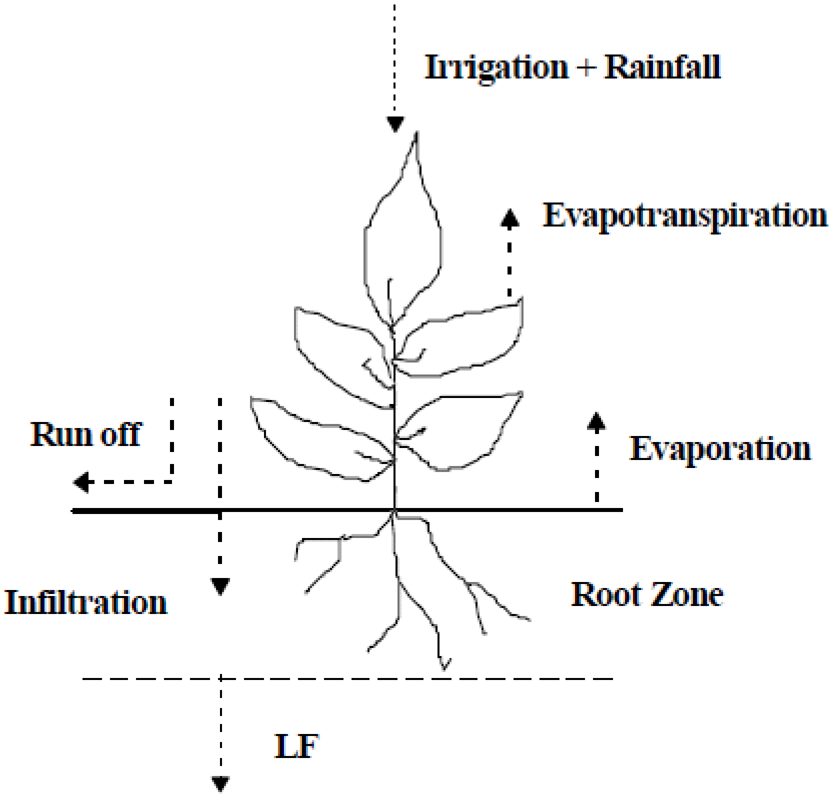


Figure 2—Diagram of the leaching fraction (LF) concept

Average root zone leaching fractions for four soil types are listed in Table 2.

Table 2—Soil type and average root zone leaching fraction

Soil type	Average root zone LF
Sand	0.6
Loam	0.33
Light clay	0.33
Heavy clay	0.2

Average root zone salinity (ECse) can then be calculated using the following equation:

$$EC_{se} = \frac{EC_i}{2.2 \times LF}$$

where:

ECse = average root zone salinity in dS/m

ECi = electrical conductivity of irrigation water in dS/m

LF = average leaching fraction.

The calculated ECse can then be compared against the ECse values in Table 3 to assess the general level of salinity tolerance required of the preferred crop in the particular irrigation situation.

Table 3—Soil and water salinity criteria based on plant salt tolerance groupings

Plant salt tolerance grouping	**Water or soil salinity rating**	**Average root zone salinity** EC_{se} (dS/m)
sensitive crops	very low	< 0.95
moderately sensitive crops	low	0.95–1.9
moderately tolerant crops	medium	1.9–4.5
tolerant crops	high	4.5–7.7
very tolerant crops	very high	7.7–12.2
generally too saline	extreme	> 12.2

Self-Check – 5	Written test

Name…………………………………………… ID………………………… Date…….

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers. (2 Points each)

1. What are the factors that should be considered to Assesse irrigation salinity?
2. Discuss briefly the relationship between SAR and ECi of irrigation water for prediction of soil structure stability
3. How do calculate EC, SAR and EC_{se}

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

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

Information sheet: 6- Assessing crop growth and water use efficiency

6.1. Assessing crop growth

Crop stage is directly dependent on water balance in its body. Water deficit affects all physiological processes and reduces growth and development. It is not easy to know when and to what extent water deficit has developed in the plant. Some plants (maize, sun flower) show the symptoms of deficit quickly and easily where as others (cacti) do not, at the time crops exhibits stress symptoms, a lot of irreparable damage has already been done to it.

Measurement of plant water status provides fundamental approach for the problem but none of the techniques developed so far is full proof and applicable to field conditions directly. The techniques used to know as the plant is under moisture deficit /stress is;

- **Visual indications**:-color, drooping of leaves, wilting sing.
- **Movement**:-leaf angle, dendrometer reading for shrinkage of girth.
- **Growth indices**:-size of leaf, fruit shedding.
- **Plant water content**:- relative turgidity, relative moisture deficit etc.

And there are some sophisticated methods like reflectance (infrared photograph) such methods are generally limited to measurement of individual plant parts such as leaves and petioles.

Critical growth stage concept is found to be more practical than other methods. In crop life, certain stage/s is / are more important than other with respect to susceptibility to moisture stress affecting growth and development. The crop is to be irrigation at such critical stage (s) to guard against reduction in yield. Critical stages of growth of deferent crops have been given elsewhere in irrigation and agronomy books (example irrigation and drainage by D.LENKA 3rd edition page 103)

6.2. Water use efficiency of crops.

Self-Check – 6	**Written test**

Name…………………………………………… ID……………………….. Date…….

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers. (3 points each)

1. How do you assesse crop growth and water use efficiency?
2. Elaborate the techniques used to know as the plant is under moisture deficit /stress .

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

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

Information sheet: 7- Measuring soil characteristics and assessing soil moisture

7.1. Environmental Impact of irrigation

Basically the potential environmental impacts of the proposed projects were assessed and analyzed against the background of the present situation. The predicted beneficial and adverse effects of the proposed irrigation development are described below based on data obtained from local offices, consultation with local people, and field investigation in the project area.

