Module-4

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Sub:- Hydrology and Irrigation

Irrigation:-

It is a process of artificial supply of water from source (dam, reservoir, weir, barrage) to a crops in a agricultoral land through a canals is called irrigation.

(or)

simply, It is a process of supplying water to crops artificially.

Necessity of Irrigation:-

① **Insufficient Rainfall**

Irrigation is necessary in the areas where rainfall is insufficient for the satisfactory growth of crops.

② **Uneven (or) Non-uniform Rainfall**

Irrigation is necessary in the areas where rainfall is not evenly distributed for the satisfactory growth of crops.

③ **Improvement of perinnial crops**

We know that Rainfall is not uniform in all season (or) throughout a year. But perinnial crops require water through-out the year so Irrigation is necessary for the production of these crops.

④ **Development of Desert land**

Irrigation is necessary for the conversion of dry land and (or) desert land into Beautiful crop land.

Benefits of Irrigation (or) Advantages of Irrigation (or) Merits of Irrigation

1. Yield of crops :- Yield of crops can be increased by Irrigation even during less Rainfall.

2. Optimum benefits :- optimum use of water is possible by Irrigation to obtain Maximum benefit.

3. Water supply :- Irrigation water may also be used for Domestic as well as Industrial water supply.

4. Development of fishery :- Irrigation water may also used for development of fisheries in canals and reservoirs.

5. Hydro-Electric power generation :- Irrigation water in a dams (or) reservoirs may be used for generation of powers. Besides that, canal falls (or) canal drops in which mini hydroprojects may be installed.

6. Elimination of Mixed Cropping :-

If Irrigation water is not assured, Mixed cropping is adopted. Mixed cropping means sowing different types of crops in a same field. Here Mixed cropping is not desirable because diff types of crops requires diff amount of water which leads to reduce yielding of crops. So, farmers aren't getting Benefitted

If Irrigation water is assured, Mixed cropping is Eliminated and single superior crop may grown to get Maximum benefit.

7. Prosperity of farmers:- If Irrigation water is assured through -out the year, farmers can grow two (or) more crops within a year which adds to their prosperity.

8. Source of Revenue:- If water tax is taken from farmers for supplying water, it adds to the revenue of the Country.

9. Aesthetic view:- If ~~made~~ Man-Made lake is preserved carefully, which may increase aesthetic view of surroun-dings

10. Tree plantation:- If trees can grow along the canal bank, which helps to increase the wealth from timber and also controls soil Erosion of the canal bank.

Ill - Effects of Irrigation (or) Disadvantages of Irrigation (or) Demerits of Irrigation

1. Loss of valuable land :-
Valuable land may be submerged due to Construction of reservoir by dam, weir and Barrages.

2. Breeding places of mosquitoes:-
Due to Excess application of water, Seepage from canal then Marshy land is formed which leads to Breeding places of mosquitoes.

③ **Rising of Water table :-**

In a unlined canal, excessive seepage of water through bed and sideslopes of canal takes place which raises the water table of the surrounding areas. Soil in a root zone of crops is saturated and becomes alkaline which is harmful to crop plants. Thus the nearby area may be waterlogged called Marshy land.

④ **Returns of Revenue :-**

· Irrigation projects are complex and expensive. If project fails due to absence of regular maintainance, returns of revenue to Government becomes low compared its cost of construction.

⇒ Methods of Irrigation (or) Systems of Irrigation (or) Types of Irrigation

Irrigation Methods

- Surface Irrigation
  - Flow Irrigation
    - Perennial Irrigation
    - Flood Irrigation
  - Lift Irrigation
- Subsurface Irrigation
  - Natural (Seepage)
  - Artificial (pipes)
- Drip Irrigation
- Sprinkler Irrigation

1) Surface Irrigation :- It is a method of application and distribution of water over the soil surface by a gravity.

Surface Irrigation can be classified into two types:-

ⓐ Flow Irrigation

ⓑ Lift Irrigation

~~ⓐ Lift Irrigation~~

ⓐ Flow Irrigation :- If the water is available above the ground level then it can be easily applied to the agricultural land by a action of gravity.

