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COIMBATORE

DEPARTMENT OF CIVIL ENGINEERING

19CET305-IRRIGATION AND WATER RESOURCE ENGINEERING

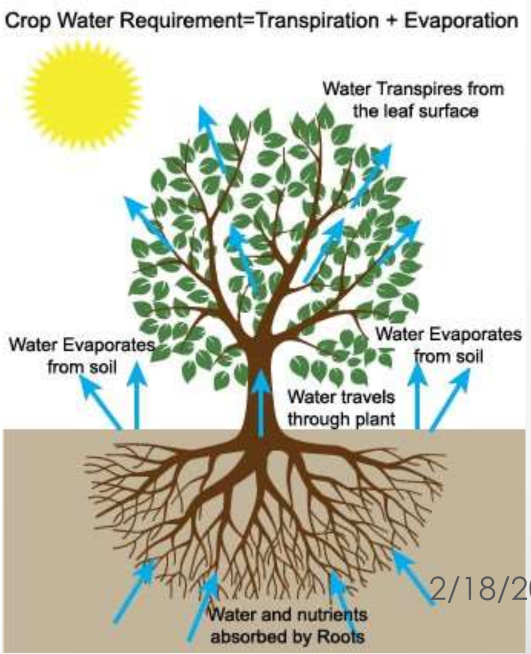
III YEAR / VI SEMESTER

Unit 1 : IRRIGATION & ITS METHODS

Topic 1

UNIT-1

Need Need and classification of irrigation -merits and demerits of irrigation - types of crops-crop season-duty, delta and base period- consumptive use of crops - Estimation of Evapotranspiration using experimental and theoretical methods.



Sylla

Tank irrigation – Well irrigation –Surface and Sub-Surface and Micro Irrigation –drip and sprinkler irrigation – ridge and furrow irrigation -Irrigation scheduling – Water distribution system

Irrigation- Definition

- **Irrigation is an artificial application of** **to the soil.**
- **It is usually used to assist the growing of crops in dry areas and during periods of inadequate rainfall.**

Need of the Irrigation

- Less rainfall
- Non uniform rainfall
- Commercial crops with additional water
- Controlled water supply

Benefits of Irrigation

- Increase in food production
- Protection from famine
- Cultivation of cash crop (Sugarcane, Tobacco)
- Addition to the wealth of the country
- Increase the prosperity of people
- Generation of hydro-electric power
- Domestic & industrial water supply
- Inland navigation
- Improvement of communication
- Canal plantations
- Improvement in the ground water storage
- General development of the country.

Historical development of Irrigation

- Indus Civilization flourished on the banks of rivers and the water was harnessed for sustenance of life.
- Irrigation technologies during the Indus Valley Civilization were in the form of small and minor works like digging wells.

Advantages of irrigation

I.Direct Benefits

- Multiple cropping for cultivation
- Productivity is high
- Quality of the crop is improved
- Higher economic return and employment opportunities.
- Development of pisciculture and afforestation
- Prevention of damage through flood

Indirect Benefits

1. Increase in gross domestic product of the country, employment, land value, higher wages to farm labour, agro-based industries and groundwater storage.
2. General development of other sectors and development of the country
3. Increase of food production.
4. Modify soil or climate environment – leaching.
5. Lessen risk of catastrophic damage caused by drought.
6. Increase income & national cash flow.
7. Increase labor employment.

Indirect Benefits

1)Increase standard of living.

2)Increase value of land.

3)National security thus self sufficiency.

4)Improve communication and navigation facilities.

5)Domestic and industrial water supply.

6)Improve ground water storage.

7)Generation of hydro-electric power.

Disadvantages of Irrigation

- Water logging.
- Salinity and alkalinity of land.
- Ill aeration of soil.
- Pollution of underground water.
- Results in colder and damper climate causing outbreak of diseases like malaria.

Types of Crops:

1) **Wet crops-** which lands are irrigated and than crop a.. cultivation

2) **Dry crops-**which do not need irrigation.

