EduTap

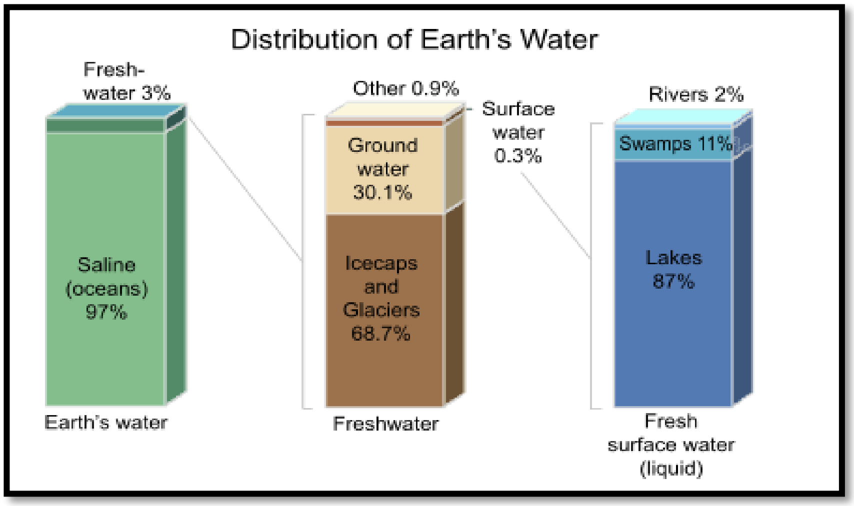
SUMMARY SHEET

Water Resources and Irrigation Management

Table of Contents

1 Distribution of water resources on the planet Earth

- ✓ The figures given below show approximate values.



Credit: Timothy Bralower

2 Hydrologic Cycle

- ✓ **Moisture circulates from the earth into the atmosphere through evaporation and then back into the earth as precipitation.** In going through this entire process, which is known as the Hydrologic Cycle
- ✓ The hydrologic cycle consists of **4 key components-**
  - Precipitation
  - Runoff
  - Storage
  - Evapotranspiration

2.1 Precipitation

- ✓ Precipitation occurs when **atmospheric moisture** becomes **too great to remain suspended in clouds.**
- ✓ It denotes **all forms of water that reach the earth from the atmosphere**, the usual forms being rainfall, snowfall, hail, frost, and dew.

2.2 Runoff

- ✓ Runoff is the water that flows across the land surface.
- ✓ As the flow bears down, it notches out rills and gullies which combine to form channels. These combine further to form streams and rivers.

2.2.1 Types of Runoff

- ✓ There are 3 types of Runoff-

2.2.1.1 Surface Runoff

- ✓ It is that portion of rainfall which enters the stream immediately after the rainfall.
- ✓ **It occurs when all losses are satisfied and if rain is continued, with the rate greater than in filtration rate**; at this stage the excess water makes a head over the ground surface which tends to move from one place to another, known as overland flow.
- ✓ **As soon as the overland flow joins the streams, channels, or oceans, termed as surface runoff.**

2.2.1.2 Sub – surface Runoff

- ✓ **That part of rainfall, which first leaches into the soil and moves laterally without joining the watertable to the Streams Rivers or oceans is known as sub – surface runoff.**
- ✓ Sometimes sub – surface runoff is also called service runoff because it takes very little time to reach the river or channel in comparison to ground water.
- ✓ **The sub – surface runoff is usually referred to as interflow**.

2.2.1.3 Base flow

- ✓ The **part of rainfall which after falling on the ground surface and infiltrates into the soil and meets the water table and flows to the streams, oceans** etc.
- ✓ The movement of water in **this type of runoff is very slow,** that is why it is also referred to as **delayed runoff**.
- ✓ It takes a long time to join the rivers or oceans. Sometimes base flow is also known as ground water flow.
- ✓ Thus, Total Runoff = Surface runoff + Base flow (Including sub – surface runoff)

2.3 Storage

- ✓ **The portion of the precipitation falling on land surface** which **does not flow out** as **runoff** gets **stored as either as surface water bodies** like Lakes, Reservoirs and Wetlands or as **sub-surface water body**, usually called **Ground water**.

2.4 Evapotranspiration

- ✓ Evapotranspiration is the **combination of two terms** – **evaporation and transpiration.**
- ✓ Evaporation is the process of liquid converting into vapour.
- ✓ Transpiration is the process by which water molecules leave the body of a living plant and escapes to the atmosphere.
- ✓ **Evapotranspiration, therefore, includes all evaporation from water and land surfaces, as well as transpiration from plants**.

3 Classification of Water Resources

The water resources can be divided into **two equal parts**: Surface Water Resources and Sub Surface Water Resources.