Flow Irrigation can be classified into two types.

(i) perennial Irrigation

(ii) Inundation Irrigation

(i) perennial Irrigation :- In this method, constant and continous supply of water to the agricultural land during crop period.

The water for such irrigation may be available from rivers or from wells.

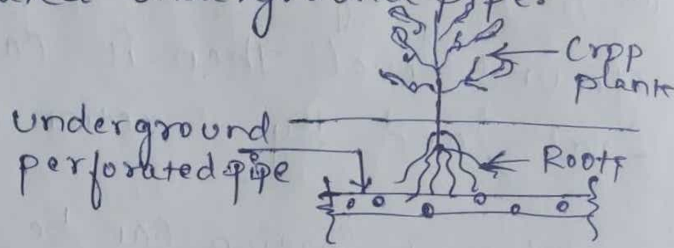
(ii) Inundation Irrigation :- In this method, large quantities of water flowing in a river during floods is allowed to inundate (Fill or immerse) the land to be cultivated, thereby saturating the soil. The Excess water is then drained off & land use for cultivation.

This method is common in the areas near river deltas, where the slope of river & land is small.

It is also called as Flood Irrigation.

⑥ Lift Irrigation:- If the water is available below the ground level then water is lifted up by using Man power (or) Mechanical devices then applied to the agricultural land.

② Subsurface Irrigation:- It is a method of application of water to a roots of plants by a perforated underground pipe.



③ Drip Irrigation:- It is a method of applying irrigation water drop by drop near the plant roots through a small opening called drippers.

④ Sprinkler Irrigation:- It is a method of applying irrigation water which similar to natural rainfall. Here water is distributed through a system of pipes usually by pumping. water is under pressured & sprayed into air above the crop.

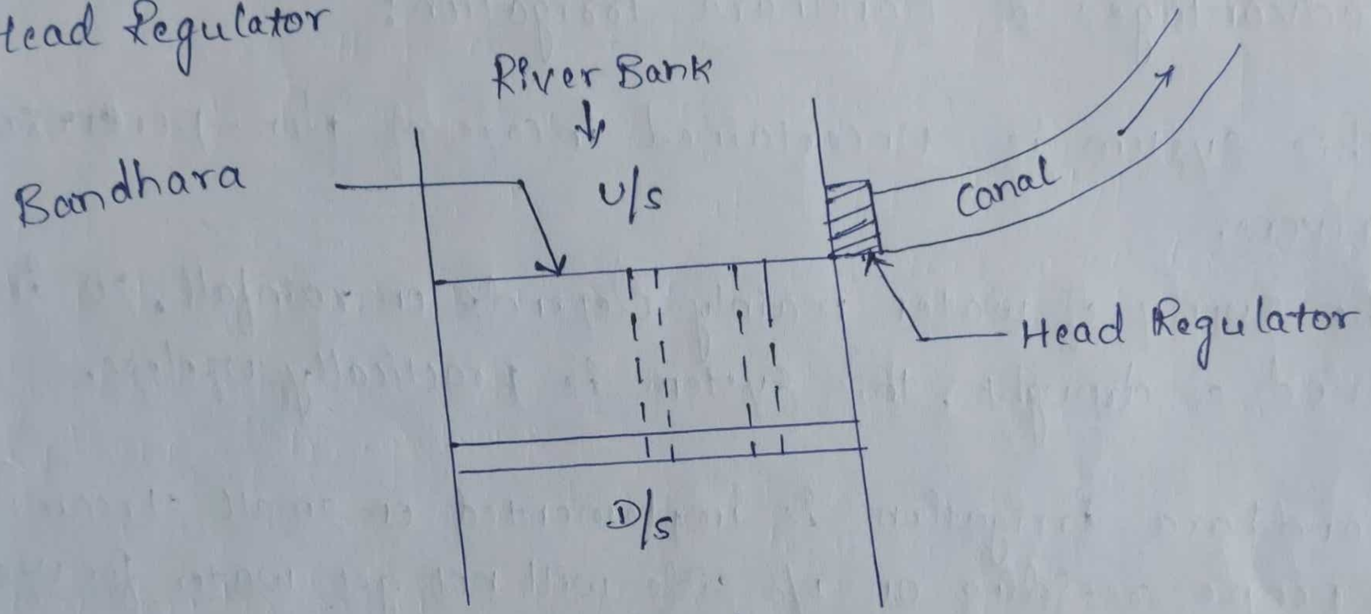
⇒ Bandhara Irrigation:-

* It is a special type of irrigation adopted across small perennial rivers.