1. **Potential positive impacts**

Implementation of the proposed irrigation project is expected to bring several economic and social benefits particularly to the local population. These positive impacts will include:

- It will enable the beneficiary farmers to produce a larger quantity and/or more valuable crops, i.e. to increase production and diversify the cropping pattern and crop varieties or shifting to more valuable crops.
- It will give the opportunity to increase yields per unit area of land.
- It will help the local farmers to be self sufficient in food
- It will reduce the risk of crop failure due to shortage of rainfall or its erratic nature
- It will help to improve the living standard of the local population including health standards due to increased production and improved incomes
- It will supplement the government objectives to alleviate food shortage and food insecurity
- The implementation of the project substantially changes to mode of life of the society as the user receives more income from intensified crop production
- The generation of more revenues enables the beneficiaries to adopt new technology on area of energy consumption such as replacing the existing energy source to use of biogas plants for their home consumption
- In short, the project will increase balance diet (health condition of the society), job opportunity especially for women and youngsters and animal feeds of the beneficiaries.

2. **Potential negative impacts**

Construction and operation of the irrigation scheme may also bring some adverse environmental and socio economic impacts. The main potential adverse impacts of the proposed project are mentioned in the following sections.

a. Impacts related to project location

The important impacts likely to due to the location of the project will include loss of farm land, changes of downstream hydrology and impediment to movement of people animals due to construction of the main canals, runoff intercepting drains, and headwork and farm roads. However, the effects due to land loss a lining land structures are expected to be minor compared to the benefit to be gained from the project. In addition, the adverse effect will be reduced by implementing some mitigation measure such as provision of crossing structure to allow easy movement of the local people and their animal

b. Impacts related to soil erosion

Construction of the scheme involves earth work activities that will remove the vegetation cover and expose the soil to erosion. The main activities that will disturb the top soil and subsoil and expose it to soil erosion will be construction of the main canals, runoff intercepting drains, headwork and farm roads, as well as quarrying to obtain construction materials. Run off from unprotected or exposed area will cause soil erosion, which ultimately will result in increased sediment loading of the river, the canals and drains.

c. Loss of vegetation and wildlife habitats

Construction of the main canals, runoff intercepting drains, headwork and farm roads will bring significant change to the vegetation (large trees and shrubs) and wildlife habitat.

d. Impact and endangered species

None of the plant and animals species identified from the project area is considered as threatened species. The presence of any particularly rare or endangered species in impact zone is not certain but it is most unlikely. Loss will most likely be of numbers in individual species, not in species themselves. Thus the loss is probably not one of biodiversity.

e. Health risks

At those localities stagnant ponds can be formed due to the construction of the main canals, runoff intercepting drains, and headwork and farm roads. These ponds can become suitable breeding site for disease, vectors particularly for malaria mosquitoes resulting in increased incident of the disease.

7.2.Measuring soil characteristics

Soil moisture is always being subjected to pressure gradients and vapor pressure differences that cause water to move. Thus it cannot be constant at any pressure. But for particularly significance agriculture, same soil moisture constants are used. These are;

- Saturation capacity
- Moisture equivalent
- Available water
- Field capacity
- Permanent writing point

Saturation capacity: - when all the pores in the soil are filled with water. The tension of water at this Level is almost zero and it is equal to free water surface.

Field capacity:-soil moisture content after draining excess water and it is relatively stable. -the soil moisture tension at field capacity varies from soil to soil, but ranges from 1/10 to 1/3 atmospheres.

Moisture equivalent: the amount of water retained by a sample of initially saturated soil material after being subjected to a center fugal force of 1000times that of gravity for a definite period of time, usually hour in hour.

Permanent wilting percentage /pwp: - soil moisture content at which plant cannot longer obtain

Enough moisture to meet transpiration requirement, and remain wilted unless water is added to the soil. The moisture tension here ranges from 7 to 32 atmospheres.

Available water: - soil moisture between Fc and pwp. It is moisture available for plant use. In general, fine texture soil has a wide range of water b/n Fc and pwp than course textured soil.

Kinds of soil water

a. **Hygroscopic water**: - is water held tightly to the surface of soil particles by adsorption forces.

b. **Capillary water**: - is water held by forces of surface tension and continuous films around soil particles and in the capillary spaces.

c. **Gravitational water**: - is water that moves freely in response to gravity and drains out of the soil.

N.B from the above three water forms, only capillary water is available to the plants.

Measurement of soil moisture

Soil moisture Measurements are important in the suitable scheduling of irrigation and estimating the amount of water to be applied in each irrigation and to estimate evapotranspiration. There are also many experimental situations where careful measurement and control of soil moisture is necessary if the results of investigation on soil –plant-water relationships are to be interpreted properly.

The principal methods of expressing soil moisture are:-

I. By the amount of water in a given amount of soil and,

II. The stress or tension under which the water held by the soil

7.3.Methods of measuring soil moisture.

1. **Feel and touch:** - this is by far the easiest method. Assessment by feel is good for experienced people who have sort of calibrated their hands.

Table. Guide lines for evaluating soil moisture by feel and touch

% depiction	Loam sandy to fine sandy	Fine sandy loam to silt loam	Silt loam to clay loam
At Fc	No free water on ball but wet out line on hand	Same	same
0-25	Make ball but breaks easily and doesn't feel stick	Makes tight ball, ribbons easily, slightly sticky and slick	Easily ribbons, slick feeling
25-50	Balls with pressure but easily breaks	Pliable under pressure or slick, ribbons and feels damp	Pliable ball, ribbons easily , slightly slick
50-70	Will not ball, feels dry	Balls under pressure but Is powdery and easily breaks	Slightly balls, still pliable
70-100	Dry loose, flows through fingers	Powdery dry	Hard backed cracked crust

2. Gravimetric method

- Known volume of soil samples are taken from the field, weighed, and then dried in an oven for 24 hours at an average temperature of 1050 c
- After dried, the samples will be taken out from the oven and weighed again. The d/ce in weight before and after drying is the amount of moisture present in the soil.

