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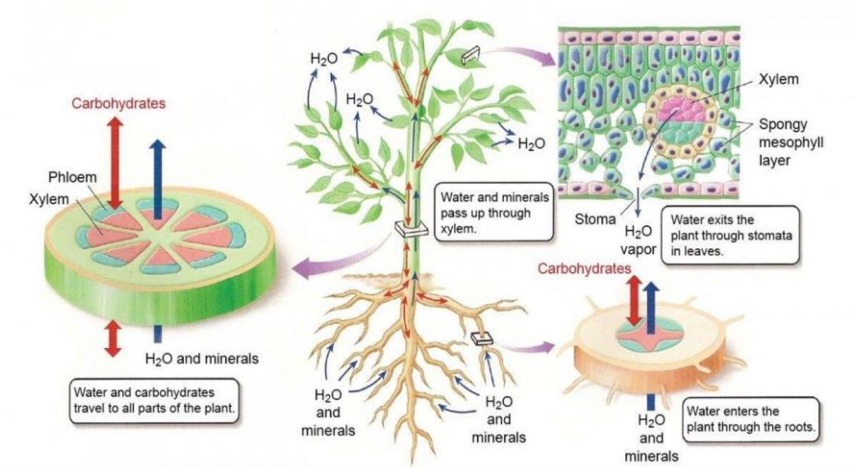
Ministry of Labor and Skills

Crop Production

Level-III



Based on December 2021, Version 4 Occupational Standard

Module Title: - Perform Irrigation Schedule and crop water requirement

LG Code: AGR CRP3 M03 LO (1-4) LG (13-16)

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Table of Contents

Introduction to the Module

This module covers the knowledge, skills and attitude required to monitor crop environment, check water supply and availability, coordinate irrigation shifts and irrigation system and record irrigation information and activities

LG #1	LO #1 Monitor Crop Environment

Instruction Sheet
This learning guide is developed to provide you the necessary information regarding the following content coverage and topics: • Introduction to the module • Monitoring crop environment and interoperating results • Crop inspection on signs of stress. • Recommending changes to irrigation shifts 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 crop environment and interoperating results • Inspect crops on signs of stress. • Recommend changes to irrigation shifts
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 4. Accomplish the Self-checks 5. Perform Operation Sheets 6. Do the “LAP test”

Information Sheet 1

1.1 Monitoring crop environment and interpreting results

There are many different factors that affect the timing and amount of irrigation water needed for crop growth and maximizing the economic yield of crops.

Failure to know and understand the various factors, then to monitor these factors and respond when the factors start to have a negative effect on crop performance will potentially lead to serious loss of yield. Farmers need to:

- Identify what factors are to be monitored and specify the target range for satisfactory performance for the different factors and different crops, then
- Develop Enterprise Procedures for monitoring key factors which include:
  - ✓ Who is responsible for monitoring, recording, and reporting?
  - ✓ How the various factors are to be monitored?
  - ✓ When and how often the various parameters are to be monitored?
  - ✓ Who is responsible for decision making, action planning and follow up?

Factors that affect the irrigation water requirements of crops and provision of irrigation can be divided into two groups, **environmental factors,** and **external factors**. Frequent monitoring of these factors will help to identify trends and changes, and to plan and take correction measures.

Environmental factors

Environmental factors that should be monitored in irrigated crops include factors in the aerial environment (climate) and factors in the soil.

- **Aerial Environment factors** include temperature, sunshine, humidity, wind, and rainfall.
- **Soil factors** include soil moisture content, waterlogging, and soil conductivity.

Note: Information about the soil type, structure and texture, infiltration rate and drainage characteristics, etc. is useful but this information is relatively stable, so these soil factors are measured once but not usually 'monitored' during the life of the crop.

Environmental factors can be monitored on an irrigated farm using field observation and simple equipment as shown below.

Field observations include monitoring weather conditions and examining the soil.

- Consider the recent past, current, and forecasted weather with reference to rainfall, wind, sunshine, cloudy weather, average temperature, and possibility of frost.
- Observe and feel the soil and note the soil moisture and signs of dryness or flooding, soil erosion and salt crystal formation on the soil surface

Simple equipment designed for on-farm use includes:

- Rain gauge
- Max Min Thermometer
- pH and Conductivity meters to measure soil and water pH and conductivity
- Soil tensiometers or a soil moisture meter to measure changes in soil moisture

Farmers may also access data from the Ministry of Agriculture, meteorology and the irrigation Water Users Associations typically:

- Rain fall data, current season and historical
- Calculations of evapotranspiration for different Agro-climatic Areas, Crop types and stages of crop growth

External factors

Important External factors that can have an impact on crop irrigation include crop establishment and occurrence of crop pests, water supply, irrigation infrastructure, availability of inputs, and target market date.

- **Low crop plant population and loss of crop yield potential due to pest attack** may reduce the economic viability of investment in irrigation
- **Problems with low water supply** will limit the availability of water for irrigation

Check, the level of the water in the river, reservoir, well or bore hole according to the supply type used.

- **Technical problems with water supply**, e.g. power interruption or lack of fuel for pumps, pump breakdown, water shortage and conflict of requirements with other users and crops, etc. are all technical difficulties that will require intervention from management.
- **Problems with irrigation infrastructure,** e.g. collapse or blocking of canals, furrows and drains, burst pipes and leaking joints, clogging of filters and dripper emitters will all affect the delivery of water evenly to the crop and have an impact on yield so all need regular checking and maintenance as necessary
- **Harvest date and or target Market** also need to be considered. In many crops, irrigation is reduced prior to harvest to induce ripening, e.g. cereals or neck drying, e.g. onions but in other crops, e.g. spinach or lettuce the last irrigation may be timed to be the day before harvest to ensure that the crop is fully turgid at harvest.

Note: Availability of inputs can also be a limiting factor for crop performance. Irrigation is only profitable when other factors that limit crop yield potential are not limiting the possible response to irrigation. E.g. Irrigating a low yielding variety or failing to supply the necessary fertilizer will severely limit the crops response to irrigation. Ensuring the availability of the correct and sufficient inputs is a Management issue that needs to be addressed at the start of the season and is not usually a routine monitoring activity in relation to planning irrigation shifts.

1.2 Crop inspection on signs of stress

Due to the multiple roles of water in plants, there are many different visual signs of stress due to water related issues in crops. These include wilting, stunting, changes in leaf size and shape or orientation, nutrient disorders, bud and flower abortion, increased incidence of some pests and diseases.

Farmers or Irrigation Supervisors should undertake regular (Weekly) inspection of their crops for signs of stress due to dryness or excessive wetness of the soil. This inspection may be carried out as part of the Crop Inspection (Scouting), for Pests and Diseases or may be done by the Team responsible for Irrigation. Findings should be recorded and if necessary reported. **DAs** visiting Farmers and at Farmer Training Days, should also note signs of water stresses in crops and discuss the cause, effect, and solution with the Farmer(s) concerned.

Signs of stress due to low soil moisture include:

- **Wilting (Loss of Turgor / leaves become flaccid):** If the soil is dry, the plant will lose water faster than the roots can extract water from the soil and the **leaves will wilt**.

  As the plant wilts, the **stomata in the leaves will close**, and **growth is reduced**. If the dryness of the soil is corrected promptly, the plant will recover, and the loss of growth or yield will be small. If water is not applied, the plant will eventually reach '**Permanent Wilting Point'.** After reaching this stage of wilting the plant cannot respond to water application and will die.

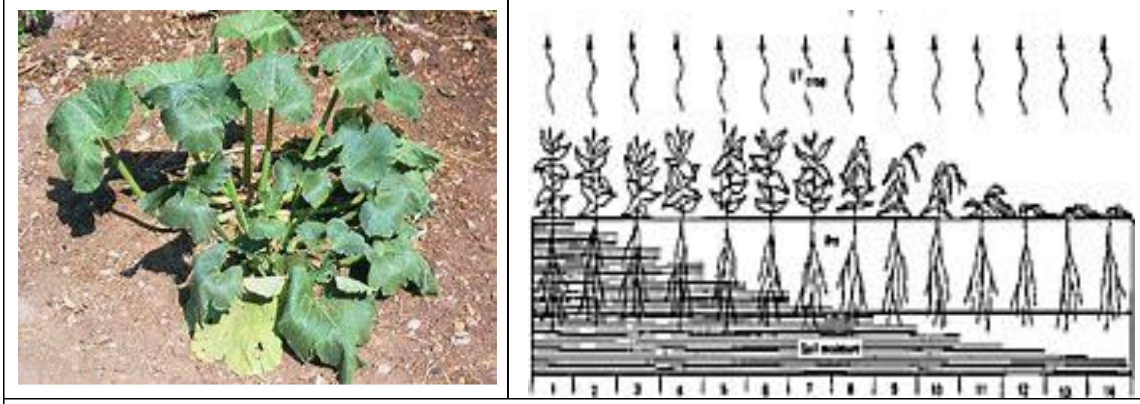
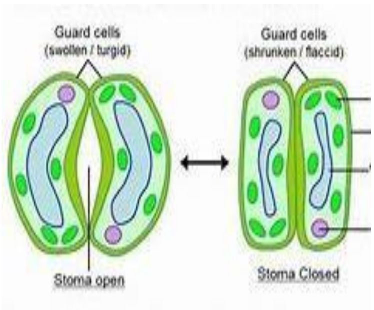


Figure 1.1. Sign of moisture stress

  Farmers need to understand wilting and the importance of not delaying irrigation until wilting occurs, particularly at sensitive times of crop growth, e.g. establishment, flowering, fruit of seed swelling. Farmers should also be aware that in the highest heat of the day, **Transient wilting** may occur, (Water loss exceeds uptake for a short time) and if the soil is moist, the plants will recover when the temperature falls in the evening. Wilting will also occur when the roots have been damaged by disease or over watering.