* In Bandhara Irrigation, a small masonry weir (or) Barrage (obstruction) have a height of 1.2m to 4.5m is constructed across a river (or) stream.

* The main object of bandhara Irrigation is to rise a water on upstream side (U/s) and divert this water into a small canals.

* The U/s water (or) stored water can be diverted into a one (or) Both sides of River Bank and flow into a canal is Controlled by Head Regulator



Layout of Bandhara

* The Irrigation capacity of Bandhara is about 400 hectors and length of main canal (or) river bank is usually stricted to 8 to 9 km

* This system of irrigation is adopted in central Maha-rastra and is commonly known as phad system

Advantages of Bandhara Irrigation

(1) The Initial and Maintainance Cost is less

(2) As a length of canal is short, so seepage and Evaporation loss is less.

(3) Small quantity of flow in the main canal (or) River Bank is fully utilised otherwise it might have gone waste.

(4) As there is no much loss due to transmission, then the duty of water is High.

Disadvantages of Bandhara Irrigation:-

(1) This system is Uncertained in case of Non-perennial rivers.

(2) The supply of water mainly depends on rainfall. so in the period of drought, this system is practically useless.

(3) Bandhara irrigation is implemented on small streams. so people residing on D/s side will not get water for use.

Water requirement of crops:-

Water requirement of a crop means the total quantity of all water and the way in which a crop requires H_2O from the time it sown to the time it is harvested. The H_2O requirement of crops Varies with the crop as well as with the place. the same crop may have different requirements at the different places of the same Country depending upon type of soil, Method of cultivation & useful rainfall.

Functions of Irrigation Water

* Irrigation Water acts as Nutrient carrier as supply moisture to the soil which is essential for growth which is Beneficial for the growth of plants.
* Moisture facilitates chemical action within plant leading to growth.
* It controls the temperature of soil and Makes more favourable Environment for the healthy growth of plants.
* Irrigation water is controlled supply with dilutes salts present in a soil.

Factors affecting the total Water Requirement:- (for Crops)

The following water requirements of crop depends on following factors.

① Water table :- If the water table is nearer to the ground surface the water requirement is less. If it is much below the ground surface then water requirement for crop will be more.

② Climate :- In hot climate, the Evaporation loss is more and hence requirement will be more & vice-versa.

③ Ground Slope :- If the slope of the ground is steep, the water flows down very quickly and the soil gets little time to absorb moisture resulting the water loss & hence water requirement will be More.
If the ground is flat, the water flows slowly and soil gets sufficient time to absorb moisture & Hence water requirement is less.

④ Intensity of Irrigation :- The Intensity of Irrigation for a particular crop is high then more area comes under the irrigation system & water requirement is more & vice-versa.

⑤ Type of soil :- In sandy soil, water perculate very quickly and can't be retained, so water requirement is more But the clay soil can retain water near to the root zone of crop, so it requires less water.

(6) Method of application of water :- If surface method are used more water is required because to meet Evaporation losses. In subsurface Method less water is required ∵ soil absorbs optimum moisture

In sprinkler method, less water require as it is just moist the soil like rain H_2O.

(7) Method of ploughing :- In deep ploughing (by means of tractors) less water is required becaz soil can retain moisture for longer period. but in shallow ploughing (by means of bullocks) more water is required becaz soil can't retain moisture for longer period due to Evaporation.

Net Irrigation Requirement :- It is a depth of Irrigation H_2O

(i) Exclusive precipitation

(ii) Carryover soil moisture

(iii) Ground - water contribution

(iv) other gains in soil moisture i.e required amount for crop production.