- The amount of moisture that is held by a certain mass or volume of soil can be expressed as *weight percent or volume percent*. Soil moisture on weight basis is based on the dry weight of sample.

Soil moisture content percent by weight :

$$\text{SM (\%)} = \frac{(\text{weight of moisture sample} - \text{weight of oven dry sample}) \times 100}{\text{Weight of oven dry sample}}$$

N.B expression of soil moisture content as % age of dry weight may not indicate the amount of water, available to plant, unless the soil moisture characteristics carve or the Fc and pwp are known but it is useful to convert moisture content per units of weight into moisture content per units of volume.

Moisture content (% by volume) = moisture content (% by weight) x balk density.

Balk density is the ratio of the mass of dried particle to total volume of soil (including particles and pores)

Gravimetric method is an accurate method but time consuming and the method is not practical for form use, as the oven cannot orderly be owned by farmers. But it is a standard against w/c other methods of moisture determination are compared.

1. Neutron probe

- It is indirect way of determining soil moisture content.
- It uses radioactive sources like beryllium and the sure emits fast neurons, some of which are slowed down when they collide with water molecules (hydrogen molecule)
- A cloud of slow neutrons (thermal neutrons) build up near the probe and are registered by the rate mater or rate scalar w/c measures the number of slowed down neutrons and it is necessary to have a graph of standardized calibrated curve of counts vs. moisture content of soil and used for wide range of soil moisture content but not suitable for small samples.
- It is dangerous since it is radioactive and must be used with care.

2. Tensiometer:

- It provides a direct measurement of the tenancy with w/c water is held by soils and used to estimate the soil moisture content.
- It consists of porous ceramic cup filled with water which is buried in soil at any desired depth and connected to a water filled tube to a manometer or vacuum gauge which measure the tension, the reading is then taken and correlated to moisture content using a calibration carve.

7.2. Assessing soil chemical characteristics

Salt affected soil and their management

Salt affected soil is the soil which shows the electrical conductivity of the saturation soil extract (ECe) greater than 4 dS/m at 25OC; with exchangeable sodium percentage(ESP) less than 15 and PH of saturated less than 8.5.

The causes of salinity:

- Use of saline irrigation water

- Deposition of salts on soil surface from high water table.
- Seepage from the canals
- Arid climate
- Poor drainage

Soil can be classified as saline, sodic and saline-sodic based on;

- Electrical Conductivity of soil extract (ECe)
- Sodium Absorption Ratio (SAR)
- Exchangeable Sodium Perce age (ESP)
- Hydrogène ion concentration (PH)

a. Saline soils

The distinguished (well-known) characteristic of saline soil is that they contain sufficient neutral soluble salts which harmfully affect the growth of most crops.

Saline soils usually are described by the following properties

ECe>4dS/m

ESP<15

PH <8.5

Sodic Soils

Where the concentration of sodium salts is high relative to other types of salt, a sodic soil may develop.

Properties of sodic soils

ECe<4 dS /m

ESP>15

PH>8.5

SAR>13

c. Saline -sodic soils

These soils have intermediate characteristics between saline & sodic soils.

EC > 4 ds/m

ESP > 15

PH < 8.5

SAR< 13

Self-Check – 7	**Written test**

7.4.Reclamation Measures

The processes and practices involved in bringing saline and alkaline soil in to productive condition are known as reclamation measures.

Reclamation measure can be done on temporary or permanent basis.

Reclamation on temporary basis

- Removing the salt crust from the surface of the soil
- Plowing salt- surface crust deep into the soil
- Neutralizing the effects of certain salts by adding other salts

Reclamation on permanent basis

- Lowering of water table (if high), (growing alfalfa, eucalyptus, rice etc)
- Improving infiltration rate of the soil (plowing in depth, addition of organic fertilizer, etc) Leaching salt from saline soils and providing adequate sub surface drainage

Texture and Organic Matter

The relative amounts of sand, silt, and clay are estimated by the feel of the soil in a moist condition. The soils are then classified into three categories: C (coarse textures of sand, loamy sand and sandy loam), M (medium textures of loam and silt loam), and F (fine textures of clay loam, silt clay loam, silt clay and clay.

Organic matter is determined by ashing a 5 gram scoop of the soil sample at 360oC for 2 hours in a muffle furnace. The loss by weight of the sample during this ignition is calculated as the organic matter. Results are reported as per-cent organic matter by weight in the soil.

Name…………………………………………… ID………………………… Date…….

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

1. Discuss the positive and the negative impact of irrigation.
2. _____________is an indication of alkalinity or sodicity of a soil.
3. _____________is the process of salt development in the soil
4. What are generally accepted criterions for judging the quality of water?
5. What is the most common cause of toxicity problem?
6. What are the methods used to measure water usage?
7. Which soil components are responsible for chemical properties of soil?

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

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

Information sheet 8:-Measuring labor performance

8.1. Measuring labor performance

The power produced by human beings, manual power, continues to be the main source of farm power in most developing countries.

Where this is so, it is commonly referred to as hoe farming. A human can develop 80W power but this, of course, varies with environmental conditions and the type of food intake. Therefore, human labour is characterized by limited power output compensated by versatility (variety of skills), quickness and judgment.

Men can serve as a source of power and and/or as a control device but the extent to which they may be used as one and/or the other depends on the degree the type of irrigation

However, human power is generally a source of supplementary power, in conjunction with other power sources.

Animals such as horse, mule, ox, water buffalo, and even camel are still the principal sources of power in Africa, in certain Latin America, European and Asiatic countries.