3.1 Surface Water Resources

- ✓ **Surface water** is **water on the surface of the planet** such as in a **river, lake, stream, reservoirs, wetland, or ocean.**

3.2 Sub-surface water resources

- ✓ It includes **groundwater**. Groundwater is an important part of the water cycle.
- ✓ Groundwater **comes from rain and snowmelt** that seeps into the ground. Gravity pulls the water down through the spaces between particles of soil or through cracks in rocks.
  - ✓ **Some layers of rock are so solid that they don't let water move through; this is called an impermeable layer.** Others are very crumbly or have lots of big cracks. **If the cracks are connected to each other, then water can move through the rock, termed as Permeable layer.**
- ✓ Eventually the water reaches a depth where all openings in soil or rock are filled with water; this is called the saturated zone. The water in the saturated zone is called **groundwater.**
- ✓ The top of the saturated zone is called the **water table**.

3.3 What is an Aquifer?

- ✓ A **saturated soil** or **rock layer with spaces** that **allow water to move through** is called an **aquifer**. Aquifers may be separated by layers of rock or clay that do not allow water to move through it.

3.3.1 Unconfined Aquifers

- ✓ Where **groundwater is in direct contact** with **the atmosphere through the open pore spaces** of the overlying soil or rock, then the **aquifer is said to be unconfined**.
- ✓ The **upper groundwater surface** in an **unconfined aquifer** is called the **water table.**
- ✓ An **unconfined aquifer's bottom is a layer of nonporous rock**, which restricts water flow, creating a barrier to the aquifer.
- ✓ Since the water table is the top layer of the unconfined aquifer, it is because of this reason that it can be also called as water table aquifers.

3.3.2 Confined Aquifers

- ✓ Confined aquifers are **permeable rock units** that are usually **deeper** under the ground than unconfined aquifers.
- ✓ They are overlain by relatively impermeable rock or clay that limits groundwater movement into, or out of, the confined aquifer. Thus, a confined aquifer sits below an

unconfined aquifer and layer of nonporous rock. Groundwater in a confined aquifer is under pressure and will rise inside a borehole drilled into the aquifer.

4 Functions of water in plants

- ✓ It is **essential for the germination of seeds and growth of plants**. And forms **over 90% of the plant body** by green or fresh weight basis.
- ✓ During the process of photosynthesis, plants synthesize carbohydrates from carbon dioxide and water. Therefore, water is one of the essential components for the plant.
- ✓ Water serves as the medium in which plants absorb soluble nutrients from the soil and **a medium for transport of chemicals to and from cells**.
- ✓ Water pressure in plant cells provides firmness to the plants.
- ✓ **Aquatic life is possible in water only**.
- ✓ Water helps in the transpiration, which is essential for maintaining the absorption of nutrients from the soil.
- ✓ Water regulates the temperature and cools the plant.

Now that we know about the importance of water to Plants, let's study about the supply of water to plant.

5 What is Irrigation?

- ✓ Irrigation is defined as the **application of water to the soil for the purpose of crop growth or crop production** in supplement to rainfall and ground water contribution.

5.1 What is Irrigation Management?

- ✓ Irrigation water management is the **act of timing and regulating irrigation water applications** in a way that will **satisfy the water requirement of the crop** without the waste of water, soil, plant nutrients, or energy.
- ✓ It means **applying water according to crop needs**.
- ✓ **To carry out the Irrigation Management effectively, we have to have an idea regarding the following:**
    - The soil physical and chemical properties
    - Biology of crop plants
    - Quantity of water available
    - Time of application of water
    - Method of application of water
    - Climatological or meteorological influence on irrigation and
    - Environment and its changes due to irrigation
- ✓ Management of all the above said factors constitute **Irrigation Agronomy**

- ✓ Management of irrigation structures, conveyances, reservoirs constitute **Irrigation Engineering**
- ✓ Social setup, activities, standard of living, irrigation policies, irrigation association and farmer's participation, cost of irrigation etc., constitute **Socio-economic study**.

5.2 Importance of Irrigation Management

- ✓ To allocate the water with proper proportion based on area and crop under cultivation.
- ✓ To convey the water without much loss through percolation and seepage.
- ✓ To apply enough to field crops.
- ✓ To utilize the water considering cost-benefit.
- ✓ To distribute the available water without any social problem.
- ✓ To meet the future requirement for other purposes like domestic use of individual and to protect against famine.
- ✓ To protect the environment from overuse or misuse of water.

5.3 Necessity of Irrigation

- ✓ **Uncertainty of monsoon rainfall**
  - **80% of rainfall in India is received during monsoon period.**
- ✓ **Uneven distribution of rainfall**
  - To compensate for the uneven distribution in an area, supplemental irrigation is needed.
- ✓ **Cultivation of high yielding crops**
  - High yielding crops produce heavy biomass and economic yield. Higher biomasses need more water for its production. Hence supplementation of water as irrigation is essential.
- ✓ **Difference in water holding capacity of the soil**
  - Sandy soil - low WHC – frequent irrigation. Clay soil - high WHC - frequency is less.