Gross Irrigation Requirement :- It is the total amount of H_2O applied through irrigation. It is basically Net irrigation requi-rement + loss in application of H_2O including other losses.

∴ Gross - Irrigation requirement in field Equals to Net Irrigation Requirement by field efficiency of system i.e $\text{Gross Irrigation Requirement} = \dfrac{\text{Net Irrigation Requirement}}{\text{Field Efficiency of System.}}$

Problem

① The Net amount of irrigation required for field Equals to 6.4 cm. If the field efficiency is 80% what is the gross amount of H_2O required to be applied in the field?

$$\frac{NIR}{FES} = \frac{6.4}{0.8} = \underline{\underline{8\,cm}}$$

Module-4 ((Continue)...)

Water - Crop Requirement

Define Base (B), Duty (D) and Delta (Δ)?

* Base (B) :- It is also called as Base period. Base period is a period from 1st watering (after sowing) to the last watering (just before Harvesting) to a Crop.

It is denoted by 'B'

It is Expressed in Number of days.

Eg :- period for Common Crops.

Kharif Crop - Rice, Maize, - 120 days

Rabi crop - Wheat, Mustard - 120 days

Perrenial Crop - tobacco - 200 days

Cotton - 200 days

Annual crop - Sugar Cane - 365 days.

* Delta (Δ) :- Depth of water is required to raise the Crop is called Delta (Δ).

We know that, Each Crops Requires Certain amount of H_2O for its Maturity. If the total amount of water is supplied to the crop from 1st watering to the last watering (Base period) is stored on the land without any losses, then thick layer of water standing on land. this depth of H_2O is known as delta of crop.

It is denoted by 'Δ'

It is Expressed in 'cm'

Eg:- Δ for some of common Crops

Kharif - Rice - 125cm
Maize - 45cm
Groundnut - 30cm

Rabi - Wheat - 40cm
Mustard - 45cm
potato - 75cm

(x) Duty (D):- It is defined as No. of Hectares that can be Irrigated by constant supply of water at a rate of 1 cumec throughout its Base period.

It is denoted by 'D'

It is Expressed in 'Hec/cum'

Eg:- Rice - 900 Hec/cum, sugar cane - 800 hec/cum

Wheat - 1800 Hec/cum

Factors affecting Duty:-

① Soil characteristics:- If the soil in a canal bed is more porous (coarse grained) seepage loss is more. then duty will be less.

If the soil in a canal bed is less porous (fine grained). seepage loss is less, then duty will be more.

(2) Climate condition:- If the temperature is more in the atmosphere, Evaporation is more then duty will be less & vice-versa.

(3) Rainfall:- If the rainfall is sufficient (or) more during the crop period, then duty will be more (or)/and vice-versa.

(4) Base period:- If the Base period is longer, water requirement will be more and duty will be less & vice-versa.

(5) Types of crop:- Water requirement for various crop is different. so duty also varies from crop to crop.

(6) Method of Irrigation:- The Duty of Irrigation (or) water is High in case of perennial irrigation system as compared to Inundation Irrigation system.

(7) Method of ploughing:- proper deep ploughing is done by tractors requires less quantity of water & Hence duty of water is High.

(8) Water tax:- If tax is imposed then the farmers will use the water Economically then duty of water is increased.

→ Methods to improve Duty of Water:-

We have following Methods to improve duty of water.

① Proper ploughing :- The Duty of water is High in case of deep & proper ploughing because it helps to increase moisture retaining capacity of the soil for a long period. so, the duty of water should be improved by avoiding shallow ploughing and adopt deep ploughing.

② Crop rotation :- The rotation of crop must be practised to increase the fertility of the soil as well as to increase the moisture retaining capacity of the soil.

③ Method of Irrigation System :- The Duty of water is High in case of perennial irrigation system Because, in this system, the Head Regulator is used. so, by using this type of irrigation system, the duty of water is High.

④ Implementation of Tax :- The Water Tax should be implemented Based on the water consumption volume. As a result, the farmers will use the water Economically, and thus the duty of water will be High.