- **Changes in leaf position, color, and size:**

Plants are adapted to respond to water stress by trying to reduce evaporation (Water loss). Typically, stomata will close, leaves may roll, and or Leaves may hang downwards.

		
Stomata close to reduce water loss and transpiration	Leaf rolling in Maize Also occurs in tomato	Leaves hang down e.g. Apple
Figure 1.2. Changes that occur in leaves as a result of moisture stress		

- **Bud or flower abortion and failure to pollinate and set fruit are** other common symptoms of water stress that will lead to a loss of yield. This is a common problem in fruit and seed crops.
- **Nutrient deficiency may also occur** because soil conductivity will increase, roots may not be able to take up nutrients or nutrients are not transported effectively within the plant. Blossom End Rot in Tomatoes is a common problem due to irregular watering and periods of dryness. Fruit skin will also harden, and the fruit may crack when irrigation is applied.
- **Incidence of Pest and diseases, e.g.** Red Spider Mite and Powdery Mildew may also increase when plants are under water stress
- All these responses to water stress combine to cause reduced crop growth and yield**.** **Note:** Where the whole crop is affected by drought, yield loss is only measurable by comparison with other farms and crops planted in previous years.

Signs of stress due to too much water caused by poor drainage or over irrigating:

Figure 1.3. Sign of moisture stress due to too much water

- **Poor drainage,** often due to blocked drains or poor land preparation, causes the soil to become waterlogged and crop plant roots will die due to lack of air in the soil. Symptoms of waterlogging, aside from wet soil and puddles include wilting, nutrient deficiency, and an increase in the occurrence of root diseases, e.g. Fusarium Wilt**.** Problems of poor drainage are exacerbated by over irrigating.

1.3 Recommending changes to irrigation shifts

Over irrigating is a waste of water which may lead to shortages later in the season and will cause leaching of nutrients resulting in potential nutrient deficiency, wastage of fertilizer and making changes to the irrigation shift.

Irrigation Shift defines the frequency of irrigation and the amount of irrigation water to be applied at each application or the frequency and the length of each irrigation cycle or irrigation interval. This information may also be referred to as the Irrigation Schedule for the crop.

Irrigation shifts (the irrigation schedule), are planned in advance then changes are made to the plan based on, the findings from monitoring weather conditions, soil moisture, run off / drainage, the crop condition and the stage of growth of the crop.

Changes related to Weather conditions

High temperature, sunshine, low humidity, high wind and lack of rainfall all increase the crops requirements for irrigation. Low temperature, cloudy weather, high humidity, absence of wind and occurrence of rainfall all reduce the crops needs for irrigation.

Farmers will consider the previous irrigation shift and environmental pollution.

- If more water is needed, the interval between irrigation cycles may be reduced and or the amount of irrigation water to be applied per cycle may be increased.
- If less water is needed, the interval between irrigation cycles may be increased and or the amount of water applied per cycle may be reduced.

Changes related to soil moisture

Soil moisture should be checked before, during and immediately after irrigation.

- The check before irrigation will indicate how much the soil has dried since the last irrigation and use this as a guide for the amount of water to be applied in the next irrigation application, (no change, increase or decrease according to findings).
- The check during irrigation and after irrigation will give some indication about water penetration in relation to the size and position of the root zone. Farmers should also check for run off / water draining out of the production area as this is water and fertilizer wastage caused by over application.

Irrigation managers, Small Farmers and Development Agents will observe the Crop and take note of the stage of growth and any signs of water stress. Then the necessary adjustment can be made to the length of the irrigation cycle planned and the interval between irrigation cycles.

Changes related to crop growth

- Newly transplanted crops and seedlings are very sensitive to water stress and have a small root system so require frequent applications of small amounts of water.
- As the crop grows, the need for water increases, water loss due to transpiration increases (Plant has more leaves) and the root system becomes larger. In this case the amount of water applied per application will need to be increased gradually as the crop grows and the frequency of irrigation cycle will be reduced.

- As the crop grows, it will pass through different stages of growth, e.g. vegetative growth, flowering, fruiting, and setting seed. For some crops, the yield is seriously reduced it water stress occurs at these sensitive stages, see Table 1 below.

Table 1.1. Sensitive growth period of vegetable for water shortage

Crop	Growth periods sensitive to water deficit
Cabbage	During head enlargement and ripening
Carrot	Throughout the growth period
Onion	Bulb enlargement, particularly during rapid bulb growth for ware crops and for seed production, flowering is very sensitive to water stress
Pepper	Throughout but particularly just prior to and at start of flowering
Potato	Period of stolonization and tuber initiation, also tuber swelling
Tomato	Flowering, yield formation and the vegetative period, particularly during and just after transplanting
Avocado	Flowering and fruiting
Banana	Throughout but particularly during first part of the vegetative period, flowering, and yield formation
Citrus	Flowering and fruit set is very sensitive and water stress at fruit enlargement will also reduce yield
Mango	Flowering and fruiting
Papaya	Flowering and fruiting

Other factors to be considered when planning irrigation shifts are:

i. Other agronomic activities
ii. Water shortages

Other agronomic activities

Irrigation needs to be coordinated with other activities to be carried out in the crops.

- Irrigation should not be carried out in a crop that is being sprayed or has recently been sprayed with pesticide. This is to protect the Irrigation workers and to allow time for the pesticide to be active or absorbed by the plant.

- Fertilizer application also needs to be considered. Fertilizer should be applied to moist soil and the irrigation after application should be carefully monitored and controlled to minimize the risk of leaching.
- The planned Harvesting date also needs to be considered. Irrigation may be increased or reduced according to the type of crop and the target market in the days leading up to harvest.

Response to Water shortages

After planning the required changes to the irrigation shift based on crop needs and environmental conditions, Farmers also need to consider the availability of irrigation water as this is an overriding limiting factor that is unfortunately common in Ethiopia.

The planned Irrigation shift may need to be changed when water shortage occurs.

Water shortage may occur due to:

- Prolong dry season where the source of water may not have enough water
- Waste of water (Over application and leakages) in the upstream area of the scheme,
- The scheme management deciding to spread the available water over a large area allowing more farmers to irrigate
- Poor construction of irrigation infrastructures that lead wastage of waters.

When such situations are observed it will be necessary to adjust the irrigation planned shift, to give priority to selected crops, and to make savings in the total amount of water required.

Guidelines for maximizing the return on what water is available include:

Give priority for:

- Crops which suffer most from water stress, typically leafy vegetables and crops where the yield is very sensitive to water supply
- Crops at sensitive growth stages see Table 1 above.
- High value crops and crops that are critical for food security

Implement measures to reduce water usage, for example:

- Reduce the planned irrigation by a small amount for several crops
- Implement deficient irrigation, e.g. by irrigating alternative furrows,
- Reduce water loss and water wastage, e.g. apply mulch and repair leakages
- Consider sacrificing a crop of low value or where the crop population is low.

Figure 1.4. Alternative furrow irrigation

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. List five environmental factors that affect crop production in an irrigated crop. Explain why it is important to monitor the crop environment in an irrigated crop
2. List the equipment’s and techniques used for monitoring irrigation farm
3. Describe five signs of crop stress due to water shortage and explain how to distinguish these signs from other forms of stress
4. Most of our farmers irrigating their crops when it shows sign of wilting. What advice would you give these Farmers?
5. List four reasons why irrigation water shortage may occur.
6. Explain three actions that a Farmer can take to reduce water use in times of shortage
7. When making adjustment to irrigation shifts, what crops or crop conditions should be given priority?

LG #2	LO #2 Checking Water Supply and Availability

Instruction Sheet
This learning guide is developed to provide you the necessary information regarding the following content coverage and topics: • Identification and manipulating type of crop and water requirement • Recognition of external factors affecting irrigation requirements • Preparing and understanding irrigation schedule • Giving sufficient notice of water order 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: • Identify and manipulate type of crop and water requirement • Recognize the external factors affecting irrigation requirements • Prepare and understand irrigation schedule • Give sufficient notice of water order
Learning Instructions:
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Information Sheet 2

2.1. Identification and manipulating type of crop and water requirement

Crop Water Requirement

Crop water requirement is the total quantity of water required by the crop in a given growing season or from the time it is sown to the time it is harvested. This water is required for compensating the evapotranspiration loss plus water used for metabolic processes, photosynthesis, transportation of minerals and foods, growth, and structural support.

Irrigation water requirement

The irrigation water requirement for a crop is the water required for plant growth plus the water lost from the cropped area by evapotranspiration plus water losses due to irrigation system inefficiencies.

Irrigation water needs will be affected by the climate, see Table 2

Table 2.1. Effect of major climate factors on crop water need (FAO, 2020)

Climate	Crop water need	
	High	**Low**
Sunshine	Sunny (no clouds)	Cloud (no sun)
Temperature	Hot	Cool
Humidity	Low (dry)	High (humid)
Wind speed	windy	Little wind
Crop season	Mid/late	Initial or ripening
Crop spacing	Dense plant	Wide spacing
Soil moisture	Dry	Moist

It is important to know the amount of water required for irrigation to be able to:

- Determine the area of crop that can be grown with the water that is available
- The capacity of water storage that is needed for planned production
- Order water to meet daily, weekly, seasonal and annual irrigation needs.

For established farms, the farmer will know how much water was used on previous occasions and this can be used as guide to future requirements.

For the design of irrigation schemes and for management of shared water supplies, e.g. in a Water Users Association or Water Cooperative, Water use based on planned cropping will be calculated using standard data by an Irrigation engineer or Irrigation specialist.