3) **Garden crops-** which need irrigation throughout the year

4) **Summer crop (Kharif)**-which are sown during the south west monsoon & harvested in autumn.

5) **Winter crops(rabi)**-which are sown in autumn & harvested in spring.

6) **Cash crop –** which has to be encased in the market. As it cannot be consumed directly by the cultivators.

S.No	Crop	Sown	Harvested
1	Summer season (Kharif crop)		
	Rice	June -July	Oct-Nov
	Maize	June -July	Sep-Oct
	Bajra	June -Aug	Sep-Oct
	Jowar	June -July	Oct-Nov
	Pulses	June -July	Nov-Dec
2	Winter season (Rabi Crops)		
	Wheat, Barley, peas	Oct-Nov	March - April
	Gram	Sep- Oct	March - April
	Tobacco	Feb-Mar	June
	Potato	Oct	Feb
3	Eight Months Crop cotton	May-June	Dec-Jan
4	Annual crop sugercane	Feb-March	Dec-march

Crop Seasons:

- In north India the crop season is divided as Rabi & Kharif.
- Rabi crops are called as winter crops and kharif crops are called as summer crops.
- Kharif crops required more water than rabi crops.
- Rabi starts from 1 st oct and ends on 31 march
- In TamilNadu crops are classified as wet and dry crops.

Crops rotation:

Rotation of crops implies the nature of the crop sown in a particular field is changed year after year.

Necessity for rotation :

- Fertility of land gets reduced as the soil becomes deficient
- More balanced fooding
- Rotation will check the diseases
- increase nitrogen content of soil
- The soil will be better utilized
- rotation of cash crops, fooder and soil renovating crops.

General rotation of crops can be summariz

1. Wheat – great millet – gram.
2. Rice – gram
3. Cotton – wheat – gram.
4. Cotton – wheat – sugarcane
5. Cotton – great millet – gram.

Consumptive Use of Water for crop

- Considerable part of water applied for irrigation is lost by evaporation & transpiration.
- This two processes being difficult to separate are taken as one and called Vapor-transpiration or Consumptive use of water.

Types of Consumptive Water Use

1.Optimum Consumptive Use
2.Potential Consumptive Use
3.Seasonal Consumptive Use

1. Optimum Consumptive Use:
It is the consumptive use which produces a maximum crop yield.
2. Potential Consumptive Use:
If sufficient moisture is always available to completely meet the needs of vegetation fully covering the entire area then resulting evapotranspiration is known as Potential Consumptive Use.
3. Seasonal Consumptive Use:
The total amount of water used in the evapo-transpiration by a cropped area during the entire growing season

Consumptive Use of Water

- Considerable part of water applied for irrigation is lost by evaporation & transpiration.
- This two processes being difficult to separate are taken as one and called Vapor- transpiration or Consumptive use of water.

Duty:

It may be defined as the number of hectares of land irrigated for full growth of a given crop by supply of 1 m^3/s of water continuously during the entire base of that crop.

Simply we can say that, the area (in hectares) of land can be irrigated for a crop period, B (in days) using one cubic meter of water.

Duty, Delta & Base period

Duty

The term duty means the area of land that can be irrigated with unit volume of irrigation water. Duty represents the irrigating capacity of a unit. It is the relation the between the area of a crop irrigated and the quantity of irrigation water required during the entire period of the growth of that crop.

Delta

It is the total depth of the water required by a crop during the entire period the crop is in the field and is denoted by the symbol Δ.

Base period

Base period for a crop refers to the whole period of cultivation from the time when irrigation water is first issued for preparation of the ground for planting the crop, to its last watering before harvesting.