⑤ Frequently Cultivation :- The land should be cultivated frequently becaz. frequent cultivation minimizes the loss of moisture from the soil.

⑥ Canal lining :- The canal lining should be done such a way that it reduces the percolation loss of water.

7. Transmission Loss :- To overcome transmission loss of the water, the canals should be as possible as near to the cultivated land.

→ Relationship b/w Base (B), Duty (D), and Delta (Δ) :-

Volume of water = $1\,m^3/sec$ for 'B' days

$= B \times 24 \times 60 \times 60 \quad m^3 \longrightarrow (1)$

Area of land (Hectares) $= D \times 10^4 \quad m^2 \longrightarrow (2)$

W.K.T Volume = Area × Depth

then, $\text{Depth} = \dfrac{\text{Volume}}{\text{Area}}$

$$\Delta = \frac{B \times 24 \times 60 \times 60}{D \times 10^4}$$

$$\boxed{\Delta = 8.64\,\frac{B}{D}}$$ in cm (or) m

Problems

1. The gross commanded area for a distributory is 20,000 Hectares, 75% of which can be irrigated. The intensity of irrigation for Rabi season is 40% that for kharif (or) Rice season is 10%. If kor period is 4 weeks for rabi and 2.5 weeks for ~~Rice~~ kharif, determine the outlet discharge. outlet factors for rabi and ~~rice~~ kharif may be assumed as

1800 Hec/cum & 775 Hec/cum. Also calculate delta for each crop.

Soln:-

Given

G.C.A = 20000 Hec

$C.C.A = \frac{75}{100} \times 20000$

$= 15000$ Hec

I.O.I for Rabi = 40%

I.O.I for kharif = 10%

Base period (B) for Rabi = 4 weeks

$= 4 \times 7$

$= 28$ days

Base Period (B) for Kharif = 2.5 weeks

$= 2.5 \times 7 = 17.5$ days

Duty for Rabi (D) = 1800 Hec/cum

Duty for Kharif (D) = 775 Hec/cum

Delta (Δ) for Rabi = ?

Delta (Δ) for Kharif = ?

Q for Rabi & Kharif = ?

W.K.T

$$\text{Intensity of Irrigation} = \frac{\text{Area for particular Crop}}{\text{Culturable Command area}}$$

$\text{Area for Rabi} = \frac{40}{100} \times 15000$

$= 6000$ Hec

$\text{Area of Kharif} = \frac{10}{100} \times 15000$

$= 1500$ Hec

W.K.T

$$\text{Discharge} = \frac{\text{Area}}{\text{duty}}$$

Now,

$$\text{Discharged Required for Rabi} = \frac{6000 \text{ Hec}}{1800 \text{ Hec/cum}}$$

$= 3.33$ cumec

$= 3.33 \ m^3/sec$

$$\text{Discharged required for Kharif} = \frac{\text{Area for kharif}}{\text{Duty of kharif}}$$

$$= \frac{1500 \text{ Hec}}{775 \text{ Hec/cum}}$$

$= 1.935$ cum $= 1.935 \ m^3/sec$

(1 week → 7 days)

For Rabi, $\Delta = 8.64 \dfrac{B}{D}$

$$= 8.64 \times \frac{4 \times 7 (\text{days})}{1800} = \underline{\underline{0.134\,m}}$$

For Kharif, $\Delta = 8.64 \times \dfrac{B}{D}$

$$= 8.64 \times \frac{2.5 \times 7}{775} = \underline{\underline{0.195\,m}}$$

② What is the discharged capacity required at the outlet to irrigate 2600 hec of sugarcane having a kor depth of 17cm & kor period of 30 days?