There are a number of reasons for this; such as

- Size of farms,
- Topography,
- Kinds of crops grown,
- Lack of suitable fuel at a reasonable cost,
- High initial cost of mechanical equipment, and
- Plentiful supply of low cost labour.

Animals generally have a capacity to be over loaded for short periods of time and they provide good traction (grip) even in difficult conditions.

Animals can also pull loads that are many times heavier than those that they can carry.

A donkey can pull about 80% of its weight for a short period and about 10-15% of its weight for sustained periods.

An ox can provide a pull of about 15% of its weight.

The output power available from animals depends up on;

1. The food intake,
2. The breed of animals,

3. The training given,
4. The load used for hitching

The use of mechanical devices to do farm work has allowed farms to multiply their effort many folds.

Wind power, solar power, waterpower, electric power and engine power are all included under mechanical power.

In general

Labor performance = The percentage of ratio of input to output of work done.

Self-Check – 8	Written test

Name…………………………………………… ID………………………… Date…….

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

1. Compare and contrast labor performance of human being,animals and mechanical energy in irrigation work.
2. How do you measure labor performance

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

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

Information sheet:9- Recording climate and weather condition

9.1. Recording climate and weather condition

Every information relevant to irrigation should be recorded. These can be; crop environment data, water orders and usage, irrigation shifts and system process data like, irrigation interval, irrigation frequency and so on.

Water supply – irrigation:

Detail the actual water usage (ML) and associated type and area (ha) of crops irrigated per irrigator/month. Record all water taken against each irrigator' irrigation right (a spread sheet and graph may assist in showing this).

Record total water allocation against actual delivery, link to restriction % (a graph may assist in showing this).

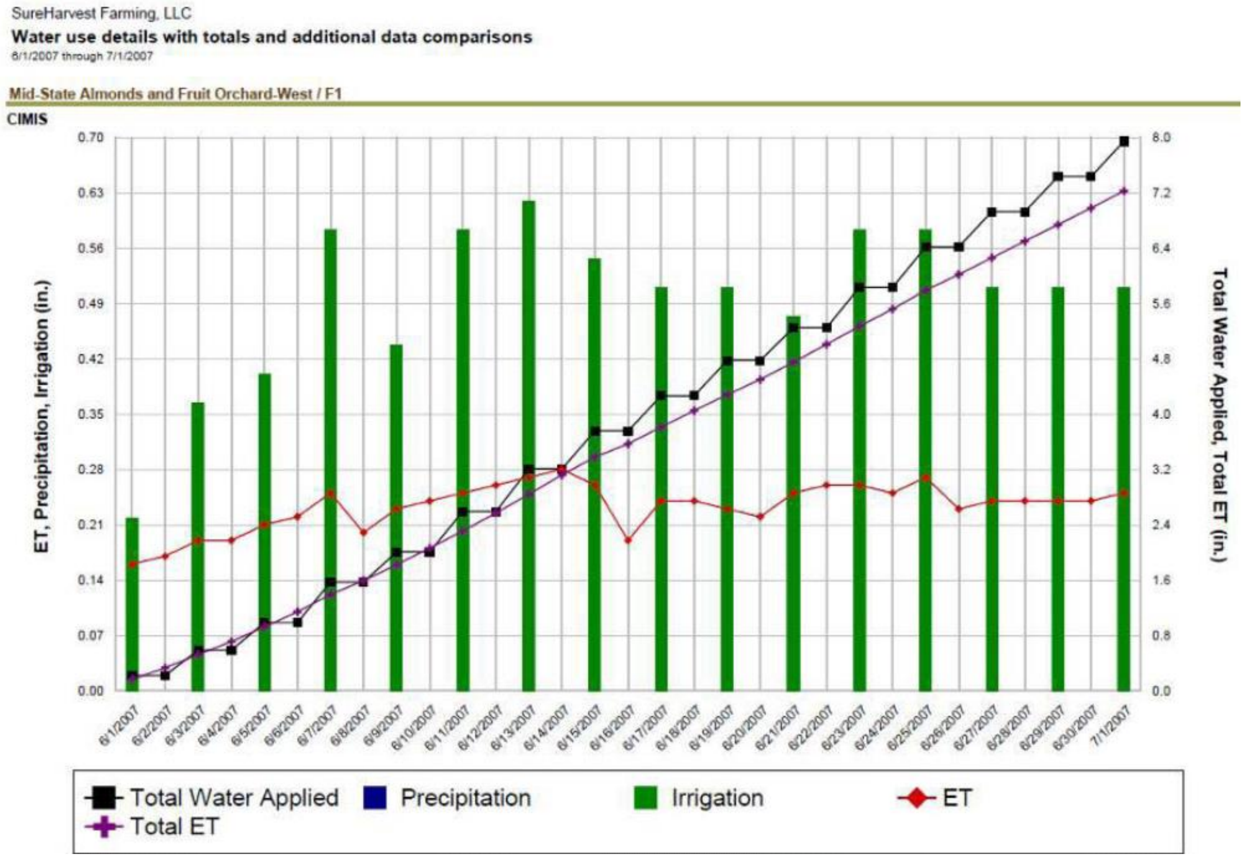
Show how total water taken for irrigation purposes was consistent with the allocations on the water entity and water license.

Environmental Conditions

Measurement of meteorological variables is necessary to understand weather conditions in the field. Daily records of maximum, minimum and mean temperature (air and soil), total precipitation, mean wind speed, potential evapotranspiration, relative humidity and sunshine intensity should be recorded. When irrigation is used to supplement rainfall, timing and amounts of irrigation water should also be reported. Historical climatologically data should be obtained to help evaluate site data with respect to long-term regional variation, and the source and location of the historical data should be specified. Historical climatic information should include monthly average rainfall, average monthly minimum and maximum temperatures, and the dates and the number of days in the average annual frost-free period.