Relationship between Duty and Delta

If we take a field of area D hectares, water supplied to the field corresponding to the water depth Δ metres will be

$$= \Delta \text{ x } D \text{ hectares-metres} = D \text{ x } \Delta \text{ x} 10^4 \text{ cubic-metres} \qquad \text{..... (1)}$$

Again for the same field of D hectares, one cumec of water is required to flow during the entire base period. Hence, water supplied to this field.

$$= (1) \text{ x } (B \text{ x } 24 \text{ x } 60 \text{ x } 60) \text{ m}^3 \qquad \text{..... (2)}$$

Equating Equations (1) and (2), we get

$D \text{ x } \Delta \text{ x } 10 = B \text{ x } 24 \text{ x } 60 \text{ x } 60$

1 hectare = 10^4 sq metres

cumec-day = 8.64 hectare-metres

Relationship between Duty and Delta

Let Base Period B days, 1 cumec of applied water

Vol of water applied to the crop during B days

V= (1 x 60 x 60 x 24 x B) cumec

w.k.t D is 1 cumec supplied for B days matures D hectars of land (10^4 sq.m)

Total depth of water applied on the land = (Volume /Area)

V= (1 x 60 x 60 x 24 x B) cumec

A= 10^4 D

= 86400 B / D (meters)

Delta :– Total depth of water = 8.64 B / D (m)

Problem –1: If rice requires about 10 cm de water at an average interval of about 10 days, and the crop period for rice is 120 days, find out the delta for rice.

***Solution*:**

No. of watering required = 120/10 = 12

Total depth of water required in 120 days = 10 × 12 = 120 cm

Δ for rice = 120 cm

Problem –2: If wheat requires about 7.5 c water after every 28 days, and the base period for wheat is 140 days, find out the value of delta for wheat.

***Solution*:**

No. of watering required = 140/28 = 5

Total depth of water required in 140 days = 7.5 × 5 = 37.5 cm

Δ for wheat = 37.5 cm

Relation between duty and delta

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

Where,

Δ=Delta in meter

D = Duty in Ha/cumec

B = Base period in days

Also $$\Delta = \frac{2B}{D}$$

Where,

Δ=Delta in meter

B = Base period in days

D = Duty in acre/cures

Factors on which duty depends:

- Type of crop
- Climate and season
- Useful rainfall
- Type of soil
- Efficiency of cultivation method

Importance of Duty

- It helps us in designing an efficient canal irrigation system.
- Knowing the total available water at the head of a main canal, and the overall duty for all the crops required to be irrigated in different seasons of the year, the area which can be irrigated can be worked out.
- *Inversely, if we know the crops area required to be irrigated and their duties, we can work out the discharge required for designing the channel.*

Measures for improving duty of water:

(1) Proper Ploughing

(2) Methods of supplying water

- Furrow method For crops sown ion rows
- Contour method For hilly areas
- Basin For orchards
- Flooding For plain lands

(3) Canal Lining

(4) Minimum idle length of irrigation Canals:

(5) Quality of water:

(6) Crop rotation:

Irrigation Requirements of crops

(1) Consumptive Irrigation Requirement (CIR)

$$CIR = Cu - P_{eff}$$

Where, Cu= total consumptive use requirement

P_{eff}= Effective rainfall.

(2) Net Irrigation Requirement (NIR)

$$NIR = CIR + \text{Leaching requirement}$$

(3) Field irrigation requirement (FIR)

$$FIR = \frac{NIR}{\eta_a}$$

(4) Gross irrigation requirement, (GIR)

$$GIR = \frac{FIR}{\eta_c}$$

Irrigation Efficiency - Definition and Its Types

Definition

The ratio of the amount of water available (output) to the amount of water supplied (input) is known as Irrigation Efficiency. It is expressed in percentage.

Types of Irrigation Efficiency

The following are the various types of irrigation efficiencies:

(a) Water Conveyance Efficiency (ηc):

It is the ratio of the amount of water applied, to the land to the amount of water supplied from the reservoir. It is obtained by the expression,

$\eta c = Wl\ Wr \times 100$ Where,

ηc = Water conveyance efficiency

Wl = Amount of water applied to land

Wr = Amount of water supplied from reservoir

(b) Water Application Efficiency (η_a):

It is the ratio of the water stored in root zone of plants to the water applied to the land. It is obtained by the expression,

$\eta_a = W_z \ W_l \times 100$ Where,

η_a = Water application efficiency

W_z = Amount of water stored in root zone

W_l = Amount of water applied to land

(c) Water Use Efficiency (η_u):