Soln:-

$Q = ?$

Area, $A = 2600$ ha

depth, $\Delta = 17\,cm$
$= 0.17\,m$

Kor period (or) Base period, $B = 30$ days

W.K.T

$$Q = \frac{\text{Area (A)}}{\text{duty (D)}}$$

W.K.T $\Delta = 8.64 (B/D)$

then, $D = 8.64 \left(\dfrac{B}{\Delta}\right)$

$$D = 8.64 \times \frac{30}{0.17}$$

$$= \underline{\underline{1524.7}}\ \text{Hec/cum}$$

Now, $Q = \dfrac{2600 \text{ Ha}}{1524.7 \text{ Ha/cum}}$

$$Q = \underline{\underline{1.71\ m^3/sec}}$$

(3) The gross commanded area for a distributary is 6000 Hec, 80% of which is culturable irrigable. The intensity of irrigation for kharif season is 25% and that for Rabi season is 50%. If the average duty at the head of distributary is 700 Hec/cum for kharif season and 1700 Hec/cum for Rabi season, find the discharge required for design at the head of distributary.

Soln:-

G.C.A = 6000 Ha

$$C.C.A = \frac{80}{100} \times 6000$$

$= 4800$ Ha

duty)kharif = 700 Hec/cum

duty)Rabi = 1700 Hec/cum

W.K.T $Q = \dfrac{\text{Area}}{\text{duty}}$

$$\text{Area under kharif} = \frac{25}{100} \times 4800$$

$= 1200$ Ha

$$\text{Area under Rabi} = \frac{50}{100} \times 4800$$

$= 2400$ Ha

$$Q)_{kharif} = \frac{A)_{kharif}}{D)_{kharif}}$$

$$= \frac{1200 \text{ Ha}}{700 \text{ Ha/cum}}$$

$= 1.714$ cumec

(or)

$= 1.714\ m^3/sec$

$$Q)_{Rabi} = \frac{A)_{Rabi}}{D)_{Rabi}}$$

$$= \frac{2400 \text{ Ha}}{1700 \text{ Ha/cum}}$$

$= 1.411$ cumec

(or)

$= 1.41\ m^3/sec$

(4) The Gross command Area of irrigation project is 1.5 lakh Hec where 7500 hec area is unculturable. The Area of kharif crop is 60,000 hec & rabi is 40,000 hec, The duty of kharif is 3000 Hec/cum & duty of rabi is 4000 hec/cum (21)

(i) find the design discharge of channel. assuming 10% of transmission loss.

(ii) find the Intensity of Irrigation for both kharif & rabi

Soln:-

Given

G.C.A = 1,50,000 Hec

C.C.A = G.C.A - Unculturable area

= 1,50,000 - 7500

= 1,42,500 Ha

$Area)_{kharif}$ = 60,000 Ha

$Area)_{Rabi}$ = 40,000 Ha

$Duty)_{kharif}$ = 3000 Hec/cumec

$Duty)_{Rabi}$ = 4000 Hec/cumec

W.K.T

$$\text{Discharge, } Q)_{kharif} = \frac{A)_K}{D)_K}$$

$$= \frac{60,000}{3000}$$

$$= 20 \text{ m}^3/\text{sec}$$

$$Q)_{Rabi} = \frac{40,000}{4000}$$

$$= 10 \text{ m}^3/\text{sec}$$

Assumed loss is 10%. so we have to design the discharge for 10% Excess to the actual discharge.

$$\text{So, } Q)_K = 20 + \left(\frac{10}{100} \times 20\right) \;\&\; Q)_R = 10 + \left(\frac{10}{100} \times 10\right)$$

$$= 20 + 2 \qquad\qquad = 10 + 1$$

$$= 22 \text{ m}^3/\text{sec} \qquad\qquad = 11 \text{ m}^3/\text{sec}$$

So canal is to be designed to carry discharge of $22\ m^3/sec$ because this capacity will able to supply of water in Both season.

(ii) Intensity of Irrigation

(a) Kharif

$$I.O.I = \frac{C.A}{C.C.A}$$

$$= \frac{60,000}{1,42,500}$$

$$= 42.15\%$$

(b) Rabi

$$I.O.I = \frac{C.A}{C.C.A}$$

$$= \frac{40,000}{1,42,500}$$

$$= 28\%$$

Crop Seasons In India :-

Crop Season → During which some particular type of crop can be grown Every year on the same land is known as crop season. The following are Main crop seasons.