Soil conditions. These can be soil moisture, aeration characteristics, and soil temperature and so on.

All the above data can be presented by; text, graph, table and computer programs See the following examples.



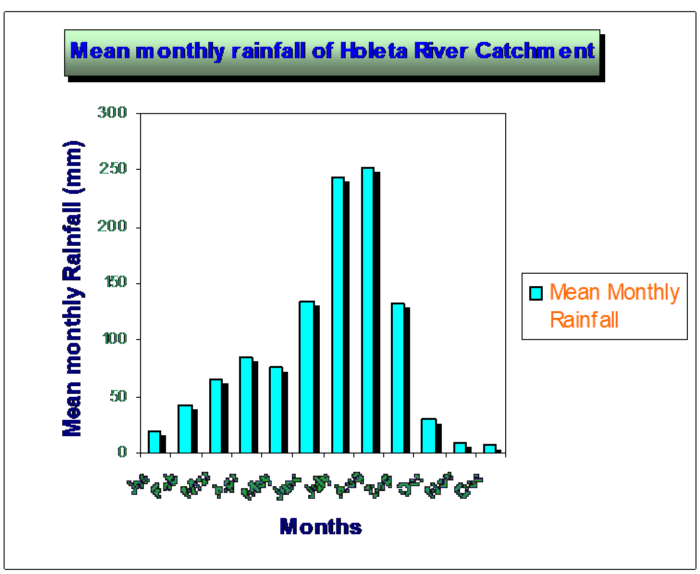


Figure 9.1 Rainfall Pattern of Holeta area.

Element: monthly total Rainfall in mm
Coordinate: Long. 38º30', Lat. 09º05'
Station:Holeta
Elevation: 2000m.a.s.l.

Climatological Data

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Aver.
1962	X	X	X	0	70.9	84.6	152.1	107.6	184.3	29.9	45.8	31.7	
1963	45.2	67	86	181.9	121.3	248.4	280.2	187	93.4	0	9.2	67	115.6
1964	0	7	37.9	69.1	75.9	280.8	373.8	329.4	263.7	49.3	0	28.6	126.3
1965	31.1	7.3	64.1	49.9	63.4	160.9	271.9	396.4	190.4	8.3	22.9	0	105.6
1966	7.7	65.5	97.8	155.3	2.5	65.7	295	387	491	78.9	26.8	0	139.4
1967	0	29	497.4	716.1	1196.9	1023.5	1333.1	1401.5	1195	381	13	0	648.9
1968	362	780.5	432.7	256.5	9.8	400.2	152.5	661.5	300.9	6.5	2.5	0	280.5
1969	44.4	435.7	64.7	42.4	68.5	84.1	204	285.9	139.2	0	14.9	0	115.3
1970	34.2	69.3	30.7	41.7	7.7	139.6	83.6	255.5	392	64.4	0	13.1	94.3
1971	30.2	0	155.2	160	215.6	335.5	415.2	628.7	314	29.2	12.1	0	191.3
1972	43.3	190.2	126.9	334.7	110.9	222	520.6	529.8	256	0	44.3	55.4	202.8
1973	15.3	0	2.1	82.6	160.1	297.5	522.1	536.1	335.9	60.3	0	12	168.7
1974	0	24.2	137.2	68.7	131.3	111	248.8	151.2	156.6	4.3	0	0	86.1
1975	0	5.2	20.2	79.4	68.4	124.2	271.9	270.8	216.5	13.9	0	0	89.2
1976	5.9	9.8	58.3	67.4	63	118	236.1	346.3	97.9	5.3	14.4	1.0	85.3
1977	185.9	45	28.2	41.9	80.1	444.6	778.7	821	247.5	25.2	154.5	15.3	239.0
1978	0	44.5	204.1	60.9	62.5	206.9	304.1	562.6	217.1	53.2	0	0	143.0
1979	46.6	78.7	56.5	93.6	61.5	110.4	224.8	264.5	145.4	13.2	0	14.5	92.5
1980	30.3	33.1	70.3	69.7	95.2	148.4	229.4	329.9	169.0	45	0	0	101.7
1981	34.3	64.5	111.3	107.7	122	145.8	449.5	663.5	572	14.4	0	7.5	191.0
1982	61.7	61.9	124.3	83.4	192.2	173.4	341.2	256.8	167.6	53.1	51.5	39.8	133.9
1983	19.9	49.9	120.4	126.6	219.1	87.5	241.2	284.1	101.9	23.8	3.9	22.7	108.4
1984	0	0	41.8	8.5	141.6	178.5	258.3	221.8	106.1	0	0.6	13.1	80.9
1985	15.2	0	47.7	49.1	48.5	45.6	257.3	281.9	105.1	21.1	4.1	0	73.0
1986	0	51.2	88	135.5	89	157.9	243.9	279.4	144	11.9	0	0	100.1
1987	2.4	77.3	112.1	92.4	137	86.2	182	261.8	112.9	19	1.4	21.4	92.2
1988	9.3	80.7	5.2	90.1	21.1	107	203.7	283.7	239.5	29.9	0	0.2	89.2
1989	4.8	86.9	78	69.8	8.3	74.9	240.7	279.3	117.5	3	0.3	21	82.0
1990	0.5	101.3	34.9	95.4	55.5	131.8	262.4	338.2	155.7	8	0	0.9	98.7
1991	21.1	74.8	118	21.3	37.2	89.9	232.1	229	172.5	2.6	0.3	5.8	83.7
1992	57.4	33.5	58.8	95	34.6	115.4	190.9	312.6	135.1	36.3	0.6	1.4	89.3
1993	18.2	83.8	3.8	127	59.3	103.1	210	276.1	214.3	26.5	0	0	93.5
1994	0	2.3	86.7	85.9	25.7	107.3	216.4	203.3	149.7	0	34.8	0	76.0
1995	0	84.6	41.9	123.8	81.3	91.6	196.9	264.5	82.1	15.5	0	34	84.7
1996	0	8.5	94.1	58.4	55.4	183.8	213.9	236.4	120.7	5.3	0	4.2	81.7
1997	15.3	0	21.1	95.4	13.5	95	233.2	193.1	40.5	46.5	23.6	1.0	64.9
1998	52.7	42.3	25.7	62.2	42.7	103.8	238.1	159.2	75.0	29.0	3.4	0	69.5
1999	18.9	4.6	15.8	12.7	31.0	105.1	144.8	169.5	27.0	41.5	0.0	0.0	47.6
	1213.8	2800.1	3400.0	4110.7	4010.8	6705.3	11302.4	13539.3	8060.6	1225.3	439.1	379.9	4765.6
Ave.	32.8	75.7	91.9	111.1	108.4	181.2	305.5	365.9	217.9	33.1	11.9	10.3	128.8

