MODULE 1: IRRIGATION

Definition of Irrigation

Irrigation is the process of artificially supplying water to land or soil to support the growth of crops, maintain landscapes, and help in soil rehabilitation, especially in regions that experience inadequate rainfall. It compensates for the irregularity and unpredictability of natural precipitation. In agricultural practices, irrigation is critical because many crops require a consistent and timely supply of water to ensure healthy growth and optimum yield. Without sufficient irrigation, it is impossible to cultivate crops successfully in arid or semi-arid areas. Additionally, irrigation systems support horticulture, gardening, and the cultivation of crops beyond traditional rainy seasons, enabling year-round farming.

Benefits of Irrigation

The practice of irrigation brings numerous advantages:

- **Increased Crop Production:** Reliable water supply through irrigation significantly boosts crop yields, ensuring food security for growing populations.
- **Multiple Cropping:** Farmers can grow more than one crop in a year by utilising irrigation, thus making better use of land and increasing annual income.
- **Crop Diversification:** With dependable water sources, farmers can diversify into cash crops such as fruits, vegetables, and flowers, increasing their profitability.
- **Drought Resistance:** Irrigation serves as an insurance against droughts and dry spells, reducing the risk of crop failure.
- **Land Reclamation:** Irrigation can transform barren or semi-arid lands into fertile agricultural zones, expanding cultivable areas.
- **Economic Development:** A flourishing agricultural sector supported by irrigation creates job opportunities, improves rural livelihoods, and fosters industrial development linked to agriculture.

- **Environmental Benefits:** Managed properly, irrigation can help in maintaining soil structure, reducing erosion, and sustaining wetlands and forests.

Ill Effects of Irrigation

While irrigation has numerous benefits, improper and unscientific irrigation practices can cause several adverse effects:

- **Waterlogging:** Excessive irrigation leads to a rise in the groundwater table, saturating the soil. Waterlogged soils lack oxygen, affecting root respiration and leading to poor crop health and reduced yields.
- **Salinisation:** As water evaporates from the soil surface, it leaves behind dissolved salts. Over time, salt accumulation renders the soil infertile, a condition known as salinisation.
- **Groundwater Depletion:** Unregulated extraction of groundwater for irrigation, especially through borewells and tube wells, can lower the water table, leading to long-term shortages.
- **Soil Degradation:** Constant flooding of fields or over-irrigation can lead to soil compaction, reducing permeability and affecting soil health.
- **Impact on Natural Ecosystems:** Diverting large quantities of water for irrigation can harm rivers, lakes, and wetlands, impacting aquatic life and biodiversity.
- **Displacement and Conflicts:** Construction of large irrigation projects (dams, reservoirs) sometimes displaces communities and creates conflicts over water sharing among regions.

Systems of Irrigation

Surface and Ground Water Sources

The two primary sources of irrigation water are:

- **Surface Water Sources:** Include rivers, reservoirs, ponds, lakes, and canals. Surface water systems often involve large-scale community or government-managed projects.
- **Groundwater Sources:** Include wells, borewells, and tube wells. Groundwater irrigation is generally more decentralised and is commonly

used by individual farmers, especially where surface water is not easily available.

Flow Irrigation

In flow irrigation systems, water is transported and distributed across agricultural fields by the force of gravity. This method depends on the availability of a perennial source of water at a higher elevation relative to the fields. Flow irrigation is subdivided into:

- **Direct Irrigation:** Water is diverted from rivers during flood seasons without storage.
- **Storage Irrigation:** Water is stored in reservoirs during rainy seasons and used during dry periods.

Flow irrigation is cost-effective but requires well-designed networks of canals and properly levelled fields.

Lift Irrigation

Lift irrigation involves lifting water from lower sources such as rivers, tanks, or wells to higher ground using pumps or other mechanical devices. It is employed where gravitational flow is not possible. Lift irrigation systems are more flexible but require energy inputs (electricity or diesel) for operating pumps. Examples include tubewell irrigation and river lift schemes.