(i) Kharif Season :- This season ranges from June to October. their crops sown in Every begging of Monsoon and harvested at the End of Autumn. The Major Kharif crops are Rice, Maize, Groundnut.

(ii) Rabi season :- This season ranges from Oct to March. their crops sown in Every begging of winter and harvested at the End of spring. The Major Rabi crops are Wheat, Mustard, onion

Apart from kharif & Rabi there are several crops requires more time & they cover both main crop seasons. Here(i.e) Cotton requires more time mnz 8 months to mature and hence they are designed for 8months as a perennial crops.

Seasons	period	Base period	Common crops
kharif	15 Jun - 14 OCT	123 days	Rice, Maize Groundnut
Rabi	15 Oct - 14 Feb	122 days	Wheat, onion Mustard
Hot Weather	15 Feb - 14 Jun	120 days	Vegetables
8 months	15 Jun - 14 - Feb	245 days	tobacco, cotton
Annual	15 Jun - 14 Jun	365 days	Sugarcane.

In Irrigation Efficiency (continue) (pg.26)

6. Water distribution efficiency (η_d):- It is determined from Expression $\eta_d = [1 - y/d] \times 100$,

where y = avg. numerical deviation in depth of H_2O stored from the avg. depth of water 'd' stored in root zone during irrigation. Here water distribution efficiency Evaluates degree to which water is uniformly distributed throughout root zone during irrigation & hence it is also known as uniformly co-efficient. Higher the value of Efficiency (η_d)

Higher will be uniformly co-efficient (or) more uniformly water distributed in root zone which inturn will result in better crop response.

for Eg:- A water distribution efficiency of 80% means that avg depth of H_2O applied 10% is the excess depth of water applied & 10% is the difficient depth of water required. The H_2O distribution efficiency provides a measure for comparing different methods of irrigation.

→ **Irrigation Frequency (or) Frequency of Irrigation**

It refers to the number of days b/w irrigation has to be done without rainfall. It depends on consumptive use of rate of crop and on the amount of available moisture in the crop root zone. It is a function of crop, soil and climate.

It is defined as the ratio of available soil moisture depletion to rate of consumptive use.

i.e

$$\text{Frequency of irrigation} = \frac{\text{available soil moisture depletion}}{\text{rate of consumptive use}}$$

→ **Consumptive use:-** Consumptive use for a particular crop may be defined as the total amount of water used by the plants in transpiration and evaporation from the adjacent soils, in any specified time. The values of consumptive use (Cu) may be different for different crops & may be different for the same crop @ different time & place.

Irrigation Efficiency :-

It is the ratio of amount of water consumed by the crop to the amount of water supplied through irrigation (either surface or subsurface or sprinkler or drip)

It is denoted by 'η'

i.e
$$\eta = \frac{\text{amount of water consumed by crop}}{\text{amount of water supplied through irrigation}}$$

Types of Irrigation Efficiency

① **Water conveyance Efficiency (η_c)** :- It is a ratio of quantity of water delivered to the field to the quantity of water delivered into the canal system from reservoir.

i.e $\left[\eta_c = \frac{W_f}{W_R} \times 100\right]$

$$\text{Water conveyance Efficiency} = \frac{\text{qty of } H_2O \text{ delivered to the field.}}{\text{qty of } H_2O \text{ delivered to the canal from reservoir.}}$$

② **Water application Efficiency (η_a)** :- It is a ratio of quantity of water stored in root zone of plants to the quantity of water delivered to the field. ie $\left[\eta_a = \frac{W_s}{W_f} \times 100\right]$

$$\text{Water application Efficiency} = \frac{\text{qty of } H_2O \text{ stored in root zone of plants}}{\text{qty of } H_2O \text{ delivered to the field.}}$$

③ **Water Use Efficiency (η_u)**:- It is the ratio of the quantity of water used beneficially including the water required for leaching to the quantity of water delivered.

i.e $$\boxed{\eta_u = \frac{W_u}{W_f} \times 100}$$

i.e

$$\text{Water use Efficiency} = \frac{\text{qty of } H_2O \text{ used beneficially including } H_2O \text{ leaching}}{\text{qty of } H_2O \text{ delivered to the field.}}$$

④ **Water storage Efficiency (η_s)**:- It is the ratio of quantity of water stored in root zone during irrigation to the quantity of water needed to bring water content of soil to the field capacity

i.e $$\boxed{\eta_s = \frac{W_s}{W_n} \times 100}$$

i.e

$$\text{Water storage Efficiency} = \frac{\text{qty of } H_2O \text{ stored in root zone during irrigation}}{\text{qty of } H_2O \text{ to bring water content of soil to the field capacity.}}$$

Here, W_n = field capacity - available moisture in the soil prior to irrigation.