Calculation is based on the following processes:

- Evapotranspiration (ETo) has been measured for a reference crop (Grass) grown in different conditions to create standard reference data
- Results for the reference crop are adjusted for different crops and different growth stages by multiplying the evapotranspiration of the reference crop, ETo, by Crop coefficient, Kc, for the chosen crop to give the Evapotranspiration for the crop (ETc). ETo x Kc = ETc
- Then the irrigation requirements is calculated by subtracting the Rainfall from the Evapotranspiration of the crop

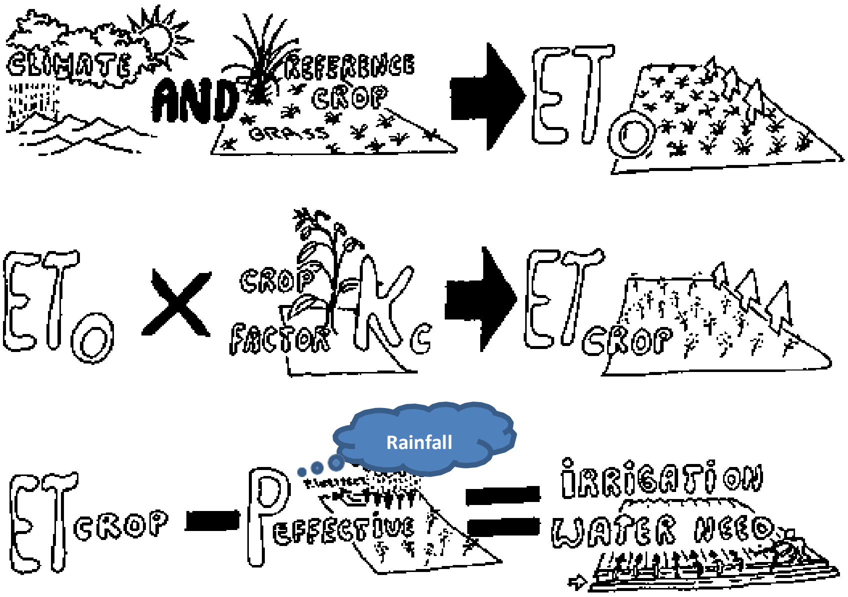

Figure 2.1. ETo, ETc and irrigation requirement

The Crop Coefficient varies with type of crop, Table 2.2 and the stage of crop growth, Figure 2.2.

Table 2.2. Crop coefficient (Kc) and number of growth days of crops at each growth stages

Crops	Growth stages Kc (Number of days at each growth stage)				Depth of Rooting (cm)	Maximum Allowable depletion % MAD
	Initial	Crop development	Mid-season	Late & Harvest		
Cabbage	0.45 (**20**)	0.75 (**25**)	1.05 (**60**)	0.90 (**15**)	40-50	0.45
Carrot	0.45 (**20**)	0.75 (30)	1.05 (30)	0.90 (20)	50-100	0.35
Lettuce	0.45 (20)	0.60 (30)	1.00 (15)	0.90 (10)	30-50	0.30
Onion	0.50 (20)	0.75 (50)	1.05 (20)	0.85 (15)	30-50	0.25
Pepper	0.35 (30)	0.75 (35)	1.05 (40)	0.90 (20)	50-100	0.25
Potato	0.45 (25)	0.75 (30)	1.15 (30)	0.75 (20)	40-60	0.25
Tomato	0.45 (25)	0.75 (40)	1.15 (40)	0.80 (25)	70-150	0.40

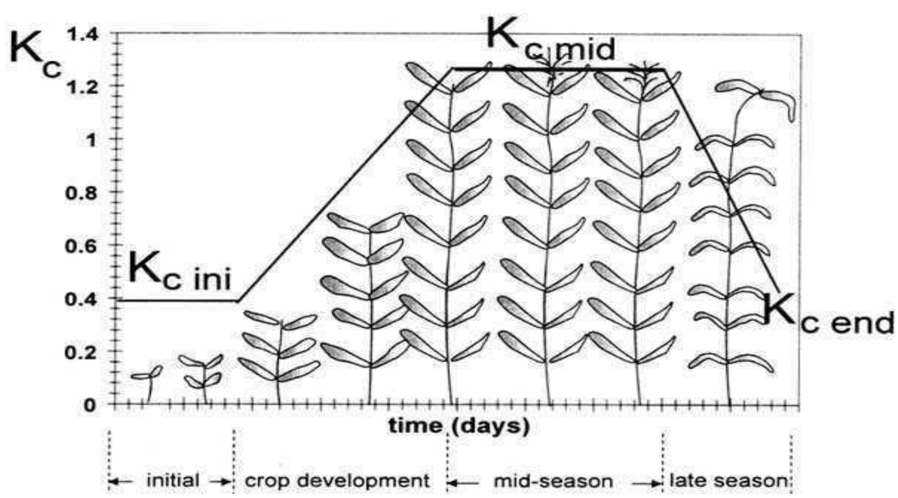

Figure 2.2. Kc value of representative crop at different growth stage

Procedures to determine crop water requirement (ETc)

1. Select the type of crop grown
2. Establish planting dates

3. Identify the crop growth stage and determine their growth length
4. Select the crop coefficient (Kc) value from Table 3
5. Construct the crop coefficient table (allowing one to determine kc value for any period during the growing period)
6. Calculate ETc as the product of ETo and Kc (each growth stage)

The evapotranspiration for the reference crop (ETo), in each agro-ecological one is available from reference data and Rainfall can be measured in the farm. In Ethiopia, this data will also be available at the MoA, Regional Agriculture Office. Sample data is shown in table 4, below.

Table 2.3. Average ETo and RF of sample area collected from nearby meteorological station

Month	J	F	M	A	M	J	J	A	S	O	N	D
ETo (mm/day)	3.3	4.1	5.2	5.5	6.2	6.3	5.6	5.0	4.9	4.7	4	4.7
Rainfall (mm)	15	75	49	126.4	29.3	16.2	249	0	110	21.3	15.6	0

Example: Calculation of Evapotranspiration for a named crop.

To determine crop water requirement of Onion, planting date September 15.

Use the Crop growth stage in Table 3 and the Average rainfall and Evapotranspiration for the sample area are shown in Table 4

Calculate the ETo for each stage of growth using the formula: ETo = No of days x ETo per day

- ETo for onion during initial stage will be: Sep 15 x 4.9 + Oct 5 x 4.7 = 97mm

  (since number of days during initial stage is 20 days)
- ETo for onion during development stage Oct 25 x 4.7 + Nov 25 x 4 = 217.5mm
- Mid-season stage

  ETo Nov 5 x 4 + 15 x 4.7 = 91.2mm

- Late season stage

ETo Dec 15 x 4.7 = 70**mm**

Therefore, the total ETo = 97 + 217.5 + 91.2 + 70 = 475.7mm for whole growing season

Then calculate crop water requirement (ETc) using the formula

ETc = ETo x Kc.

Sample Kc values are provided in Table 2.2.

Results are shown in Table 2.3 overleaf.

Table 2.3. Calculated ETc at each stage of crop growth in the sample growing season

Crop	**Growth stage**	**Initial stage**	**Crop development stage**	**Mid-Season stage**	**Late Season stage**	**Total**
Onion	No. Days	20	50	20	15	105
	Months	15sep-5 Oct	6 Oct-25 Nov	26Nov-15Dec	16-30 Dec	
	Kc value	0.5	0.75	1.05	0.85	
	ETo(mm)	97	217.5	91.2	70	475.7
	ETc(mm) = Kc x ETo	48.5	163.1	95.8	59.5	**367.7**

Determination of Irrigation Water Requirement

The total amount of water that must be applied by irrigation during the crop growth period is termed as irrigation water requirement (net, IRn). The irrigation water requirement of a certain crop is, the difference between the crop water need and that part of the rainfall which can be used by the crop (the effective rainfall). If irrigation is the sole source of water supply for the plant, then the irrigation requirement will be at least equal to the crop water requirement. In area where there is not enough rain for crops, some time we will provide irrigation as supplementary and this is called supplementary irrigation.

Net irrigation requirement will mathematically be expressed as:

IRn (mm) = ETcrop (mm) – Effective rainfall (Pe) (mm)

IRn = Net irrigation requirement (mm) ETc = Crop evapotranspiration (mm)

Pe = Effective dependable rainfall (mm

Effective Rainfall (Pe) is estimated using different empirical formulas Pe = 0.6P-10 for P<75 mm/month

Pe = 0.8P-25 for P>75 mm/month Whereas P = Monthly mean rainfall

Then the net irrigation requirement needs to be adjusted to consider the efficiency of the irrigation system to be used.

Irrigation system efficiency

While transporting and applying water to the irrigated field, some water wastage is almost inevitable. Water losses occur even in best irrigation water management. Therefore, when computing the actual irrigation requirement, (the gross irrigation requirement), an efficiency factor needs to be applied to account for losses. The most important efficiency terms in connection with irrigation are conveyance (Ec), distribution (Ed), application efficiencies (Ea) and overall project efficiencies (Ep) and where Ep = Ec x Ed x Ex.

Gross irrigation amount = Net amount (mm) for whole growing season

Irrigation efficiency

Gross irrigation amount = Manageable Allowable Depletion (MAD) for each application

Irrigation efficiency

Example:

Suppose a tomato crop grown in a certain area has a total growing period of 150 days from February to June. The rainfall incidence, as recorded from the meteorological station, and the ETcrop, as predicted from certain model, are as shown in table 7. Then Irrigation water requirement can be calculated on a monthly basis and for the total growth period. The total ETcrop of tomato over the entire growing season is 786 mm of which 68 mm is applied by rainfall. The remaining quantity (786 - 68 = 718 mm) must be applied by irrigation.