In general the following Recording climate and weather condition will be recorded for design of small scale irrigation

1. Climatologically (monthly total rainfall in mm of the last l0 yrs. Of the area, longitude, latitude, altitude, mean monthly temperature of the last 10 years of the area, mean monthly wind speed, relative humidity and sunshine hours of the last 10 years of the area, mean monthly pan evaporation data of the last 10years of the area)
2. The mean monthly discharge of stream or river of the last 10 years of the area
3. The types soil and existing moisture condition of the cropping area,
4. Types of crops and their characteristics as well as their respective area

Self-Check – 9	Written test

Name…………………………………………… ID………………………… Date…….

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

1. Briefly elaborate the parameters used in Recording climate and weather condition under the following : (2 point each)

a) Water supply – irrigation.
b) Environmental Conditions.
c) Soil conditions.

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

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

Operation Sheet 1- Water flow measurement using float method

PROCEDURE

1. select a straight section of a channel about 30m long with fairly uniform cross section, with a measuring tape
2. Take the measurement of the top width at the water surface, the bottom width and the depth of water flow width and the the depth of the water flow at several section in the channel, using the scale and the point gauge to arrive at an average cross sectional area of the water flow.
3. Stretch a sting across each end of the section at right angles to the direction of the flow.
4. Place the flow in the centre of the channel, a short distance upstream from the trail section
5. Record the time taken by the float to travel the marked length using stopwatch.
6. Repeat the steps (4 and 5 several times to arrive at the average time of interval.

Observations

S.No.	Top width of channel (T), m	Bottom width of channel (B),m	Depth of flow (D),m		Time taken by float to cover the reach (t),sec	Remark
			Upstream end	Downstream end		
1						
2						
3						
4						

Length of the reach selected (L) = ____________________________________m

Calculations

The mean velocity of the water flow and the rate of flow in the channel as per the formula given below:

Average top width of channel (T)= $\frac{T_1 + T_2 + T_3 ....+ T_n}{n}$

Where, n= Number of observations

Average bottom width of channel (B)= $\frac{B_1 + B_2 + B_3 + ...+ B_n}{n}$

B=________________________m

Average depth of flow at upstream end (Du) = $\frac{du_1 + du_2 + du_3 + ...+ du_n}{n}$

Du=________________________m

Average depth of flow at downstream end (Dd)= $\frac{dd_1 + dd_2 + dd_3 + ...+ dd_n}{n}$

Dd=__________________________m

Average depth of flow (d) = $\frac{Du + Dd}{2}$

d=_________________________m

Cross sectional area of flow (A) = $\frac{1}{2}(B+T)*d$

A = ___________________________________m^2

Average time to cover the reach (t) = $\frac{t_1 + t_2 + t_3 + ...+ t_n}{n}$

t=_____________________________sec

Mean velocity of water flow in the channel (V) = $0.85\frac{L}{t}$

Where, L = length of the reach selected, m

t= the time to cover the reach, sec

The rate of flow (m^3/s) in the channel (Q) = AV

Where, A= cross sectional area of flow, m^2

V= mean velocity of water flow in the channel, (m/s)

Operation Sheet 2- Determination of moisture content of the soil

PROCEDURE

1. Take the weight of empty moisture boxes with their lids (W_1) and number them.
2. Drive the auger or core samlpler vertically in to the soil to a desired depth (e.g. 0 – 15cm, 15cm -30cm etc
3. Take out the auger and collect the soil sample.
4. Mix the sample and take three samples of about 30 – 50 gm. In to the weighted moisture box.
5. Weigh these moisture boxes with the soil sample and record W_2
6. open the lids and keep the boxes in an oven at 105^0c for 24 hours.
7. After 24 hours of drying close the lids of the boxes and take them out.
8. Cool these boxes in the desiccators for about 10-15min.
9. Weigh these boxes with the soil and record W_3
10. Calculate the average moisture content as per the procedure given in the calculation

Observations.

Sample No.	Weight of empty box with lid (W_1), gm	Weight of moisture soil with box (W_2), gm	Weight of oven dry soil with box (W_3), gm
1			
2			
3			

LAP TEST	Performance Test

Name………………………………. ID……………………………..

Date…………………………………….

Time started: ________________________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within **3** hour. The project is expected from each student to do it.

Task-1 Go to the river near by your college and calculate the velocity & the discharge of the river using float method

Task-2 Go to the demonstration site of your college and calculate the moisture contents of the soil of three locations by selecting randomly

LG#104	LO5- Record irrigation information and activities

Instruction sheet

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

- Plant or crop environment data is recorded.
- Water orders and water usage is recorded.
- Irrigation shifts are recorded.
- System process data are recorded

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Record Plant or crop environment data.
- Record Water orders and water usage.
- Record Irrigation shifts.
- Record System process data.