5.4 Seasons of rainfall in India

Winter (Cold dry period)	**January – February**
Summer (Hot weather period)	March – May
Kharif (South-West monsoon)	June – September
Rabi (North-East monsoon)	October – December

5.5 What is a Water Budget?

- ✓ Water budget can be defined as the **relationship between the inflow and outflow** of water through a **specified region or a country,** making it possible to identify periods of excess and deficit precipitation.
- ✓ **The rainfall below 2.5 mm is not considered for water budgeting**. Since it will immediately evaporate from surface soil without any contribution to surface water or ground water.
- ✓ According to **IMD, rainy day is defined as a day with rainfall of 2.5 mm** or more rainfall.

5.6 Water Scarcity

- ✓ Water scarcity, can broadly be understood as the lack of access to adequate quantities of water for human and environmental uses.
- ✓ One of the most used measures of water scarcity is the **'Falkenmark indicator' or 'water stress index**', which is as per United Nations Development Program
    - o If the amount of renewable water in a country is **below 1,700 m3 per person per year, that country is said to be experiencing water stress; below 1,000 m3 it is said to be experiencing water scarcity; and below 500 m3, absolute water scarcity**.
- ✓ An alternative way of defining and measuring water scarcity is to use a **criticality ratio**.
    - o Using this approach, a country is said to be **water scarce if annual withdrawals are between 20-40% of annual supply, and severely water scarce if they exceed 40%.**

6 Important Irrigation Terminologies

6.1 Seepage

- ✓ It is the **horizontal flow of water channel**.
- ✓ **Water loss** from the **irrigation channel or canal** is mainly due to seepage.
- ✓ **Seepage is not only a waste of water**, but also may lead to **other problems** such as **waterlogging** and **salinization of agricultural land.**

6.2 Infiltration

- ✓ **Entry of water** from the **upper layer of the soil is called infiltration**.
- ✓ It occurs in **unsaturated soil.**
- ✓ The **infiltration characteristics of the soil** are one of the **dominant variables influencing irrigation**.
    - o ***Infiltration rate*** is the soil characteristic determining the maximum rate at which water can enter the soil under specific conditions, including the presence of excess water.
    - o The **actual rate at which water is entering the soil** at any given time is termed the ***Infiltration velocity*.**
- ✓ Infiltration rates on **grassland is substantially higher than bare uncultivated land.**
- ✓ Additions of **organic matter increase infiltration rate substantially.**

6.3 Percolation

- ✓ Downward movement of water through saturated or nearly saturated soil in response to gravity or we can put it as the descending motion of infiltered water through soil and rock layers.

Difference between Infiltration and Percolation?

Infiltration occurs closer to the surface of the soil. Infiltration delivers water from the surface into the soil and plant rooting zone while Percolation moves it through the soil profile to replenish ground water supplies or become part of sub-surface run-off process.

6.4 Leaching

- ✓ Downward movement of nutrients and salts from the root zone with the water is called leaching.

6.5 Saturation capacity

- ✓ This is the **maximum water holding capacity of the soil** where all the soil pores (Macropores and Micropores) are filled with water.

6.6 Field capacity (FC)

- ✓ The soil moisture content after 2-3 days of irrigation and after drainage of gravitational water has become very slow and soil moisture content has become relatively stable.
- ✓ At the field capacity, the large pores are filled with air and the micro pores are filled with water.
- ✓ It is considered as the **upper limit of water availability to plants**.

6.7 Permanent Wilting Point (PWP)

- ✓ The **concept of PWP was proposed by Briggs and Shantz** in 1912. They utilized **dwarf sunflower as an indicator plant**.
- ✓ It is the soil moisture content at which plants can no longer obtain enough moisture to meet their requirement and remain wilted unless water is added to the soil.
- ✓ It is the **lower limit of available water to the plant.**

6.8 Wilting coefficient

- ✓ The percentage of moisture in root zone at the permanent wilting of plants is called wilting coefficient or critical moisture point.

6.9 Available water

- ✓ This concept was given by Veihmayer and Hendrickson in 1981. It is the **moisture available for maximum plant use**.
- ✓ It is arrived at by subtracting the water at Field Capacity and water at the Permanent Wilting Point (PWP).

6.10 Ultimate Wilting Point (UWP)

- ✓ The moisture content at which the wilting is complete, and the plants die is called UWP.
- ✓ At UWP, the soil moisture tension is as high as -60 bars.

6.11 Soil Moisture Tension

- ✓ Soil moisture tension is a **measure of the tenacity with which water is retained in the soil** and shows the **force per unit area that must be exerted to remove water from a soil**.