Table 1. Calculation of Irrigation water requirement for tomato

Months	Feb	Mar	Apr	May	June	Total(mm)
ET crop (mm/month)	69	123	180	234	180	**786**
Rainfall: P (mm/month)	20	38	40	80	16	**194**
Effective rainfall: Pe (mm/month)	2	13	14	39	0	**68**
Net-irrigation water requirement, IR n(mm)	67	110	166	195	180	**718**
Gross irrigation requirement for furrow irrigation (Ea =55%= 0.55)	122	200	301	355	327	**1305**
Gross irrigation requirement for drip irrigation) Ea=90%=0.9)	74	122	184	216	200	**797**

As it is shown on the above table the depth of water required for tomato for the whole growing season is 1305mm in furrow and 797mm for drip irrigation. If necessary, we can change this to liters or m^3 in relation to plot to be cultivated. For example, if we want to know for hectare, we just multiply by 10 and we will get m^3 of water that is enough for 10,000m^2 or one hectare.

- If our irrigation method is drip, we need 7970m^3 (797x10) water for one hectare of tomato crop, but
- If we use furrow irrigation, we require 12050m^3 of water for one hectare of tomato.

So, we must ensure that this amount of water will be available **before planting this crop**.

2.2 Recognition of external factors affecting irrigation requirements

External factors can have a profound impact on irrigation requirements, especially in horticulture. One of the most significant factors is weather conditions. Hot and dry weather can cause plants to lose water faster, requiring more frequent irrigation. Conversely, cool and wet weather can lead to waterlogging, which can affect root health and growth.

Another important factor is soil type and structure. Sandy soils have a low water holding capacity, meaning that water will drain quickly and require more frequent irrigation. On the other hand, clay soils have a higher water holding capacity, but also have poorer drainage, which can cause waterlogging and root damage.

The type of plant being grown is also a crucial factor to consider. Different crops have varying water requirements at different stages of their growth cycle. For example, fruiting crops like tomatoes and cucumbers need more water during the fruiting stage, while root crops like carrots and potatoes need consistent moisture throughout the growing season.

The age of the crop also affects irrigation needs. Younger plants require more frequent irrigation as their root systems are not yet fully developed to access water deeper in the soil. As they mature and establish their roots, they can tolerate longer periods between watering.

Other external factors that can affect irrigation requirements include wind, humidity, and altitude. Windy conditions increase evaporation rates, leading to greater water loss from the soil and plants. Humidity can reduce the rate of evapotranspiration, which is the process by which plants release water into the atmosphere through their leaves. Altitude affects air temperature and atmospheric pressure, which in turn affects humidity levels and evapotranspiration rates.

The external factors that affect irrigation requirements include humidity levels, soil type, plant variety, and maturity stage. These factors can influence water uptake and retention by crops. For example, crops grown in sandy soils require more frequent irrigation than those grown in clay soils because sandy soils have lower water-holding capacity. Similarly, plants grown in hot and dry climates require more water than those grown in cooler and humid climates. The type of crop also affects irrigation requirements as different crops have different water requirements at different growth stages. For instance, young plants require more water than mature plants because they have shallow roots and are more susceptible to drought stress. In summary, external factors such as humidity levels, soil type, plant variety, maturity stage and climate conditions play a significant role in determining irrigation requirements for horticultural crops.

- The two main consideration namely, water need of crops and the availability of irrigation water decide the irrigation frequency. Once these two are known, the frequency of irrigation is influenced mainly by climate, soil characteristics, crop characteristics and management practices.
- In summary, external factors like weather conditions, soil type and structure, plant type and age, wind, humidity, and altitude all play crucial roles in determining irrigation needs in horticulture. By understanding these factors and monitoring them regularly, growers can optimize irrigation practices to reduce water usage while ensuring healthy plant growth and maximum crop yields. Some factors affecting irrigation requirement of crops are described as follows:

i. Climate

- Climate is responsible for causing variations in consumptive use rate and frequency of irrigation. High temperature, low humidity, high wind velocity and greater solar radiation in a place emphasize the need to irrigate crops more frequently as evapotranspiration takes place at a higher rate due to greater evaporative demand of the atmosphere.
- This is particularly evident in arid regions and during summer season. On the other hand, higher rainfall and greater relative humidity during the rainy season reduce the irrigation requirement of crops and irrigations may be applied at longer interval, if it becomes necessary.

ii. Soil characteristics

- Water retentive capacity of soil is considered as the most important soil factor deciding the frequency and interval of irrigation. A soil with greater water retentive capacity serves as a bigger water reservoir for crops and can supply water for longer duration. Consequently, frequency of irrigation is lower and interval of irrigation is longer. On the other hand, the frequency is higher in porous sandy soils with coarse texture, poor structure and low organic matter content. Retention of greater amount of available water is considered more important than total quantity of water retained by a soil.
- Depth of soil is another factor that influences the frequency of irrigation. A shallow soil cannot hold enough water to meet the crop demand for a longer period. Necessarily,

frequent irrigations are required with smaller depth of water each time. Irrigations at longer interval is applied to deep soil that has a greater water storage capacity. Such a soil can supply water for longer duration particularly when the root system is quite deep and extensive.

iii. Crop characteristics

- Crops vary in their consumptive use of water, sensitivity to water stress, water extraction capacity and optimum water regime. Frequency of irrigation thus varies with crops. Crops like vegetables, onion and sugar beet that require a higher level of water to be maintained in the soil need frequent irrigations than other field crops.
- Many crops have varieties that are either sensitive or tolerant to drought conditions. Varieties sensitive to drought conditions require frequent irrigations compared to tolerant varieties.
- Rooting characteristics of crops such as shallow or deep, fibrous or tapering, vertically or laterally extensive root systems decide the frequency of irrigation. When the root system is shallow and fibrous, crops are not able to utilize water from deeper soil layers and are frequently irrigated with smaller depth of water to wet only the upper soil layers. Crops with deeper and extensive root system command a greater depth of soil and water reserve and require irrigations at longer interval. Sometimes, they may get water from water table which is not deep enough. Shallower water table reduces the irrigation requirements and help to increase the interval between irrigations. Besides, the concentration and relative proportion of the root mass in different soil layers decides the water extraction capacity. They represent the extraction capacity of crops from different depths of soils.
- Irrigation frequency varies with stages of crop growth. The consumptive use rate, sensitivity to water stress and rooting characteristics of crops change at different stages. A crop when young and delicate needs frequent irrigations. Subsequently, the consumptive use rate gradually increases and at the same time the root system also develops. Irrigations can then be applied at longer interval, as roots are able to draw water from greater volume of soils. When a crop approaches maturity, the demand for water greatly declines because of steep fall in consumptive use rate.

iv. Management practices

- Soil water conservation practices such as artificial or soil mulching and crop cultural practices like weeding and hoeing help to reduce the evaporation loss and conserve more soil water for crops use. Thus, there is a reduction in irrigation requirement of crops. Method of irrigation, depth of water applied each time and the water distribution efficiency influence the frequency of irrigation.

v. Irrigation period

- Irrigation period is the time, usually expressed in days, that can be allowed for applying one irrigation to a given design crop area during the peak consumptive use period of the crop. It is a function of the peak-period consumptive use rate. It is considered for designing the irrigation system capacity and equipment. The irrigation system must be so designed that the irrigation period is not greater than the irrigation interval.

2.3 Ordering water according to water management authority standards and procedures

Proper irrigation management demands application of water at the time of actual need of the crop with just enough water to wet the effective root zone soil. The principal aim is to obtain maximum crop yield by making the most efficient and economic use of water. Time of irrigation is usually governed by two major conditions namely,

i. Water need of crops and
ii. Availability of irrigation water

i. Water need of crops

- Water need of crops is, however the prime consideration to decide the time of irrigation.

ii. Availability of Irrigation Water

- Irrigation water is often in short supply in most locations and therefore demands a careful and economic use.
- Economy of water helps to bring more areas under protective irrigation and leads to greater crop production in areas of limited water supply.
- In areas where water is scarce, farmers are not able to apply normal irrigation to crops and are forced to skip some irrigation.

2.3.1. Criteria for scheduling irrigation

- The optimum scheduling of irrigation should be based on crop needs to avoid both over and under-irrigation and to ensure high water use efficiency.
- A thorough understanding of the soil-water - atmosphere relationship is essential for proper scheduling of irrigation, since irrigation needs of crops are decided by the evaporative demand of the atmosphere, soil water status and plant characteristics.
- The criteria for scheduling irrigation, as attempted from time to time, may be grouped into three categories, namely,
    i. Plant criteria,
    ii. Criteria based on soil water status and
    iii. Meteorological criteria.
- Plants show up certain characteristic changes in their constitution, appearance and growth behavior with changes in available soil water and atmospheric conditions.

i. Plant criteria

- Different plant criteria considered to schedule irrigation are presented below:-

A) Plant appearance

- With water stress, some characteristic changes usually occur in the general appearances of plants.
- There may be changes in the normal colour of plant or distortions of plants such as wilting or drooping of plants and curling or rolling of leaves.
- Some crops like leafy vegetables are very sensitive to soil-water changes and develop scarcity symptoms easily, while others do not. Changes in colour appear first in the lower leaves.
- Water stress is also shown by temporary wilting of plants, as with sugar beet during the hottest part of the day.
- Fruit plants do not easily show up water stress by changes in appearance until serious retardation in growth takes place. However an experienced orchardist can detect early signs of stress by the appearance of the foliage especially during the period of peak transpiration demand.
- Young leaves are the most sensitive part in this regard.

- This technique is however quite simple and rapid, but suffers from many deficiencies. Changes in colour may be misleading since nutritional disorder, insect damage, disease attack and varietal character cause variable changes in foliage colour.