⑤ **Consumptive use Efficiency (η_w)**:- It is a ratio of normal consumptive use of water to the net amount of water depleted from the root zone.

i.e $$\boxed{\eta_w = \frac{W_{cu}}{W_d} \times 100}$$

i.e

$$\text{Consumptive Use Efficiency} = \frac{\text{Normal Consumptive use of water}}{\text{Net amount of } H_2O \text{ depleted from the root zone.}}$$

Problems on Irrigation Efficiency.

① A stream of 135 lt/sec was delivered from a channel and 100 lt/sec was delievered into field. An area of 1.6 Hectares was irrigated in 8hrs. the Effective depth of root Zone was 1.8cm. the runoff loss in the field was 432 m³. The depth of water penetration varied linearly from 1.8m @ the head End of the field to 1.2m @ End of tail End. available moisture holding capacity of soil is 20cm per meter depth of soil. Determine the η_c, η_a, η_s, & η_d Irrigation was started @ a moisture Extraction level of 50% of H_2O available as moisture?

Soln:- Given data

(1) W_f = 100 lt/sec

(2) W_R = 135 lt/sec

(3) loss of H_2O in field = 432m³

(4) Holding Capacity of root Zone = 20 cm/m depth

(5) depth of root Zone = 1.8cm

(6) moisture Extraction level before prior irrigation = 50%

(7) Area, A = 1.6 Hec

(i) Water Conveyance Efficiency (η_c)

$$\eta_c = \frac{W_f}{W_R} \times 100$$

$$= \frac{100}{135} \times 100$$

$$\boxed{\eta_c = 74.08\%}$$

(ii) Water application Efficiency (η_a)

$$\eta_a = \frac{W_s}{W_f} \times 100$$

Here, W_s = W_f - losses

But water delievered to field, W_f = 100 lps

$$= \frac{100 \times 8 \times 3600}{1000}$$

$$= 2880 \, m^3$$

Now,

water stored in root Zone, W_s = 2880 - 432

$= \underline{\underline{2448\ m^3}}$

So, $\eta_a = \frac{2448\ m^3}{2880\ m^3} \times 100$

$\boxed{\eta_a = 85\%}$

(iii) Water Storage Efficiency (η_s) :-

W.K.T $\eta_s = \frac{W_s}{W_n}$

Water holding capacity root Zone = 20 × 1.8

$= \underline{\underline{36\ cm}}$

(W_n) = Water holding capacity of root Zone - available moisture in the soil prior to irrigation

$= 36 - (50/100 \times 36) = \underline{\underline{18\ cm}}$

∴ qty of H_2O required, W_n = $18 \times 10^{-2} \times 1.6 \times 10^4$

$= 2880\ m^3$

So, $\eta_s = \frac{2448}{2880} \times 100 = \underline{\underline{85\%}}$

$\boxed{\eta_s = 85\%}$

(iv) Water distribution Efficiency (η_d)

$$\eta_d = [1 - y/d] \times 100$$

d = avg. depth of H_2O

$$d = \frac{1.8 + 1.2}{2} = 1.5\,m$$

y = avg deviation in depth of H_2O stored

deviation at upper end = 1.8 − 1.5
= 0.3m

deviation at lower end = 1.5 − 1.2
= 0.3m

$$\therefore y = \frac{0.3 + 0.3}{2} = 0.3$$

Now, $\eta_d = \left[1 - 0.3/1.5\right] \times 100$

$$\boxed{\eta_d = 80\%}$$