6.12 Soil Water Potential

- ✓ **Water moves constantly in the direction of potential energy** (*i.e.,* wet to dry soil).
- ✓ **Soil water potential (Ψ) indicates the tendency of soil water to move and is defined as the work water can do as it moves from its present state to the reference state.**
- ✓ The reference state is the energy level of water in saturated soil, where Ψ is nominally zero (~0).
- ✓ Soil water potential (Ψ) is usually **negative (-ve) and becomes more negative as the soil dries out**.
- ✓ "High" soil water potential (Ψ) means it is less negative and close to 0, indicating loosely held water that is readily available to move elsewhere.
- ✓ **There are three important factors affecting total soil water potential.**

    - This includes soil water potentials of
      $\boldsymbol{\Psi_g}$ Gravitational
      $\boldsymbol{\Psi_o}$ Osmotic
      $\boldsymbol{\Psi_m}$ Matric
    - The general relationship between total soil water potential ($\boldsymbol{\Psi_t}$) and the various factors is expressed as - $\boldsymbol{\Psi_t = \Psi_g + \Psi_o + \Psi_m}$

- ✓ **Gravity plays a role in the movement of soil water**, with higher gravitational potential (Ψg) near the soil surface compared to the subsoil. This leads to downward flow of water in response to heavy precipitation or irrigation.
- ✓ **Osmotic potential (Ψm**) is influenced by the attraction between water molecules and ions/solutes in the soil solution. High levels of soluble salts can reduce soil water potential, making it **difficult for plants to extract water, resulting in physiological drought and plant wilting in saline soils.**
- ✓ **Adhesion** of water to the soil matrix creates a matric force through adsorption and capillarity, reducing the energy of water particles near surfaces. This has an impact on the ability of water to do work, such as water being held in capillary pores or absorbed into the soil.

- ✓ In saturated soil, where water can freely flow, Ψm is not a factor and its value is 0.

Note: Matric and Osmotic potentials are negative and reduce the free energy level of the soil water. These negative potentials are referred to as suction or tension. The force of gravity is always positive.

6.12.1 Methods of expressing suctions

- ✓ There are two units to express differences in energy levels of water.
  - pF scale
  - Atmospheric pressure or Bars

6.12.1.1 pF Scale

- ✓ The concept of the pF curve for expressing the relation between the amount of water in a soil and the force with which it is held there was introduced by **Schofield.**
- ✓ The **free energy** is measured in terms of the **height of a column of water** required to **produce necessary suction** or pressure difference at a particular soil moisture level.
- ✓ The pF, therefore, represents the **logarithm of the height of water column (cm)** to give the necessary suction.
- ✓ **Soil condition and the corresponding pF value and Pressure**

6.12.1.2 Atmospheric pressure or Bars

- ✓ The atmosphere pressure is the average air pressure at sea level.
- ✓ If the suction is very low as occurs in the case of a wet soil containing the maximum amount of water that it can hold, the pressure difference is of the order of about 0.01 atmospheres or 1 PF equivalent to a column of water 10 cm in height.

Soil Condition	pF values	Pressure (atm/bars)
Saturated Soil (filled with water completely)	0	0.001
Field Capacity	2.53	1/3
Permanent Wilting Point (PWP)	4.18	15
Hygroscopic point	4.50	31
Oven Dry Soil	7.0	10000

6.13 Moisture Equivalent

- ✓ Moisture equivalent is defined as the **amount of water retained by a sample of initially saturated soil material after being subjected to a centrifugal force of 1000 times** that of gravity for a definite period, usually half an hour.

6.14 Duty of water

- ✓ The volume or **quantity of water** required for **irrigation** to **bring a crop to maturity**.
- ✓ Duty of water= 8.64 * Base period/Delta

Gross Duty of Water: *Area commanded by the flow of water as measured at the source of supply; It includes wastage in channel in addition to what is used for measuring crops.*

Net Duty of Water: *Area commanded by water delivered at field. It includes the losses of water in the field.*

The difference between gross and net duty of water gives efficiency of distributaries.

6.15 Base period

- ✓ The period (days) during which irrigation water is supplied to the crop.

6.16 Delta

- ✓ Delta is the total depth of water (cm) required by a crop.

6.17 Kor watering

- ✓ Crop water requirement is not uniform all through base period. The first watering is known as Kor watering.

6.18 Rostering/ water regulation

- ✓ The process of distribution of irrigation water.

6.19 Palco

- ✓ Palco is the **first irrigation before sowing the crop** for **seed germination** and seedling establishment.

6.20 Moisture Regime

- ✓ The percentage of moisture in the soil at atmospheric pressure is known as moisture regime.

6.21 Total Cultivable Area (TCA)

- ✓ It is the total area where cultivation is possible. This consists of net sown area, current fallows, fallow lands other than current fallows, Culturable waste land and land under miscellaneous tree crops.

6.22 Net Sown Area (NSA)

- ✓ This represents the total area sown with crops and orchards. Area sown more than once in the same year is counted only once.

6.23 Gross Sown Area (GSA)

- ✓ This is the sum total of the areas under all crops over the various seasons in an agriculture year (i.e. from the 01st July to 30th June next year). Under GSA, area sown twice/thrice in the same year is counted as two/three times.

6.24 Cropping Intensity

- ✓ It is the ratio of gross sown (total) area to the net sown area expressed as a percentage.

6.25 Net Irrigated Area (NIA)

- ✓ It is the area irrigated through any source once a year for a particular crop. Area irrigated more than once in the same year is counted only once.

6.26 Gross Irrigated Area (GIA)

- ✓ This is the sum total of the areas irrigated under all crops over the various seasons in the agriculture year (i.e. from the 01st July to 30th June next year). Under GIA, area irrigated twice/thrice in the same year is counted as two/three times.