B) Plant water potential and water content

- Some crops show strong correlation between the water content of leaf or leaf sheath and the available soil water.
- The relative leaf water content (RLWC) and leaf water potential change with variations in soil water availability or owing to lag between water absorption by plants and evaporative demand of the atmosphere.
- Adverse physiological and growth phenomena specific to plant species have been reported with fall in the RLWC and water potential below certain critical limits.
- As mentioned in the 3rd schedule a drop of 8-10% moisture(-5 to -6 bars of leaf water potential)causes a mild stress and crop is to be irrigated before the critical RLWC is reached.
- The RLWC and Leaf Water Potential (LWP) values for the individual crops and their stages are to be standardized for scheduling irrigation. However, sophisticated equipment, intricate measuring devices, high cost and lack of proper standardization of instruments deter the use of this technique on a large scale.

C) Plant growth

- Cell elongation is considered as the growth process that suffers first with water stress in plant.
- Subsequently, retardation in growth of height or internodal length occurs.
- Timing of irrigation can be set as and when the normal growth rate is observed to decline.
- This is, however, possible in places where a continuous measurement of plant growth is maintained.
- This technique offers many difficulties owing to unavailability and high costs of equipment and so on.
- The serious objection to this approach of scheduling irrigation is that the plants suffer before they show any retardation in growth processes.

D) Critical crop stages of water need

- Irrigation scheduling may be decided based on stages of growth more conveniently in crops in which the physiological stages are distinct to locate the critical periods of water need. Scheduling of irrigation based on these critical stages is most convenient for ordinary Indian farmers who may need, at the most, some guidance or education initially. However, it may be a little difficult in crops where stages are not so well defined.

E) Indicator plant

- There are some plants sensitive to soil-water variations.
- They may be used for detecting the water stress in crops that do not show symptoms of water stress easily or exhibit the same when they have already suffered seriously.
- Sunflower plants are often used as indicator plants in onion crop.
- An indicator plant for irrigation should be such that it shows the water stress before the crop has suffered from it.
- When an indictor plant is grown in a crop field, care should be taken not to shade the plant by crop plants.

F) Stomatal aperture and Leaf diffusion resistance

- Opening of stomata in plants is regulated by soil water availability.
- Stomata remain fully open when the supply of water is adequate, whereas they start closing with scarcity of water in soils to restrict the transpiration.
- Water deficit in plants is directly related to availability of soil water and that may be used for scheduling irrigation in crops.
- A close relationship exists between leaf diffusion resistance (LDR) and plant water stress. LDR is a sensitive index of internal water balance in the mild to moderate stress range and holds a promise for scheduling irrigation.

G) Plant temperature

- Solar radiation received on earth heats up leaf tissues besides causing evapotranspiration and heating up the ambient air.
- With water deficit in plant the temperature of leaf tissues rises.
- Many investigations have shown that leaf or canopy temperature is a sensitive index of plant water status.

ii. Criteria based on soil water status

- Scheduling irrigation based on soil water content is the most accurate and dependable method. Determination of available soil water is rather more important than estimating the total water content of soils. For the purpose, information on the optimum water regime of crops and the available water holding capacity of soils is essential. Irrigation is applied when the soil water content reaches the lowest point of optimum soil water regime. The optimum water regime for a crop in a place is determined experimentally by correlating yield with the water contents of soils.
- Various methods are used to determine the soil water status and farmers may choose any of the methods according to their needs, accuracy wanted and facilities available for estimating soil water.
- The criteria based on soil water status attempted or used to schedule irrigation to crops are discussed here.

A) Soil water content

- Early attempts were made to schedule irrigation when the soil water content reached a certain value. The idea did not succeed since there existed a wide variation in the water content retained by the different classes of soils.
- However later a new concept of scheduling irrigation based on the lower limit of soil water content for potential evapotranspiration of crop was made.
- In this approach it was assumed that the growth of crop was likely to suffer below a level of soil water.
- This threshold limit could be decided for various crops, soil types and atmospheric evaporability.
- In the fruit crops, irrigation is more effective if applied before soil moisture becomes limiting.
- As a rule of thumb, water should be applied when 50% of the available water in the root zone have been depleted. If further depletion is allowed, the plants may be subjected to a level of stress that might cause an appreciable reduction in yield.

B) Depth-interval of irrigation

- Since the water retentive capacity of soils varies widely with soil types and soil physical conditions, and root zones of crops vary with types of crops and their rooting characteristics at different growth stages, the depth and interval of irrigation require modifications in different soils and at various crop growing periods.
- The draw back of this method is that an arbitrarily fixed depth or interval of irrigation has misleading effects on crop growth and yield.

C) Critical level of available soil water

- As stated earlier, the critical level of soil water denotes the level of available water below which the crop growth and yield decline drastically.
- It is the lowest level of the optimum soil water regime.
- This level once established experimentally for various crops in different soil types and soil conditions can be profitably used for scheduling irrigation.
- This approach has been widely suggested for adoption. A periodical determination of soil water content is made to know the time when the soil water is likely to reach the critical level. This criterion is synonymous with the concept of available soil water depletion for deciding the time of irrigation. The depth of irrigation however needs revision upwards every time with increasing vegetative growth and rooting depth of an actively growing crop.
- In fruit trees more tan 80% of water is drawn from 0 – 90 cm layer and amount water to be added to fill only this depth of soil. But during summer the the depth of soil to be taken for consideration extends up to 120cm.
- The critical ASM limit for crops like brinjal, chilli and cucumber is 50%; Tomato, onion, garlic and cabbage is 60% and cauliflower and leaf vegetables is 70%.

D) Soil water tension

- Many scientific workers have used this criterion for scheduling irrigation to crops in various parts of the world. Tensiometer techniques are used for irrigation. In many countries, the tensiometer has been considered as a useful device for scheduling irrigation to orchard and vegetable crops, particularly on coarse textured soils where most of the available water is held at low tensions.

- The use of tensiometer for controlling irrigation did not find much favour with common farmers since the device presents certain difficulties in its use.
- The tensiometer can be used only in the lower tensions up to 0.85 bars.
- It does not show the actual soil water content for direct calculation of the depth of irrigation to be applied.
- The water content is calibrated from the soil tension curve.
- Again, there exists a time lag in tension-equilibrium between the porous cup and the surrounding soil that makes the tensiometer showing the energy status of soil water earlier to the existence of the actual soil water content.

E) Electrical resistance

- The concept of electrical resistance that varies inversely with the water content in soils was also tried to schedule irrigation.
- For this purpose, resistance blocks made of gypsum, nylon, nylon-resin etc, were used.
- Crops were irrigated when the electrical resistance reached a certain value.
- The value could be decided experimentally for various crops by using the resistance blocks.
- This method has however many limitations and did not become popular. T
- he limitations are that resistance blocks cannot be used at low tension at which most of the available water is held by soils, difficulty in deciding the depth of irrigation as resistance blocks do not directly show the prevailing soil water content and the existence of a time-lag in tension-equilibrium between the porous block and the surrounding soil which causes showing up the energy status of soil water earlier.

iii.Meterilogical data

- Criteria based on the climatic approach are dealt in the subsequent classes.

2.4 Giving adequate notice of water required

In a Commercial Farm, the Irrigation Manager and Supervisor will meet weekly to review the annual plan, discuss the findings from crop monitoring and plan the irrigation schedule for the next week.

In a Water Users Association or Cooperative, each Farmer must submit their requirements in accordance with the Association or Cooperative By-Laws and operating schedule and Farmers need to secure their water supply before plant in their crop.

Self-Check 2	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. Identify four different sources of irrigation water
2. Explain why we need to know irrigation water amount?
3. List the factors that determine crop water requirement
4. Explain the difference between crop water requirement and irrigation water requirements
5. List the information needed to determine irrigation water requirements and explain where to find this information
6. Explain how to calculate the irrigation water requirement of a crop
7. Explain the importance of including irrigation efficiency in the calculation of irrigation water requirement
8. Explain how the use of water for irrigation is regulated in Ethiopia

Operation Sheet 2

2.1. Determining the amount of irrigation water needed for a given cropping plan

A. **Tools (information's required):** Collect crop data for the given cropping plan and the irrigation records for previous production of these crops on the site

B. Procedures

- Collect data for rainfall and evapotranspiration for the site
- Predict the irrigation water requirements from previous irrigation records
- Use the data collected to calculate the water needs for one crop included in the cropping plan
- Collect and evaluate data relating to Irrigation use, rainfall and evapotranspiration
- Calculate crop and irrigation water requirements

LAP Test 2

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

Time started: ________________ Time finished: _________________

Instructions: Given necessary templates, tools and materials you are required to perform the following task within **30** minutes. The project is expected from each student to do it.

Task 1: Determine the amount of irrigation water needed for a given cropping plan

LG #3	LO #3 Coordinating irrigation shifts and performing irrigation system

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

- Briefing and coordinating resource
- Implementing agreed irrigation schedule
- Recording frequency of irrigation
- Measuring and recording water usage
- Calculating water usage differences between estimated water use and actual water
- Measuring water quality.
- Assessing plant or crop growth and water use efficiency
- Assessing and measuring soil chemical characteristics and moisture
- Selection and use of relevant personal protective clothing and equipment
- Identification and assessing OHS hazards and risk

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:

- Brief and coordinate resource
- Implement agreed irrigation schedule
- Record frequency of irrigation
- Measure and record water usage
- Calculate water usage differences between estimated water use and actual water
- Measure water quality.
- Assess plant or crop growth and water use efficiency
- Assess and measure soil chemical characteristics and moisture
- Select and use the relevant personal protective clothing and equipment
- Identify and assess OHS hazards and risk

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 4. Accomplish the Self-checks 5. Perform Operation Sheets 6. Do the "LAP test"

Information Sheet 3

3.1. Briefing and coordinating resource

Briefing and coordinating irrigation personnel

Personnel employed to operate the irrigation system and irrigate crops on the farm need:

- **Training and work instructions** for how to operate the system, e.g.