Bandhara Irrigation

Bandhara irrigation uses structures called **bandharas** (small check dams or weirs) built across small rivers or streams to store water. Stored water is either allowed to percolate and recharge groundwater or directly diverted into irrigation canals. Bandharas are commonly used in regions with seasonal water flows and are highly effective in conserving water, promoting groundwater recharge, and providing local irrigation support, especially in Maharashtra and other parts of peninsular India.

Water Requirements of Crops

Duty, Delta, and Base Period

- **Duty (D):** It is the area of land (in hectares) that can be irrigated with a continuous flow of 1 cubic metre per second (1 cumec) of water during the entire base period. Duty helps in planning water requirements for different crops.

- **Delta (Δ):** It represents the total depth of water (in metres or centimetres) required by a crop during its entire life from sowing to harvest. It indicates the volume of water needed per unit area.
- **Base Period (B):** This is the total time (in days) between the first watering at sowing to the final watering before harvest. It determines the irrigation scheduling and planning.

Relationship Between Duty, Delta, and Base Period

There is a mathematical relationship among duty (D), delta (Δ), and base period (B) expressed as:

$$\Delta = \frac{8.64 \times B}{D}$$

where:

- Δ is in metres,
- B is in days,
- D is in hectares per cumec.

This formula helps engineers and planners calculate the amount of water needed for a particular crop over its growing season.

Factors Affecting Duty of Water

Several environmental, technical, and management factors influence the duty of water:

- **Climatic Conditions:** High temperatures, low humidity, and strong winds increase evapotranspiration, decreasing duty.
- **Soil Characteristics:** Sandy soils with low water-holding capacity require more frequent irrigation compared to clayey soils.
- **Crop Type:** Different crops require different amounts of water; for example, rice needs more water than wheat.
- **Irrigation Methods:** Efficient systems like drip or sprinkler irrigation improve duty, whereas traditional flood irrigation reduces it.
- **Water Management Practices:** Proper maintenance of canals, avoiding leakage, and timely irrigation practices enhance the duty.

- **Topography:** Fields with steep slopes experience more runoff and less water retention, reducing duty.

Crop Seasons in India

India's cropping system is based on three main seasons:

- **Kharif Season:** Sowing starts with the onset of the monsoon (June–July) and harvesting occurs in September–October. Major kharif crops include paddy (rice), maize, sugarcane, cotton, and pulses.
- **Rabi Season:** Crops are sown after the monsoon in October–November and harvested in March–April. Common rabi crops are wheat, barley, gram (chickpea), and mustard.
- **Zaid Season:** A short intervening season between rabi and kharif (March–June), suitable for quick-growing crops like cucumber, watermelon, and vegetables.

Understanding the water requirements for different seasons is essential for planning irrigation schedules.

Irrigation Efficiency

Irrigation efficiency measures how effectively water is used for crop production. It is the ratio of the water beneficially used by crops to the total water supplied to the fields. Several types of efficiencies are considered:

- **Conveyance Efficiency:** Refers to water loss during transportation from the source to the field through canals and pipes.
- **Application Efficiency:** Refers to the proportion of water stored in the root zone compared to the water delivered to the field.
- **Water Use Efficiency:** Indicates the effectiveness with which plants use the available water to produce biomass or yield.

A high irrigation efficiency implies minimum wastage, better productivity, and conservation of precious water resources.

Frequency of Irrigation

The frequency of irrigation denotes the number of times water is applied to a crop during its growing period. Factors influencing frequency include:

- **Soil Type:** Sandy soils need more frequent irrigation due to faster drainage, while clayey soils retain moisture longer.
- **Climate:** Hot, dry climates require more frequent irrigation compared to cool, humid regions.
- **Crop Stage:** Crops are more sensitive to water stress during stages like flowering and fruit development, necessitating closer irrigation.
- **Root Zone Depth:** Shallow-rooted crops require more frequent watering than deep-rooted crops.

Proper scheduling of irrigation frequency is crucial to optimise water usage and maximise crop yield.