6.27 Irrigation Intensity

- ✓ It is the ratio of gross irrigated (total) area to the net irrigated area expressed as a percentage.

6.28 Irrigation Potential Created (IPC)

- ✓ It is the area that can be irrigated from a project in a design agriculture year (i.e. from the 01st July to 30th June next year) for the projected cropping pattern and accepted water allowance on its full development.

6.29 Irrigation Potential Utilised (IPU)

- ✓ The Irrigation potential utilised is the total gross area irrigated by a project/scheme during the agricultural year under consideration.

6.30 Ultimate Irrigation Potential (UIP)

- ✓ The ultimate irrigation potential is the gross area that can be irrigated from a project in a design agriculture year (i.e. from the 01st July to 30th June next year) for the projected cropping pattern and assumed water allowance on its full development.

7 Irrigation Project

- ✓ An **irrigation project** is an agricultural establishment which can supply controlled amounts of water to lands for growing crops. **Irrigation projects** mainly consist of hydraulic structures which collect (from a source), convey, and deliver (to farm fields) water for **irrigation**.

7.1 Classification of Irrigation Projects / Works

Major Irrigation project	More than 50 million Rupees	Covers cultural command area of more than 10,000 hectares
Medium Irrigation project	2.5 million to 50 million Rupees	Covers cultural command area of 2000 – 10,000 hectares
Minor Irrigation project	Less than 2.5 million Rupees	Covers cultural command area of 2,000 hectares.

7.2 Terminology related to Irrigation projects

7.2.1 Command Area

- ✓ The **command area** is the **area** around the dam/ project, where the **area** gets benefits from the dam, such as irrigation water, electricity, etc.

7.2.2 Cultural Command Area

- ✓ The **area** which can be irrigated from a scheme and is fit for cultivation.

7.2.3 Gross command area (GCA)

- ✓ It is the total **area** which can be economically irrigated from an irrigation system without considering the limitation on the quantity of available water.

7.2.4 Command Area Development

- ✓ Command area development plan (1974-75) was to narrow the gap between irrigation potential created and utilized in major and medium irrigation schemes. **It played a major role in increasing agricultural productivity.**

8 Types of Irrigation

8.1 Surface Irrigation

The following methods are used under Surface Irrigation

8.1.1 Flood Irrigation

- ✓ The water spreads **unguided across the entire field**, and bunds with a height of 15 cm are necessary to maximize rainfall usage.
- ✓ It is a minimum labor-intensive method. Useful in uniform surface soils with good water holding capacity.

8.1.2 Basin Irrigation

- ✓ Basins are **flat areas of land surrounded by low bunds.** The **bunds prevent the water** from flowing to the adjacent fields.
- ✓ The basins are filled to desired depth and the water is retained until it infiltrates into the soil. Water may be maintained for considerable periods of time.

- ✓ **Basin method may be divided into two types:**
  - **Check Basin method and**
  - **Ring Basin method**

8.1.2.1 Check Basin method

- ✓ Check basin method is **commonly used in India** for irrigation.
- ✓ **Land is divided into small basins** surrounded by levees.
- ✓ Water is filled in the basins without overtopping the levees, allowing it to infiltrate into the soil.
- ✓ Suitable for crops like paddy rice, maize, pearl millet, and groundnut.
- ✓ Check basins are helpful for **leaching out salts from the soil**.
- ✓ **Not suitable for crops sensitive to wet soil conditions around the stem**.

8.1.2.2 Ring Basin method of Irrigation

- ✓ The other form of basin irrigation is the ring basin method which is used for **growing trees in orchards**.
- ✓ In this method, generally for each tree, a separate basin is made which is usually circular in shape.

8.1.3 Border Irrigation

- ✓ The land is **divided into several long parallel strips called borders**. These borders are **separated by low ridges**. The border strip has a **uniform gentle slope in the direction of irrigation**.
- ✓ **Suitability:** To soils having **moderately low to moderately high infiltration rates**. It is **not used in coarse sandy soils that have very high infiltration rates** and in heavy soils having very low infiltration rate. **Suitable to irrigate all close growing crops like wheat, barley, fodder crops and legumes and not suitable for rice.**
- ✓ **Width of border strip**: It varies from 3-15 m. Border length varies according to topography i.e slope.

Slope	Soil	Length
0.25 - 0.60%	Sandy and sandy loam	60-120 m
0.20 - 0.40%	Medium loam soil	100-180 m
0.05 – 0.20%	Clay loam and clay soil	150-300 m

8.1.4 Furrow Irrigation

- ✓ Furrow irrigation: Water flows in **small channels between crop rows.**
- ✓ Water infiltrates soil as it moves along slope.

- ✓ **Crop grown on ridges between furrows.**
- ✓ Suitable for row crops and crops intolerant to prolonged water.
- ✓ The duration of water flow based on root zone needs and soil characteristics.
- ✓ **Not suitable for sandy soils with high infiltration rates.**
- ✓ Reduces soil puddling, clustering, and evaporation.