  For Drip irrigation, how to operate the pump, what order to open and close valves and how to open and close valves, how and how often to clean filters, how and when to unclogging emitters

  For Furrow irrigation, how to manage the flow of water into the furrows and throughout the cropped area

- **Clear instruction about the irrigation schedule**: Date, field/block, crop, method of irrigation to be used
- **Clear instruction about how much water to apply to each block** e.g. how much water to apply, irrigation interval, depth of soil wetting required, duration per irrigation etc.

3.1.1. Coordinating resources

Irrigation has a high investment cost for construction, tools and equipment, so it is essential that these resources are managed effectively to maximize the working life and ensure that the tools and equipment are available and in good working order when required.

The range of structures, tools and equipment involved will depend on the type and scale of irrigation used but may include any or all the following:

- **Irrigation structures:** Such as canal, pond, Reservoir, geomembrane, pipes, stand, Tanker, shallow/deep well structure etc.
- **Energy source**: Fuel, electric, wind, solar energy etc.
- **Water lifting devices**: Pump, solar pump, treadle pump, hip pump etc.
- **Water deliveries:** Pipelines, valves, sprinkler or drip lines, fittings, filters, gates, etc.

- **Tools:** spade, hoe, rake, shovel,
- **Measuring and monitoring equipment:** Water meter, tensiometer, water measuring devices, flumes, weirs etc.

Management of these various tools and equipment requires that attention be given to:

- Maintenance and repair, annual and periodic according to manufacturer's guidance
- Regular servicing, pre-start checks and carrying out repairs prompt as necessary
- Correct usage in accordance with instructions
- Correct storage and accurate stock keeping
- Tools and equipment are managed correctly and kept in good working order
- Workers are trained to use the equipment correctly
- Tools and equipment required for field irrigation are listed and available when the work is to be done.

3.2. Implementing agreed irrigation schedule

Irrigation scheduling is defined as the process of determining when to irrigate and how much water to apply.

The objective of irrigation is to replace the water used by the plant and lost by evapotranspiration and drainage.

The purpose of irrigation scheduling is to determine and document when to apply water and how much water to apply to maintain crop growth and realize the crop economic yield potential.

Factors affecting Irrigation Scheduling

Irrigation water is applied to the cultivated crops according to predetermined schedules influenced by the farmer and farm manager. Good scheduling will apply the right quantity of water at the right time to optimize production and minimize adverse environmental impacts. Irrigation scheduling is affected by the following factors.

- Soil type, use of organic matter and soil tillage practices
- Crop type, root depth and stage of development
- Irrigation method and availability of irrigation water

- Climatic conditions such as temperature, wind, humidity, and rainfall etc.

A. Soil Type:

The **soil** type influences the maximum amount of water which can be stored in the soil per meter depth of the soil. Sandy soils have a high percolation rate, good drainage and low moisture holding capacity. Therefore, on sandy soils irrigation should be supplied in lower amounts and more frequently than on clay and silty soils.

Clay and silt soils have a higher water holding capacity so irrigation can be supplied in larger volumes and with a greater amount of time between irrigation cycles. Tillage practices are also important; the addition of organic manure or use of mulch will increase water holding capacity and deep ploughing or ripping will increase the depth of rooting.

B. Crop to be grown:

The Crop type, root depth and stage of development also need consideration. Newly transplanted crops and crops with a shallow root system require more frequent irrigation than well-established crops with deep root systems. Crop sensitivity to moisture stress also varies, e.g. onions and lettuce are more sensitive to moisture stress than grass or cabbage and the flowering, flower setting and fruit swelling stages of growth are more sensitive than the vegetative stage of growth.

C. Irrigation method and source of water

These are practical considerations. For example, when using an automated system, it is possible to apply irrigation frequently with little additional labour cost but frequent irrigation with furrow irrigation requires a lot of man-hours (labour). Availability of water may also have an overriding impact on the amount of water applied and frequency of irrigation.

D. Climatic conditions

Hot dry windy conditions increase the need for irrigation and cool wet weather reduces the need for irrigation. Climate conditions cannot be reliably predicted accurately at the start of the season so irrigation schedules may need to be adjusted during the crop life in response to changing weather conditions.

Irrigation scheduling methods

Irrigations can be scheduled using varies methods from simple soil moisture monitoring using the feel and appearance method to sophisticated computer assisted programs that predict plant growth. Scheduling involves continual updating of field information and forecasting future irrigation dates and amounts.

The following are some of irrigation scheduling methods in use:

i. **Fixed irrigation interval**

Irrigation turns are mutually agreed and fixed among the growers and it is applied according to fixed pre-determined schedule. It is based on the available quantity of water and size of the land. In water shortage area the irrigation interval is wider, and the time give for one irrigation interval is also short. This means it does not give due consideration to crop water requirements. The crops are either under irrigated or over irrigated. It is the dominant irrigation scheduling methods applied in most of Ethiopian small holder farmers.

ii. **Plant observation method**

The plant observation method is based on observing changes in the plant characteristics, such as changing in color of the plants, curling of the leaves and wilting of plant. In this method crops are irrigated after they enter to stress due to moisture shortage.

iii. **The soil moisture monitoring method**

For the small-scale farmer and field irrigation technicians feeling the soil is the most practical and reliable method of determining soil moisture and irrigation need is recommended based on the dryness of the soil. This method is easy to use and results in a lower risk of yield loss than waiting for the plant to show symptoms of stress.

iv. **Computational (calculation) method**

Typically, the data that will be required to compute an irrigation schedule for a crop is:

- The type of crop, the growth stage and the rooting depth
- Available water holding capacity of the soil and
- Daily evapotranspiration rate (ETc) of the crop
- The maximum allowable moisture deficit (MAD)

The below procedure can be used to compute irrigation scheduling:

Step 1.Compute ETo and obtain appropriate Kc-values to get daily ETc,

Step 2.Find out the root zone depth (Drz) at different growth

Step 3.Find out maximum allowable deficit (MAD) for selected crops

Step 4.Find out the total available water (TAW) in the root zone at the respective growth stages

Step 5.Find out the allowable depletion/readily available water for respective root depth.

Step 6.Divide step 5 by daily ETc (step 1), this will give irrigation interval in days

Step 7.Multiply step 6 by ETc (step 1). This will give net irrigation requirement for each Interval.

Example:

Determine irrigation amount, interval and duration for onion from the following given data;

- ETc = 4.5mm/day
- Soil type = Loam
- Total available water or moisture (TAW) = 165mm/m
- Depth of Root Zone Drz = 60cm
- Maximum allowable deficiency (MAD) = 25%
- TAW at the Drz of 60cm = 165 x 0.6 = 99mm
- MAD = 25%; at root depth of 99mm it will be 0.25 x 99mm = 25mm.
- Irrigation Interval = MAD/ETc = 25/4.5 = 5.5 rounded down to 5 days
- Depth of water (net irrigation Requirement)
  = Irrigation interval * ETc = 5 x 4.5 =
  22.5mm
- Irrigation Efficiency = 60% then 22.5/.7 = 37.5mm
- Total Irrigation requirement per irrigation interval= 37.5mm

Once irrigation interval and amount are fixed, it is a matter of computing the discharge and time required to refill the soil moisture.

We can use the following formula to calculate the time taken to refill the required depth.

Discharge * time = Area * irrigation depth (QT=Ad)

Then

Calculate irrigation duration to irrigate 0.25ha if the gross irrigation depth is 35mm and the Scheme discharge rate is 5 lit/sec.

Solution:

1litre/sec = 3.6 m^3/h.

Scheme discharge = 5 lit/sec = 18 m^3/h

1 sec=1lit

3600 sec=? -------- with 1hrs=3600lit = 3.6m^3/hr

Area = 0.25ha = 2500m^2

Irrigation depth of 35mm =

0.035m QT = Ad

$$T = \frac{\text{Area x Depth}}{\text{Discharge}}$$

$$T = \frac{2500m^2 \text{ x } 0.35m}{18m3/h} = 4.8hrs$$

3.3.Recording frequency of irrigation

Definitions: Irrigation interval is the number of days between irrigation applications where as **Irrigation frequency** is a record of how often irrigation takes place.

The procedure for keeping records should include:

- What is to be recorded and how often should records be kept
- Who is responsible for keeping the records and who is responsible for analysing the records to produce useful information at the end of the crop?
- How the records are to be kept (Proforma to use and filing system)

Here are some general steps you can follow to record irrigation frequency:

1. Determine the crop type and specific water requirements.
2. Install irrigation gauges or sensors to measure water usage and soil moisture.
3. Record the date and time of each irrigation event.
4. Record the amount of water applied during each irrigation event.
5. Monitor the soil moisture level at regular intervals (daily or weekly, depending on the crop).
6. Adjust the irrigation schedule based on soil moisture levels and weather conditions.
7. Track any changes to the irrigation system or crop management that may affect water usage or plant stress.

To calculate the Irrigation frequency

For example, if the growing season of one crop is 110 days and if irrigation is stopped 10 days before harvesting, the total days that the crop irrigated is 100 days.

Let say the early growth stage of the crop is 28 days and the irrigation interval used was 4 days, and for the remaining growth period, the irrigation interval was 6 days.

Then at early stage the frequency was 7 times and at remaining stage the frequency was 12 times. Therefore, totally for the crop, the irrigation frequency was 19 times.

3.4.Measuring and recording water usage

Record water orders and water usage.

