Chapter 44: Irrigation Requirement and Frequency of Irrigation

Introduction

Irrigation plays a vital role in ensuring agricultural productivity, particularly in regions with erratic or insufficient rainfall. Understanding the *irrigation requirement* and determining the *frequency of irrigation* are critical in designing and managing efficient irrigation systems. These factors influence not only the growth and yield of crops but also water conservation, energy consumption, and sustainability of groundwater and surface water resources.

This chapter delves into the methods used to estimate irrigation requirements, the components involved, and the criteria used to determine how frequently irrigation should be applied. It also addresses factors affecting these parameters and presents methods for optimizing irrigation scheduling to minimize losses and maximize efficiency.

44.1 Crop Water Requirement (CWR)

44.1.1 Definition

Crop Water Requirement is the total quantity of water needed by a crop for its full growth and development in a specific climate and soil condition.

44.1.2 Components

- **Evapotranspiration (ET):** Combined process of evaporation from the soil and transpiration from plant surfaces.
- **Soil Evaporation:** Loss of water from soil due to solar radiation and wind.
- **Plant Transpiration:** Water vapor released from plant stomata during respiration.

44.1.3 Factors Affecting CWR

- **Climatic Conditions:** Temperature, humidity, wind speed, and solar radiation.
- **Crop Type and Growth Stage**

- **Soil Type:** Water-holding capacity, infiltration rate, texture.
- **Agronomic Practices:** Mulching, tillage, crop spacing, etc.

44.2 Irrigation Requirement (IR)

44.2.1 Definition

Irrigation Requirement is the amount of water that must be supplied to the crop field through irrigation to meet the crop water requirement, after accounting for effective rainfall and other natural water sources.

44.2.2 Equation for IR

$$IR = CWR - ER - GW - SW$$

Where:

- **IR** = Irrigation Requirement
- **CWR** = Crop Water Requirement
- **ER** = Effective Rainfall
- **GW** = Contribution from Groundwater
- **SW** = Contribution from Soil Water (Initial moisture content)

44.2.3 Methods to Determine IR

- **Soil Moisture Deficit Method**
- **Pan Evaporation Method**
- **Crop Coefficient Method (Kc Method)**

  $$ET_c = K_c \times ET_0$$

  Where:

  - **ET_c** = Crop Evapotranspiration
  - **ET_0** = Reference Evapotranspiration
  - **K_c** = Crop Coefficient

44.2.4 Gross and Net Irrigation Requirement

- **Net Irrigation Requirement (NIR):** Actual amount of water required at the root zone.

- **Gross Irrigation Requirement (GIR):** Water applied at the field inlet, accounting for losses.

$$GIR = \frac{NIR}{Efficiency}$$

44.3 Effective Rainfall (ER)

44.3.1 Definition

Effective rainfall is the portion of total precipitation that is actually available for crop use.

44.3.2 Estimation Methods

- **Empirical Methods (USDA, FAO)**
- **Soil Moisture Balance**
- **Daily Rainfall Records Analysis**

44.4 Frequency of Irrigation

44.4.1 Definition

Frequency of irrigation is the interval between two successive irrigations.

44.4.2 Factors Affecting Frequency

- **Crop Type and Growth Stage**
- **Soil Texture and Infiltration Rate**
- **Root Zone Depth**
- **Climatic Conditions**
- **Irrigation Method Used**

44.4.3 Determination of Frequency

The frequency is calculated based on soil moisture depletion:

$$F = \frac{D \times MAD}{ET_c}$$

Where:

- **F** = Irrigation Interval (days)

- **D** = Root Zone Depth (mm)
- **MAD** = Management Allowable Depletion (%)
- **ET_c** = Crop Evapotranspiration per day (mm/day)

44.4.4 Common Ranges of Frequency

- **Shallow-rooted crops:** 3–5 days
- **Medium-rooted crops:** 7–10 days
- **Deep-rooted crops:** 10–15 days

44.5 Irrigation Scheduling

44.5.1 Purpose

- Optimize water usage
- Improve crop yield
- Minimize water losses

44.5.2 Approaches

- **Soil Moisture Monitoring**
- **Climatic Data-Based Scheduling**
- **Remote Sensing & GIS Tools**
- **Decision Support Systems (DSS)**

44.5.3 IW/CPE Ratio Method

- **IW:** Depth of irrigation water applied
- **CPE:** Cumulative Pan Evaporation
- A specific IW/CPE ratio (e.g., 0.6 or 0.8) is selected based on crop and climate.

44.6 Water Use Efficiency (WUE)

44.6.1 Definition

Ratio of crop yield to the amount of water used.

$$WUE = \frac{\text{Crop Yield}}{\text{Total Water Used}}$$

44.6.2 Techniques to Improve WUE

- Drip and Sprinkler Systems
- Mulching and Conservation Tillage
- Laser Land Leveling
- Proper Crop Rotation and Selection

44.7 Duty and Delta Relationship

44.7.1 Duty (D)

Amount of land irrigated by a unit discharge of water in a base period.

$$D = \frac{Area}{Discharge}$$

44.7.2 Delta (Δ)

Total depth of water required by the crop during the entire base period.

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

Where:

- **B** = Base period in days
- **D** = Duty in ha/cumec

44.8 Leaching Requirement

44.8.1 Definition

Additional amount of water required to flush out excess salts from the root zone in saline soils.

44.8.2 Leaching Requirement Formula

$$LR = \frac{EC_{iw}}{5 \times EC_e - EC_{iw}}$$

Where:

- **LR** = Leaching Requirement

- **EC_{iw}** = Electrical conductivity of irrigation water
- **EC_{e}** = Electrical conductivity of soil saturation extract

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44.9 Case Studies and Examples

44.9.1 Example: Calculating IR Using Pan Evaporation

Given:

- Kc = 0.85,
- Pan coefficient = 0.7,
- Pan evaporation = 6 mm/day

$$ET_c = K_c \times K_p \times E_p = 0.85 \times 0.7 \times 6 = 3.57\, mm/day$$

44.9.2 Sample Irrigation Scheduling Chart

Includes crop stage, ET rate, soil moisture status, irrigation interval, and depth of irrigation.