8.1.4.1 Types of furrow irrigation

A. Based on alignment of furrows

1. Straight furrows
2. Contour furrows

B. Based on size and spacing

1. Deep furrows
2. **Corrugations:** Small and shallow furrow are known as corrugation, suitable for close growing crops like wheat, ground nut etc.

8.1.5 Surge Irrigation

- ✓ Surge irrigation: Intermittent water application in on-off cycles.
- ✓ Water is delivered to long furrows in predetermined time cycles.
- ✓ Waterfront advances during on-time and infiltration rate decreases during off-time.
- ✓ Accelerated waterfront advance reduces deep percolation and runoff losses.
- ✓ Provides high uniformity of soil moisture and irrigation efficiencies of 85% to 95%.
- ✓ Land loss limited to around 5% due to elimination of criss-cross ridges and feeder channels.

8.2 Sub-Surface Irrigation

- ✓ The application of water to fields in this type of irrigation system is **below the ground surface** so that it is **supplied directly to the root zone of the plants.**
- ✓ In sub-surface or sub-irrigation water is **applied beneath the ground by creating** and **maintaining an artificial water table at some depth**, usually 30 to 75 cm, below the ground surface.
- ✓ **There may be two ways by which irrigation water may be applied below ground and these are termed as:**
    1. Natural sub-surface irrigation method
    2. Artificial sub-surface irrigation method

8.2.1 Natural Sub-Surface Irrigation method

- ✓ Under favorable conditions of topography and soil conditions, the water table may be close enough to the root zone of the field of crops which gets its moisture due to the upward capillary movement of water from the water table.

8.2.2 Artificial sub-surface irrigation method

- ✓ The concept of maintaining a **suitable water table just below the root zone** is obtained by providing **perforated pipes** laid in a **network pattern below** the **soil surface at a desired depth.**
- ✓ This method of irrigation will function only if the soil in the root zone has high horizontal permeability to permit free lateral movement of water and low vertical permeability to prevent deep percolation of water.

8.3 Pressurized Irrigation System/Micro-Irrigation

- ✓ In pressurized irrigation systems water is pressurized and precisely applied to the plants under pressure through a system of pipes.

8.3.1 Sprinkler Irrigation

- ✓ Water is **applied with pressure to the surface of any crop or soil** in the form of a **thin spray**, somewhat **resembling rainfall**.
- ✓ The **rate of spray of water** can be **regulated** and **natural rainfall can be simulated**.
- ✓ Sprinkler irrigation can be used for all crops, (except rice and jute) and on most soils (except heavy clay soils).
- ✓ It is **especially suited for field with steep slopes or irregular topography**.

The following tabular column shows various parts of a sprinkler system

Pumping Unit	**A high speed centrifugal or turbine pump can be installed for operating the system for individual farm holdings.**
Pipeline	Pipelines are generally of two types. They are main and lateral. Main pipelines carry water from the pumping plant to many parts of the field. The lateral pipelines carry the water from the main or sub main pipe to the sprinklers.
Couplers	A coupler provides connection between two tubing and between tubing and fittings.
Sprinklers	Sprinklers may rotate or remain fixed. The rotating sprinklers can be adapted for a wide range of application rates and spacing. They are effective with pressure of about 10 to 70 m head at the sprinkler. Pressures ranging from 16-40 m head are considered the most practical for most farms. Perforated Pipe system is usually designed for relatively low pressure (1 kg/cm2). The application rate ranges from 1.25 to 5 cm per hour for various pressure and spacing.

Advantages of sprinkler irrigation

- ✓ Suitable for undulating topography and sandy soils. Significant water savings ranging from 25-50% for different crops.
- ✓ High discharge rate of over 1000 liters per hour. The sprinkler pressure ranges from 2.5-4.5 kg/cm2.

- ✓ High water use efficiency, up to 60%, surpassing surface irrigation methods. Increased irrigated area by 40% compared to surface irrigation with the same amount of water.
- ✓ Labor savings of about 40-60% compared to surface irrigation.
- ✓ Can be utilized to protect crops from frost and high temperatures.

8.3.2 Drip Irrigation

- ✓ Developed **in Israel by Simcha Blass and Yeshayahu Blass,** utilizing plastic emitters.
- ✓ Particularly suitable for areas with **water scarcity and salt problems.**
- ✓ **Precise and slow application of water** through emitters along water delivery lines.
- ✓ Highly efficient in water usage, minimizing losses from deep percolation and surface evaporation.
- ✓ Ideal for water-scarce regions with marginal water quality, undulating or steep topography, shallow soil depth, high labor costs, and valuable crops.

The following tabular column shows various parts of a drip system

Pump	**The pump creates the pressure necessary to force water through the components of the system including the fertilizer tank, filter unit, mainline, lateral and the emitters and drippers. The laterals may be designed to operate under pressures as low as 0.15 to 0.2 kg/ cm2 and as large as 1 to 1.75 kg/cm2**
Chemical Tank	A tank may be provided at the head of the drip irrigation systems for applying fertilizers, herbicides, and other chemicals in solution directly to the field along with irrigation water.
Emitters	The discharge rate of emitters usually ranges from 2 to 10 litres per hour.
Filters	It is an essential part of drip irrigation system. It prevents the blockage of pipes and drippers/emitters.