Water Orders:

All farms should keep records of water orders made and the allocation of water agreed.

- **Small farmers** will need to work within the guidelines of their 'Water Users Association or Cooperative' and **Commercial Farms** must operate within the terms of their Water Abstraction License.

Water usage:

All farms should keep records of water usage for each application and cumulatively for each crop and the whole farm. These records are useful for:

- Detection of leaks and wastage

- Estimating water needs and making water orders for the next crop / season

Being able to demonstrate that the amount of water actually used is as agreed with the Water Users Association/Cooperative or is within the amount permitted by the Abstraction License.

Record irrigation shifts.

Irrigation shift records are useful for:

- Planning the next irrigation (based on the previous irrigation, Farmers will apply the same or increase / decrease the amount of water to be applied according to the weather, crops growth, soil moisture and signs of crop stress)
- Reviewing the irrigation frequency and water use requirements and total water use at the end of a season or year.

Information that should be recorded for all types of irrigation will include:

- The date, production location, crop, and crop growth stage
- If possible, the total water use and each application rate
- Manhours used for irrigation operation and
- Fuel or electricity used for pump operation

Then for particular types of irrigation, additional records will be needed e.g.

- For furrow irrigation, drip, and fixed sprinkler lines
    - Irrigation interval, the frequency of irrigation (dates) and the depth of wetting achieved
    - In Greenhouse hydroponic systems, irrigation interval, the number of cycles /day and percentage run off

3.5. Usage differences between estimated water use and actual water

There are often differences between estimated water use and actual water use in irrigation. This is because there are a number of factors that can affect water use, such as weather conditions, changes in crop conditions, and the efficiency of irrigation systems. Estimating water use is typically done based on historical data and assumptions about crop water needs, while actual water use is measured or monitored in some way. These differences can have economic and environmental implications, as overestimating water use can lead to wasted resources and underestimating it can lead to crop stress and reduced yields.

Here’s an example of how estimated water use and actual water use can differ in irrigation:

Let's say that a farmer estimates that a particular crop will require 2 inches of water per week based on historical data and assumptions about crop water needs. The farmer sets up an irrigation system to provide the estimated amount of water to the crop. However, in the middle of the growing season, a heat wave hits the region and causes the crop to become more stressed than anticipated. As a result, the crop needs more water than was originally estimated. If the farmer does not adjust the irrigation system accordingly, the crop may suffer from reduced yields, and the farmer may waste water by providing more than the crop needs beyond what was estimated. This shows the potential discrepancy between estimated and actual water usage in irrigation.

For example:

If we have a pond containing 350m^3 water and a field with an irrigation requirement of 330m^3 and the Irrigation Team use the whole content of the pond to irrigate the field.

This means that there is over application of 20 m^3.

3.6. Measuring water quality.

Water quality relates to the physical, chemical, and biological characteristics of the water and determines the suitability of the water for use in irrigated crop production.

Important quality parameters are:

Physical quality parameters

Solid material in the water can be abrasive to equipment and blocks filters

- Water contaminated with solid material will appear cloudy and the physical material may sediment out when a sample of water is left to stand.

Chemical quality parameters

Chemicals found in some water supplies can reduce crop yield, clog irrigation emitters and affect the structure and chemical properties of the soil. Some examples are:

- Alkaline pH of the water which can raise the soil pH and cause micronutrient deficiency

- High carbonate and bicarbonate levels which will raise soil pH and clog irrigation emitters
- High sodium content which may be toxic to the crop plants and will cause soils to become sodic. Clay soils will become deflocculated and drainage will be impaired
- High nitrate or phosphate content which will support algae blooms that will block irrigation filters and emitters and may be toxic to humans and livestock
- High conductivity of the water can cause the soil conductivity to rise making it more difficult for the crop plants to take up water
- Contamination with pesticides and industrial effluent that is toxic to plants.

Biological quality parameters

Here the contamination of the water supply with human pathogens and soil or water borne crop pests and diseases are all of concern. Some examples are:

- Transfer of pests and diseases, e.g. fusarium and nematodes within a field or from one farm to another. Farms should minimise run-off. Water used in intensive hydroponic systems can be treated to minimise pest and disease transfer but in field production treatment is not practiced.
- Contamination of water supplies with human or animal faeces. Pathogens in the faeces can be a health hazard for irrigators and consumers.

3.7. Assessing plant or crop growth and water use efficiency

3.7.1. Assess plant or crop growth

Stage of crop growth e.g. germination, weaning, establishment, vegetative growth, flower initiation, fruit setting and fruit or seed swelling. All these stages can be recognized by the farmer by visual examination of the crop and, for some crops, the water regime used will be adjusted to stimulate or respond to these changes on stage of growth.

Depth of rooting is also important as efficient use of irrigation water requires wetting of the root zone but not leaching from the root zone. Depth of rooting can be established by digging to expose the root on several locations in the field to give a representative overview of the root zone depth in the crop.

Marketable yield and reasons for yield loss, e.g. poor plant establishment (Cross ref Harvest records)

3.7.2. Water use efficiency

The term efficiency refers to output /input ratio.

There are a number of ways of measuring and expressing Water Use Efficiency in plants and in crop production, the term is adapted to include 'Water productivity. Therefore, for the Farmer, in relation to irrigated crop production Water use efficiency can be taken to mean the number of kilos of marketable crop produced per litre of irrigation water applied.

Water use efficiency figures can be used as a management tool to compare the return per litre of water for various crops and to explore the interaction between use of inputs, water, and productivity.

Farmers and irrigation engineers are also interested in the various factors that contribute to the efficiency of water distribution by the Irrigation system.

3.8. Assessing and measuring soil chemical characteristics and moisture

3.8.1. Measurement of soil chemical characteristics

In some cases, the soil pH and conductivity (salinity) are affected by the use of irrigation. Where the water used is naturally alkaline the carbonate and bicarbonate ions from the water can accumulate in the root zone and cause an increase in pH. This can lead to deficiency of some micronutrients, particularly iron.

Where the water used has a high mineral content the ions from the water will accumulate in the root zone and cause conductivity. High conductivity makes it more difficult for the crop to take up water. In some cases, the ions from the water may also be toxic to the plant or will affect the soil structure leading to problems with aeration and drainage.

- Irrigate field production ….. check pH and EC every 2 years.

  Increase the frequency when a trend of increasing pH and EC is detected.

- Irrigated crops in Greenhouses …. In soil check 2-4 times per year

  …. In hydroponic systems check every 1-4 weeks

3.8.2. Assess soil moisture

There are several techniques used to measure soil moisture. Common examples include: Gravimetric moisture determination, feeling the soil and using a stick, tensiometers, a moisture meter or a neutron probe.

Gravimetric Moisture Determination

The Gravimetric technique is a laboratory-based exercise. Representative soil samples are collected from the field, weighed, then oven dried at 105^{0}C for 24 hours. The dry sample is then weighed, and the moisture content determined using the formula below.

Feel method

This is a Field technique that is widely practiced internationally. A sample of soil is taken from the root zone and tested by squeezing the soil between the thumb and forefinger or by squeezing the soil in the palm of a hand. Note whether the soil sticks together and sticks to the fingers and palm of the hand, see Figure 18 overleaf.

25-50% soil moisture available **Irrigation is urgent**	**50-75% soil moisture available** **Irrigation needed soon**	**75-100% soil moisture available** **Soil is OK for crop growth**

Figure 3.1. Feeling method soil moisture test

Tensiometer : A Tensiometer is a sealed, water-filled tube with a porous ceramic tip on the lower end and a vacuum gauge on the upper end. The porous pot is filled with deionised water and the tube is installed in the soil with the ceramic tip placed at the desired root zone depth and with the gauge above ground. A vacuum pump is then used to create a partial vacuum in the tensiometer tube. As soil dries out, water moves out of the pot creating a vacuum and the pressure reading rises. Then when the soil is irrigated, water will move from the soil into the porous pot and the pressure reading will decrease.


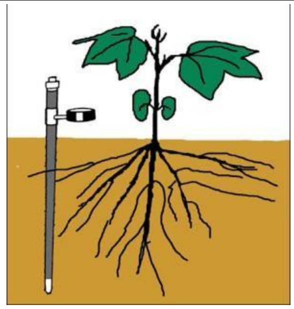


Figure 3.2. Soil moisture measurement using Tensiometers

Interpretation of Tensiometer readings

Table 3.1 Interpretation of tensiometer recording

Reading (in Centibars)	**Interpretation**
0	Very wet – Saturated
10 – 25	Favorable soil moisture and aeration condition
25 – 40	It is required to irrigate for most sensitive plants with shallow root system and light soils
40 – 50	It is required to provide irrigation for plants with moderate water needs
50 – 70	It is required to provide irrigation for plants with deep rooted system growing on moderate soils – in case of heavier soils, one c an start irrigation later when the gauge reading is about to reach the value of 70 centibars. Above 70 is stress range
80	Relatively dry soil

A soil moisture meter measures the electrical resistance of the soil which is proportional to the moisture content of the soil. The probe is inserted into the root zone and left for some minutes to equilibrate. Then the reading on the dial will indicate whether the soil is wet, moist, or dry.This is a quick and easy method of whether irrigation is needed at the time of testing.

Figure3.3. Soil moisture meter

3.9. Selection and use of relevant personal protective clothing and equipment

When it comes to personal protective clothing and equipment for irrigation personnel, there are several items that can help protect workers from the hazards associated with operating irrigation systems. Here are some relevant examples:

1. Gloves: Gloves can protect hands from exposure to chemicals, sharp objects, and rough surfaces.

2. Goggles or safety glasses: Eye protection is essential to protect against splashes and dust.

3. Respirators: When working with certain chemicals or in dusty environments, respiratory protection may be necessary.

4. Hard hats: Workers may be at risk of head injuries from falling objects or low-hanging branches, so hard hats can help prevent these types of injuries.