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". Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.
4. Accomplish the "Self-checks" which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer 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
7. Perform "the Learning activity performance test" which is placed following "Operation sheets" ,
8. If your performance is satisfactory proceed to the next learning guide,
9. If your performance is unsatisfactory, see your trainer for further instructions or go back to "Operation sheets".

Information sheet: 1-Recording plant or crop environment data

5.6. Recording plant or crop environment data

In determining crop water requirement and irrigation scheduling both primary and secondary data should properly gathered, recorded and documented. While doing so, the following plant or crope environment data information should be recorded and documented with their respective standard format table to attain the outcomes of determining crop water requirement & irrigation scheduling.

Data Sheet

Data to be recorded and calculated to determine the CWR, Irrigation frequency, and irrigation time

Location: ____________________ Date ____________________

Latitude ____________ Altitude ___________________

Longitude __________________

Months	Eto (mm	Kc	ETc (mm)	Rainfall (Rf) (mm)	Effective rainfall (Re) (mm)	Net irrigation requirement (NIR) (mm)	Irrigation Efficiency (η) %)	Growth irrigation efficiency (GIR) (m)
Jan								
Feb								
Mar								
.								
.								
.								
Dec								

Months	Growing seasons (days)				Crop factors (Kc)				FC (%)	PWP (%)	MAD (%)	ρ_b g/cm^3	Dr (cm)	Q m^3/s
	I	D	M	L	Kc_1	Kc_2	Kc_3	Kc_4						

Jan														
Feb														
Mar														
.														
.														
.														
Dec														

Information sheet:2-Recording water usage data

Name…………………………………………… ID………………………… Date…….

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

1. Mention the parameters to be collected and registered on Recording system of plant or crop environment data (6 points)

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

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

In determining crop water requirement and irrigation scheduling both primary and secondary data should properly gathered, recorded and documented. While doing so, the following water order and usage data information should be recorded and documented with their respective standard format table to attain the outcomes of determining crop water requirement & irrigation scheduling.

Irrigation water requirement of main growing season at Tsigea (Considering effective rainfall)

Crop			Month	May			June			July			August			September			October		
			Decade	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3
	Area (%)	Parameter	Unit																		
Sorghum		ETc	mm/decade	15.3	15.2	17.0	20.3	27.8	35.3	42.8	50.3	55.8	48.4	46.2	50.9	46.4	46.3	41.0	34.9	29.0	16.8
		Peff	mm/decade	8.0	3.6	2.6	1.5	0.0	0.5	0.1	0.0	4.4	19.7	28.8	21.6	10.0	3.3	8.4	17.5	22.7	9.6
		Net. Irr (Ic)	mm/decade	7.3	11.6	14.4	18.8	27.8	34.8	42.7	50.3	51.4	28.7	17.4	29.3	36.4	43.0	32.6	17.4	6.3	7.2
		Area (Ac)	....	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
	75	Ic.Ac	mm/decade	**5.5**	**8.7**	**10.8**	**14.1**	**20.9**	**26.1**	**32.0**	**37.7**	**38.6**	**21.5**	**13.1**	**22.0**	**27.3**	**32.3**	**24.5**	**13.1**	**4.7**	**5.4**
Teff		ETc	mm/decade	0.0	0.0	0.0	0.0	0.0	0.0	15.8	18.4	36.3	47.6	50.7	56.0	51.0	50.7	38.9	23.8	4.3	0.0
		Peff	mm/decade	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	4.4	19.7	28.8	21.6	10.0	3.3	8.4	17.5	6.8	0.0
		Net. Irr (Ic)	mm/decade	0.0	0.0	0.0	0.0	0.0	0.0	15.7	18.4	31.9	27.9	21.9	34.4	41.0	47.4	30.5	6.3	0.0	0.0
		Area (Ac)	....	0.0	0.0	0.0	0.0	0.0	0.0	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.0
	25	Ic.Ac	mm/decade	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**3.9**	**4.6**	**8.0**	**7.0**	**5.5**	**8.6**	**10.3**	**11.9**	**7.6**	**1.6**	**0.0**	**0.0**
Net irrigation requirement			mm/decade	5.5	8.7	10.8	14.1	20.9	26.1	36.0	42.3	46.5	28.5	18.5	30.6	37.6	44.1	32.1	14.6	4.7	5.4
Project efficiency			%	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Gross irrigation requirement			mm/decade	**10.95**	**17.4**	**21.6**	**28.2**	**41.7**	**52.2**	**71.9**	**84.65**	**93.05**	**57**	**37.05**	**61.15**	**75.1**	**88.2**	**64.15**	**29.25**	**9.45**	**10.8**
Net irrigation area			ha	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Project supply requirement			mm/day/ha	1.095	1.74	2.16	2.82	4.17	5.22	7.19	8.465	9.305	5.7	3.705	6.115	7.51	8.82	6.415	2.925	0.945	1.08
			m3/day/ha	10.95	17.4	21.6	28.2	41.7	52.2	71.9	84.65	93.05	57	37.05	61.15	75.1	88.2	64.15	29.25	9.45	10.8
Hours of opreration per day			hr	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Ratio hours of application			hr/24hr	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Actual project supply requirement			m3/day/ha	32.85	52.20	64.80	84.60	125.10	156.60	215.70	253.95	279.15	171.00	111.15	183.45	225.30	264.60	192.45	87.75	28.35	32.40
			l/s/ha	0.38	0.60	0.75	0.98	1.45	1.81	2.50	2.94	3.23	1.98	1.29	2.12	2.61	3.06	2.23	1.02	0.33	0.38
Maximum duty for design			l/s/ha	3.23																	

Example of irrigation scheduling on the basis of request forms (scheme design: upstream control with vertical slide gates)