Advantages of drip irrigation

- ✓ Suitable for water scarcity area water saving 50-70% as compared to surface.
- ✓ Fertilizer or other chemical amendments can be efficiently applied to individual or separate plants.
- ✓ Discharge rate of water per dripper is generally 1-8 lit/hr at 1.5-2.5 kg/cm^2 pressure.
- ✓ Most suitable for widely spaced crops, orchard trees and greenhouses (protected cultivation of vegetables & flowers).

Fertigation

Fertigation is a method of fertilizer application in which fertilizer is incorporated within the irrigation water by the drip system. In this system fertilizer solution is distributed evenly in irrigation. The availability of nutrients is very high therefore the efficiency is more. In this method liquid fertilizer as well as water soluble fertilizers are used. By this method, fertilizer use efficiency is increased from 80 to 90 per cent.

8.3.3 Comparative study between sprinkler and drip irrigation

Particulars	Sprinkler irrigation	Drip irrigation
Form of water	Spray or rain	Drop
Rate of delivery	>1000 litre/hr	1-4 litre/hr
Water saving	25-50 per cent	60-70 per cent
Land saving	10-16 per cent	-
Uniformity	Uniform application of water (up to 10m)	Root zone application
Suitable for	Undulating land, sandy soils, areas where water and labour scarcity is common, saline soil	Wider spaced crop, orchard and vegetable garden, areas where acute water shortage

9 Water requirement of a crop

- ✓ Water requirements of a crop is the **quantity of water needed for normal crop growth** and **yield in a period** to a place and may be supplied by precipitation or by irrigation or by both.
- ✓ Water is needed mainly to meet the demand of evaporation (E), transpiration (T) and metabolic activity of plant together known as Consumptive Use (C.U).
- ✓ **So, water requirement = IW + ER + S**

IW - Irrigation Water in cm
ER - Effective Rainfall in cm
S - Soil profile contribution

9.1 Water Requirements of Agricultural Crops in Surface Irrigation Methods (5cm depth at each irrigation)

Crop	Duration	Total Water Requirement (mm)
Rice	110	1250
Sugarcane	360	2200
Groundnut	105	510
Sorghum	105	500
Maize	100	500
Ragi	95	310
Cotton	165	600
Blackgram	65	280
Soybean	85	320
Sesame	85	150
Sunflower	110	450

9.2 Critical stages of crops for irrigation

S.No	Cereals	Critical stages of crops for irrigation
1	Rice	Tillering, panicle, initiation, heading and flowering
2	Wheat	CRI, Tillering, Late joining, flowering, milking and dough
3	Maize	Tasseling and silking to dough stage
4	Sorghum	Booting, blooming, milking and dough stage
5	Pearl millet	Heading and flowering
6	Finger millet	Primordial initiation and flowering
	Pulses	
1	Chickpea	Late vegetative phase and pod development
2	Pea	Flowering and early pod formation
3	Blackgram	Flowering and pod setting
4	Greengram	Flowering and pod setting
5	Lucern	After cutting and flowering
6	Beans	Flowering and pod settings
	Oilseed	
1	Groundnut	Flowering, peg formation and pod development
2	Soybean	Blooming and seed formation
3	Sunflower	Buttoning, knee high, flowering and early seed formation
4	Sesamum	Blooming to maturity

9.3 Important Irrigation Terminologies

9.3.1 Water Use Efficiency (WUE)

- ✓ It is the **yield of a marketable crop** produced **per unit of water** used in evapo-transpiration or it is the **dry matter produced per unit of water** used and it is expressed as kg/ha-mm(cm).
- ✓ **Water Use Efficiency is of two types-**

9.3.1.1 Field Water Use Efficiency

- ✓ It is the ratio of crop yield to the total amount of water used in the field.
- ✓ **Field WUE = Crop Yield (kg/ha)/ (ET + S + D)**

  Where **ET:** Evapotranspiration loss of water; **S:** Ground water contribution; **D:** Deep Percolation losses

9.3.1.2 Crop Water Use Efficiency

- ✓ It is the ratio of crop yield to the amount of water depleted by the crop in the process of evapotranspiration.

- ✓ **Crop WUE = Crop Yield (kg/ha)/ (E + T + G)**

  Were, **E:** Evaporation loss; **T:** Transpiration loss; **G:** Metabolic use of plant

9.3.1.3 Water use efficiency of major field crops

S.No	Crop	WUE (kg/ha mm)
1	Finger Millet	**13.4**
2	Wheat	12.6
3	Groundnut	9.2
4	Sorghum	9.0
5	Pearl millet, maize	8.0
6	Rice	**3.7 (lowest)**

9.3.2 Consumptive Water Use Efficiency

- ✓ It is defined as the ratio of consumptive water use by the crop of irrigated farm or project and the irrigation water stored in the root zone of the soil on the farm or the project area.
- ✓ $Ecu = \frac{Wcu}{\mathrm{Wd}} \times 100$

  Where, Ecu = consumptive use efficiency (%), Wcu = normal use of water and Wd = net amount of water depleted from root zone.