5. Boots: Slip-resistant boots with steel toes can protect feet from crushing injuries or punctures.

6. High-visibility clothing: Workers should wear brightly colored or reflective clothing to ensure they can be seen by others, particularly when working near roads or highways.

7. Sunscreen and sun hats: Outdoor workers should apply sunscreen and wear hats to protect against the harmful effects of the sun. 8. Insect repellent: Depending on the location and season,

workers may need to use insect repellent to protect against bites from mosquitoes, ticks, and other insects.

It's important for employers to assess potential hazards and provide appropriate personal protective equipment (PPE) to their workers. Regular training on the proper selection and use of PPE can also help prevent accidents and injuries.

3.10 Identification and assessing OHS hazards and risk

The following suggestions are aimed at ensuring the safety of the irrigator as well as preventing damage to the equipment.

- Read and follow directions in the owner's manual for each piece of equipment, paying particular attention to the safety precautions and features listed. Make sure that all employees also read and understand all directions and precautions.
- Store irrigation pipe at least 100 feet from overhead powerlines.
- Look overhead and note electric power lines that are within reach of the long pipes. When Lifting and transporting the pipe sections, keep clear of the power lines.
- Avoid moving irrigation equipment on windy days when pipes could be blown into nearby power lines and keep pipes horizontal to the ground rather than vertical to minimize the risk of contact with power lines.
- Be certain that moving irrigation equipment will not contact buildings, power lines, poles, wires, etc.
- Disconnect electric power before servicing a machine by personally shutting off and locking the master control. Also make sure that everyone is clear of the machine before it is turned back on.
- Stay away from the equipment during an electrical storm.
- When working with irrigation hydrants and valve openers care must be taken to prevent a sudden release of water pressure which could cause severe injury. When setting valve openers onto field irrigation hydrants make sure the valve opener locking lever is swiveled far enough colckwise to lock it onto the hydrant ears. Always do a quick visual check to make sure the valve opener is locked onto the hydrant ears before turning the water on or off.

- Stay out of the way of high-pressure water streams, such as end guns.
- Protect electric motors from overload, overheating, overvoltage, undervoltage, phase imbalance in three-phase electrical systems, phase failure, low current or high current.
- Be sure the engines used to power pumps are equipped with safety devices that will stop them before damage occurs from overload, overheating, loss of oil pressure or runaway (if pump becomes disconnected or loses its prime).
- Be sure all pumps are equipped with devices that will shut off the electric motor or engine if there is a break in the suction or loss of pressure in the main pipeline.
- To perform overhead maintenance, use a ladder that is sufficiently tall as well as stable.
- Have qualified service personnel perform any hazardous repair or maintenance.
- Keep all guards and shields in place, especially those covering power-take-off units.
- Make sure that service or auxiliary equipment is not in the path of the irrigation system.
- Bury all power lines around the equipment, and clearly mark where they are buried.
- Keep away from moving parts when equipment is in operation.
- If fuses or circuit breakers keep blowing, don't "correct" by over-fusing. Find the cause.
- Do not irrigate at air temperatures below 40F. Spraying has a cooling effect, and the water can freeze even though the temperature is above 32F.
- Periodically check the system for any loose or missing bolts, which could cause collapse of the equipment.
- Know what to do should an emergency situation occur, and also instruct all employees on what to do.
- If chemicals have been added to the irrigation water, avoid exposure to spray drift; and make sure that the spray does not blow past the area of intended operation.

Self-Check 3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. Short answer question

1. Define the term Irrigation schedule
2. Define irrigation interval and irrigation frequency
3. List the main components of a plan for the management of irrigation tools and equipment
4. List the factors which will affect the irrigation schedule
5. List the procedure used to compute irrigation scheduling
6. Explain why it is important to check irrigation resources before irrigation

Operation Sheet 3

3.1. Calculate the irrigation amount and irrigation interval

Calculate irrigation scheduling (irrigation amount and interval) using computation method from the following given data.

- Crop =Pepper
- ETc =4.mm/day
- Soil = Loam
- TAW = 165mm/m
- Drz =70cm
- MAD =40mm/m
- Irrigation Efficiency=60%

What time it takes to fill this depth for 1ha if discharge rate of canal is 3lit/sec

LAP Test 3

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

Time started: ________________ Time finished: _________________

Instructions: Given necessary templates, tools and materials you are required to perform the following task within **40** minutes. The project is expected from each student to do it.

Task 1: perform irrigation scheduling for a given crops from the given meteorological data

The following are the given environmental data.

- Crop =Pepper
- ETc =4.mm/day
- Soil = Loam
- TAW = 165mm/m
- Drz =70cm
- MAD =40mm/m
- Irrigation Efficiency=60%

LG #4	LO #4 Recording irrigation information and activities

Instruction Sheet
This learning guide is developed to provide you the necessary information regarding the following content coverage and topics: • Recording plant or crop response to environment • Recording crop water use irrigation schedule • Recording irrigation shifts system/data 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 response to environment • Record crop water use irrigation schedule • Record irrigation shifts system/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 4. Accomplish the Self-checks 5. Perform Operation Sheets 6. Do the “LAP test”

Information Sheet 4

4.1. Recording plant or crop response to environment

Annual planning of Irrigation is based on the cropping program for the farm. The annual cropping program for the farm should be made before the start of the farming year and should be documented. Relevant information will include:

- Crops, varieties, field location, area to be planted, planting dates, irrigation interval,

These records will be used to plan and adjust Irrigation shifts and will include for each crop:

- Crop type, variety, and field location
- Stage of crop development
- Signs of 'stress' shown by the crop, e.g. vigor of growth, leaf color, wilting, bud abortion, root death, leaf yellowing, nutrient deficiency, and plant death

Crop environment data related to irrigation should also be recorded. Environmental records will include observations made during routine monitoring before, during and after each irrigation cycle. Useful information (records), will include:

- Soil moisture status in the root zone for crops in soil and in specialised hydroponic systems, the drip and drain volume
- Water levels in surface water sources, reservoirs, wells, and boreholes. For ground water sources, draw down and recovery time are also relevant as indicators of the water status of the aquifer
- Conductivity of the water supply and of growing media will also be important for crops in greenhouses and crops in containers or hydroponic systems

Need for maintenance observed during the pre-irrigation inspection and during the operation of the irrigation, e.g. collapsed furrows and canals, weed growth, burst pipes and leaks, clogged emitters, etc.

4.2. Recording crop water use irrigation schedule

4.2.1. Recording water usage

All farms should keep records of water orders made and the allocation of water agreed.

Water usage:

All farms should keep records of water usage for each application and cumulatively for each crop and the whole farm. These records are useful for:

- Detection of leaks and wastage
- Estimating water needs and making water orders for the next crop / season
- Being able to demonstrate that the amount of water actually used is as agreed with the Water Users Association/Cooperative.

4.2.2. Recording irrigation schedule

Irrigation shift records are useful for:

- Planning the next irrigation (based on the previous irrigation, Farmers will apply the same or increase / decrease the amount of water to be applied according to the weather, crops growth, soil moisture and signs of crop stress)
- Reviewing the irrigation frequency and water use requirements and total water use at the end of a season or year.

Information that should be recorded for all types of irrigation will include:

- The date, production location, crop, and crop growth stage
- If possible, the total water use and each application rate
- Man-hours used for irrigation operation and
- Fuel or electricity used for pump operation

4.3. Recording irrigation shifts system/data

There are many processes involved in the operation of an irrigation system and each process needs to be managed and recorded. Records that are needed relate to the routine maintenance of the equipment and repair of the equipment infrastructure and to the operators of the system. Relevant records will include:

- Pump maintenance, canal repairs, cleaning filters, replacement of burst pipes, leaking joints, broken valves and 'lost' parts.

Farmers should keep records of what was done, the date and the cost. Stock records of irrigation parts and tools used for irrigation, in store and in use are also relevant.

- Worker Attendance, hours worked, worker training (Who, what, when) and accident records

These records will feed into the Farm Management record system and will contribute to the overall farm analysis of crop performance and farm financial accounts and budgeting.

Some Documentation is also useful so in addition to the 'System Process Records', farms (Particularly commercial farms), should also keep and have available for reference:

- Operator manuals for Pumps and other irrigation /fertigation equipment on the farm
- Enterprise work instructions
- Reference data relating to soil type, irrigation time or water application needed to return the soil to field capacity, crop requirements for water at the different stages of growth

Self-Check 4	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Test I: Short Answer Questions

1. List the items of information that should be included in records of the crop environment
2. Why Irrigation shift records are useful
3. Explain the benefit of recording water usage

Operation Sheet 4

4.1. Record irrigation information

Step.1: Visit one of the local farms using irrigation or your college training farm to see the pertaining to irrigation, typically:

Environmental data, Crop observation, Water usage, Irrigation shift, operation and maintenance of the irrigation system / process

Step.2: Evaluate the record keeping system and types on information recorded and present your finding and recommendations

LAP Test 4

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

Time started: ________________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to perform the following task within **40** minutes. The project is expected from each student to do it.

Task 1: perform recording for irrigation activities and crop environment data

Reference Materials

Books:

- Wellington, New Zealand. June 2001.Published jointly by the Occupational Safety and Health Service of the Department of Labour and the Accident Compensation Corporation. **(Sample)**

Web addresses

- https://www.webstersgroup.com.au/data-management-for-irrigation-why-is-it-important/(acess date: 21/05/2023)
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1569569/(acess date:21/05/2023)
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- https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0004/127282/Irrigation-scheduling.pdf((acess date:22/05/2023)

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