It is the ratio of the amount of water used to the amount of water applied. It is obtained by the expression,

$\eta_u = W_u \ W_l \times 100$ Where, η_u = Water use efficiency W_u = Amount of water used W_l = Amount of water applied to land

(b) Water Application Efficiency (ηa):

It is the ratio of the water stored in root zone of plants to the water applied to the land. It is obtained by the expression,

η_a = Wz Wl × 100 Where,

η_a = Water application efficiency

Wz = Amount of water stored in root zone

Wl = Amount of water applied to land

(c) Water Use Efficiency (ηu):

It is the ratio of the amount of water used to the amount of water applied. It is obtained by the expression,

ηu = Wu Wl × 100 Where,

ηu = Water use efficiency

Wu = Amount of water used

Wl = Amount of water applied to land

(d) Consumptive use Efficiency (ηcu):

It is the ration of the consumptive use of water to the amount of water depleted from the root zone. It is obtained by the expression,

ηcu = Cu Wp × 100 Where,

Consumptive use of crops

Definition:

- It is the quantity of water used by the vegetation growth of a given area.
- It is the amount of water required by a crop for its vegetated growth to evapotranspiration and building of plant tissues plus evaporation from soils and intercepted precipitation.
- It is expressed in terms of depth of water. Consumptive use varies with temperature, humidity, wind speed, topography, sunlight hours, method of irrigation, moisture availability.

  Mathematically,

Consumptive Use = Evapotranspiration = Evaporation + transpiration

It is expressed in terms of depth of water.

Factors Affecting the Consumptive Use of W

- Evaporation which depends on humidity
- Mean Monthly temperature
- Growing season of crops and cropping pattern
- Monthly precipitation in area
- Wind velocity in locality
- Soil and topography
- Irrigation practices and method of irrigation
- Sunlight hours

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2. Potential Consumptive Use:

If sufficient moisture is always available to completely meet the needs of vegetation fully covering the entire area then resulting evapotranspiration is known as Potential Consumptive Use.

3. Seasonal Consumptive Use:

The total amount of water used in the evapo-transpiration by a cropped area during the entire growing season.

Methods of Determination of Evapotranspiration

1)Direct Methods/Field Methods

2)Empirical Methods

3)Pan evaporation method

1. Direct Methods:

In this method field observations are made and physical model is used for this purpose. This includes,

1.Vapour Transfer Method / Soil Moisture Studies

2.Field Plot Method

3.Tanks and Lysimeter

4.Integration Method/Summation Method

5.Irrigation Method

6.Inflow Outflow Method

1.Vapour Transfer Method:

- In this method of estimation of water consumptive use, soil moisture measurements are taken before and after each irrigation.
- The quantity of water extracted per day from soil is computed for each period.
- A curve is drawn by plotting the rate of use against time and from this curve, the seasonal use can be estimated.
- This method is suitable in those areas where soil is fairly uniform and ground water is deep enough.
- It is expressed in terms of volume i.e. **Acre-feet or Hectare-meter**

ii. Field Plot Method:

- We select a representative plot of area and the accuracy depends upon the representativeness of plot (cropping intensity, exposure etc).
- It replicates the conditions of an actual sample field (field plot). Less seepage should be there.

Inflow + Rain + Outflow = Evapotranspiration

- The drawback in this method is that lateral movement of water takes place although more representative to field condition.
- Also some correction has to be applied for deep percolation as it cannot be ascertained in the field.

iii. Tanks and Lysimeter:

- In this method of measurement of consumptiv f water, a watertight tank of cylindrical shape having diameter 2m and depth about 3m is placed vertically on the ground.
- The tank is filled with sample of soil. The bottom of the tank consists of a sand layer and a pan for collecting the surplus water.
- The plants grown in the Lysimeter should be the same as in the surrounding field.