9.3.3 Irrigation Efficiency

- ✓ It is **defined as the ratio of water output to the water input**, i.e., the ratio or percentage of the irrigation water consumed by the crop of an irrigated farm, field or project to the water delivered from the source.
- ✓ $Ei = \frac{Wc}{\mathrm{Wr}} \times 100$

  Where, **Ei** = irrigation efficiency (%); **Wc** = irrigation water consumed by crops during its growth period in an irrigation project; **Wr** = water delivered from canals during the growth period of crops.
- ✓ **In most irrigation projects, the irrigation efficiency ranges between 12 to 34 %.**

9.3.4 Water Storage Efficiency

- ✓ It is defined as the ratio of the water stored in the root depth by irrigation to the water needed in the root depth to bring it to the field capacity. **Also termed as water storage factor.**
- ✓ $Es = \frac{Ws}{\mathrm{Ww}} \times 100$

  where, **Es** = water storage efficiency, per cent; **Ws** = water stored in the root zone during the irrigation; **Ww** = water needed in the root zone prior to irrigation, i.e., field capacity available

9.3.5 Water Conveyance Efficiency

- ✓ It is a **measure of efficiency of water conveyance system from canal network to watercourses and field channels**. It is the **ratio of water delivered to infields at the outlet head to that diverted into the canal system from the river or reservoir**. Water losses occur in conveyance from the point of diversion till it reaches the farmer's fields which can be evaluated by water conveyance efficiency, as under:
- ✓ $Ec = \frac{Wf}{\mathrm{Wt}} \times 100$

  Where, **Ec** = water conveyance efficiency, per cent; ***Wf* =** water delivered to the farm by conveyance system (at field supply channel); **Wt** = water introduced into the conveyance system from the point of diversion
- ✓ **Water conveyance efficiency is generally low; about 21% losses occur in earthen watercourses only.**

10 Irrigation water quality

- ✓ Irrigation water quality is determined by salt content, which affects plant growth.
- ✓ Salts influence osmotic pressure and water absorption by plant roots.
- ✓ **The suitability of water for irrigation is determined in several ways including the degree of acidity or alkalinity (pH), EC (Electrical Conductivity), Residual Sodium Carbonate (RSC), Sodium Adsorption Ratio (SAR), Permeability Index (PI) and Total Hardness (TH) along with the effects of specific ions**.

10.1 Quality of irrigation is judged with following parameters-

10.1.1 Total salt concentration

- ✓ Salt concentration of irrigation water is **measured as electrical conductivity (EC).**
- ✓ Conventionally, water containing total dissolved salts to the extent of more than 1.5 m mhos/cm has been classified as saline. Saline waters are those which have sodium chloride as the predominant salt.

Classification of irrigation water based on total salt content

Class	EC (ds/m)	Quality characterisation	Soils for which suitable
C1	<1.5	Normal waters	All soils
C2	1.5 – 3	Low salinity waters	Light and medium textured soils
C3	3 – 5	Medium salinity waters	Light and medium textured soils for semi – tolerant crops
C4	5 – 10	Saline waters	Light and medium textured soils for tolerant crops
C5	> 10	High salinity waters	Not suitable

10.1.2 Sodium Adsorption ratio

- ✓ Sodium Adsorption ratio (SAR) and residual sodium carbonate (RSC) are also the main criterion to determine the quality of irrigation water.

10.1.3 Boron content

- ✓ Irrigation water which contains more than 3 ppm boron is harmful to crops, especially on light soils.

Classification of irrigation water based on boron content

Class	Boron (ppm)	Characterisation	Soils suitable
B1	3	Normal waters	All soils
B2	3 – 4	Low boron waters	Clay soils and medium textured soils
B3	4 – 5	Medium boron waters	Heavy textured soils
B4	5 – 10	Boron waters	Heavy textured soils
B5	> 10	High boron waters	Not suitable

Kindly go through the following tabular column for summary of various indicators

Quality of water	EC (m.mhos / cm)	pH	Na (%)	Cl (me/l)	SAR
Excellent	0.5	6.5 – 7.5	30	2.5	1.0
Good	0.5 – 1.5	7.5 – 8.0	30 – 60	2.5 – 5.0	1.0 – 2.0
Fair	1.5 – 3.0	8.0 – 8.5	60 – 75	5.0 – 7.5	2.0 – 4.0
Poor	3.0 – 5.0	8.5 – 9.0	75 – 90	7.5 – 10.	4.0 – 8.0
Very poor	5.0 – 6.0	9.0 – 10.	80 – 90	10.0 – 12.5	8.0 – 15.0
Unsuitable	>6.0	> 10	>90	>12.5	>15