OVERVIEW OF REQUESTS

TU 1		TU 2		TU3		TU 4		TU5		TU6	
Hrs	Flow	Hrs	Flow	Hrs	Flow	Hrs	Flow	Hrs	Flow	Hrs	Flow
24	60	24	60	24	60	24	60	24	60	24	60
18	50	18	50	18	50	18	50	18	50	18	50
12	40	12	40	12	40	12	40	12	40	12	40
6	30	6	30	6	30	6	30	6	30	6	30
	20		20		20		20		20		20
	10		10		10		10		10		10

RESULTING IRRIGATION SCHEDULE

TU 1		TU 2		TU3		TU 4		TU5		TU6	
Hrs	Flow	Hrs	Flow	Hrs	Flow	Hrs	Flow	Hrs	Flow	Hrs	Flow
24	60	24	60	24	60	24	60	24	60	24	60
18	50	18	50	18	50	18	50	18	50	18	50
12	40	12	40	12	40	12	40	12	40	12	40
6	30	6	30	6	30	6	30	6	30	6	30
	20		20		20		20		20		20
	10		10		10		10		10		10

NOTE: Tertiary Units 2 and 3 will receive more water than requested. This was done to obtain a uniform delivery time of 12 hours per day.

Self-Check – 2	Written test

Name…………………………………………… ID……………………… Date…….

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

2. Mention the parameters to be collected and registered on Recording system of water order and usage data (6 points)

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

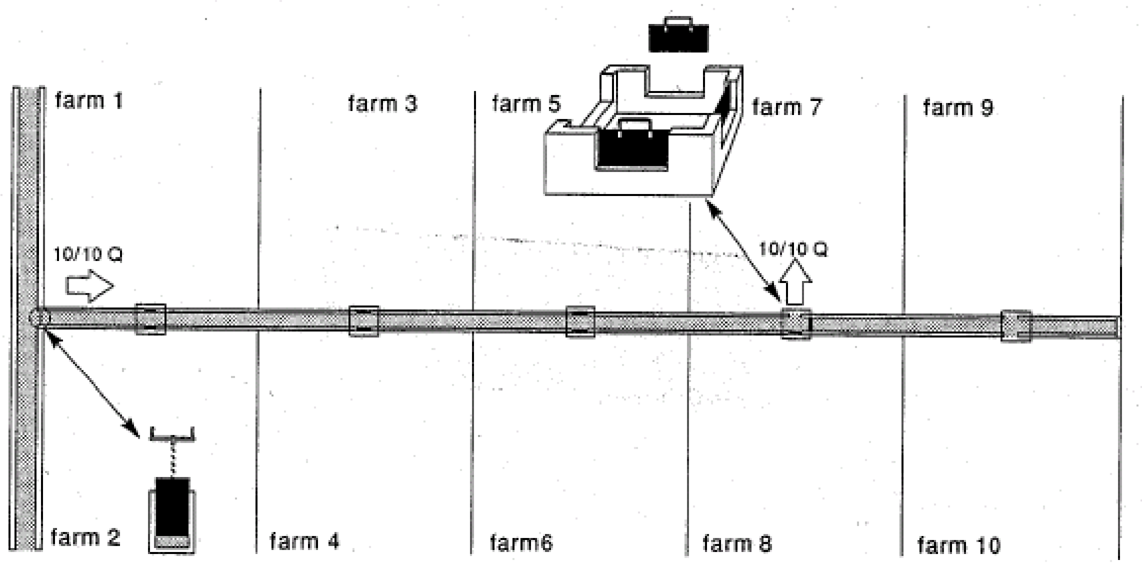
Note: **Satisfactory rating - 3 points Unsatisfactory - below 3 points**

3.1. Recording system process data

In determining crop water requirement and irrigation scheduling both primary and secondary data should properly gathered, recorded and documented. While doing so, the following system process data information should be recorded and documented with their respective standard format table to attain the outcomes of determining crop water requirement & irrigation scheduling.

Flow sharing or proportional division of a flow of 60 l/s among ten farms by means of proportional division boxes

NOTE: The flow over each weir is proportional to the width of the crest, which have the same height and shape.



Self-Check – 3	Written test

Name…………………………………………… ID……………………….. Date…….

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

3. Mention the parameters to be collected and registered on Recording system of process data (6 points)

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

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

Operation Sheet 1- Recording

PROCEDURE

1. Collect and collate climatologically (monthly total rainfall in mm of the last 1 yrs.of your area.
2. Collect and collate longitude, latitude, altitude, mean monthly temperature of the last 1 years of the area,
3. Collect and collate mean monthly wind speed, relative humidity and sunshine hours of the last years of the area, mean monthly pan evaporation data of the the area)
4. Collect and collate The mean monthly discharge of stream or river of the last 10 years of the area
5. Collect and collate The types soil and existing moisture condition of the cropping area,
6. Collect and collate Types of crops and their characteristics as well as their respective area
7. Finally report and document it in summary form and graphically

LAP TEST	Performance Test

Name………………………………. ID……………………………..

Date…………………………………….

Time started: ________________________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 2. hour. The project is expected from each student to do it.

Task-1 Go to the nearby meteorology station of Your college and collect and collate the past five years data which will be used for design purpose of the newly established farm by next years.

Reference Materials

BOOKS

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6. Suresh, 2007, Watershed hydrology, New Delhi.
7. Suresh, 2008, Land and water management principles, New Delhi
8. Taffa Tulu, 1983. Manual on soil and water conservation
9. Taffa Tulu, 2002. Soil and water conservation for sustainable agriculture

WEB ADDRESSES

1. Irrigation http://www.geolab.nrcan.gc.ca/geomag/e_cgrf.html
2. http://www.navcen.uscg.gov/gps/default.htm.
3. FAO):http://home.gdbc.gov.bc.ca/
4. Irrigation Ltd (subscription based):http://www.terrapro.bc.ca
5. Soil surveyhttp://www.nrcan.gc.ca/gsc

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