- The consumptive use of water is estima measuring the amount of water required for the satisfactory growth of the plants within the tanks. Consumptive use of water is given by,

$$Cu = Wa – Wd$$

Where, Cu = Consuptive use of water

Wa = Water Applied

Wd = Water drained off

- Lysimeter studies are time consuming and expensive. Methods 1 and 2 are the more reliable methods as compare to this method.

iv. Integration Method:

- In this method, it is necessary to know the division of total area, i.e. under irrigated crops, natural native vegetation area, water surface area and bare land area.
- In this method, annual consumptive use for the whole area is found in terms of volume.
- It is expressed in Acre feet or Hectare meter.

Mathematically,

Total Evapotranspiration = Total consumptive use

Total Area Annual Consumptive Use

= Total Evapotranspiration

= A+B+C+D

Where,

A = Unit consumptive use for each crop x its area

B = Unit consumptive use of native vegetation x its area

C = Water surface evaporation x its area

D = Bare land evaporation x its area

v. Irrigation Method:

- In this method, unit consumption is multiplied by some factor.
- The multiplication values depend upon the type of crops in certain area.
- This method requires an Engineer judgment as these factors are to be investigated by the Engineers of certain area.

vi. Inflow Outflow Method:

In this method annual consumptive use is found for lar

If U is the valley consumptive use its value is given by,

$$U = (I+P) + (Gs - Ge) - R$$

Where,

U = Valley consumptive use (in acre feet or hectare meter)

I = Total inflow during a year

P = Yearly precipitation on valley floor

Gs = Ground Storage at the beginning of the year

Ge = Ground Storage at the end of the year

R = Yearly Outflow

2. Empirical Methods:

Empirical equations are given for the estimation of water requirement. These are,

1)Blaney-Criddle method

2)Lowry Johnson Method

3)Penman Equation

4)Hargreave’s Method

a. Blaney-Criddle method:

- Blaney and Criddle (1950) observed that the amount of water consumptively used by crops during their growing seasons was closely correlated with mean monthly temperatures and daylight hours and the length of the growing seasons.
- The correlation coefficients are then applied to determine the ET for other areas where only climate data are available.
- Blaney-Criddle formula is one of the best known procedures for estimating Potential Evapotranspiration (PET) and is widely used

If CU is monthly consumptive use, its value is gi

Cu= K.f (inches)

Where,

k = crop factor to be determined for each crop; its value depends upon Certain environmental conditions

F = monthly consumptive use factor

= t×(p/100)

t = mean temperature in ^{o}F.

p = percentage of day time hours of the year, occurring during the period.

If Expressed in metric units, the above formula bec

$$C_u = k.\frac{p}{40}\left[1.8t + 32\right] = k.f$$

Where,

t = temperature in ^{o}C

Cu= monthly consumptive use in cm

b. Lowry Johnson Method:

The equation for this method is,

$$\mathbf{U = 0.0015\ H + 0.9\ (Over\ specified)}$$

U = Consumptive Use

H = Accumulated degree days during the growing season computed from maximum temperature above 32 °F

c. Penman Equation:

Penman(1948) proposed an equation for evaporation fr

water surface, based on a combination of energy balance and sink strength which is given below with changes in certain symbols in view of the recent trends.

According to this method,

$$U = ET = AH + 0.27\ EaA - 0.27$$

ET = Evapotranspiration or consumptive use in mm Ea = Evaporation (mm/day)

H = Daily head budget at surface (mm/day)

A = Slope of saturated vapour pressure curve of air at absolute temperature in °F

d. Hargreave’s Method:

- It is a very simple method.
- The pan is circular with a diameter of 1.21 m and depth of 255 mm which gives it a volume of about 0.3 m3.
- The basin is put on a 150 mm high wooden frame due to air circulation around the basin. The water level is kept about 50 mm below the rim, due to allowance of percolation and the need of water.
- The water level is measured every day, either you measure the difference between the present and the origin water level or if you have chosen to obtain the water level in the pan, you measure the amount of water you have put into the pan.

According to this method,

$$Cu = K\ Ep$$

Where,

- Cu = Consumptive Use coefficient (varies from crop to crop)

  Ep = Evapotranspiration

- K = Coefficient