Unit - 4

Irrigation

Irrigation:-

It may be defined as the Process of artifically supplying water to the soil for raising crops.

Necessity of Irrigation:-

1. **Less Rainfall:-**

When the total rainfall is less than needed for the crop, artificial supply is necessary. In such a case, Irrigation works may be constructed at a place where more water is available and then to convey the water to the area where there is deficiency of water.

2. **Non-uniform Rainfall:-**

The rainfall in a Particular area may not be uniform over the crop Period. Due to this, water is collected during excess rainfall Period and stored and then supplied to the crop when there is no rainfall.

3. **Growing a number of crops during a year:-**

The rainfall in an area may be sufficient to raise only one type of crops during rainy season (kharif crops) for which no irrigation may be required. However, with the Provision of irrigation facilities in that area, crops can be raised in other season also (Rabi crops)

4. Growing Perennial Crops:-

Perennial crops such as Sugarcane etc which need water throughout the year can be raised only through the provision of Irrigation facilities in that area.

5. Commercial Crops with additional water:-

The rainfall in a Particular area may be sufficient to raise the usual crops, but more water may be necessary for raising commercial and cash crops.

6. Controlled water Supply:-

By the construction of proper distribution system, the yield of the crop may be increased because of controlled supply of water.

Benefits of Irrigation:-

1. Increase in Food Production:-

Due to controlled and timely supply of water to the crop the yield is increased. With the assured supply of water superior crops takes the place of inferior crops and thus the value of crops is increased.

2. Protection from Famine:-

The construction of Irrigation works helps during the famine and drought Period in two ways. During the Construction of the irrigation works, employment is carried to the People and after construction of such works continuous water supply is maintained.

3. Cultivation of cash crops:-

Irrigation makes it possible to grow cash crops such as sugarcane, tobacco, cotton etc.

4. Elimination of mixed cropping:-

(i) If irrigation facilities are not available in an area, the farmers have a tendency to adopt mixed cropping whereby they grow two (or) more crops together in the same field.

(ii) The advantage of mixed cropping is that if weather conditions are not suitable for one of the crops, it may be suitable for the others and thus farmer may get atleast some yield from the same field.

(iii) But mixed cropping has several drawbacks such as field preparation, manuring and watering is different for crops.

5. Addition to the wealth of the country:-

Almost all the irrigation projects are so designed that they bring some revenue to the state. In addition to the water tax obtained from farmers, the bumper crops produced due to irrigation facilities makes country self sufficient in food requirements and thus saves the foreign exchange.

6. Increase in prosperity of people:-

Due to irrigation facility, the value of land is increased. Also due to increase in yield of the crop and due to growin of cash crops the farmer become prosperous & their livin standard is increased.

7. Generation of Hydro-Electric water:-

Major river valley projects are usually planned to provide hydro-electric power together with irrigation.

8. Domestic and Industrial water supply:-

Some of the Irrigation reservoirs also supply water to near by rural and urban areas.

9. Inland Navigation:-

Large canals can also be used for inland navigation and thus transportation of agricultural products.

10. Improvement of communications:-

Almost all the irrigation channels are provided with inspection roads. These roads can be metalled and can be used as means of communication.

11. Canal Plantations

12. Improvement in the ground water storage

13. Aid in civilisation.

14. General development of the country.

Ill-effects of Irrigation:-

1. Breeding places for mosquitoes:-

Due to excess application of water and due to leakage of water, ponds and depressions get filled up with water and create breeding places for mosquitoes. Also if the canal is leaky, mosquitoes breed all along the canal and spread malaria conditions.

2. **Water Logging:-**

If the water table is near the ground surface, over-irrigation may rise the water table. This saturates the crop root zone completely, causes efflorescence and the whole area becomes water-logged.

3. **Damp Climate:-**

The areas which are already damp and cold, becomes damper and colder due to Irrigation.

Types of Irrigation:-

Irrigation is mainly classified into two types. They are:-

- Irrigation
  - Flow Irrigation
    - Perennial Irrigation
    - Inundation Irrigation
    - Direct Irrigation (Diversion Scheme)
    - Storage Irrigation (Storage Scheme)
    - Combined Storage and diversion Scheme
  - Lift Irrigation

Flow Irrigation:-

Flow Irrigation is that type of irrigation in which the supply of irrigation water available is at such a level that is conveyed on to the land by means of gravity. Flow irrigation, may further be divided into two classes. They are:-

(i) Perennial Irrigation (ii) Inundation or Flood Irrigation.

Perennial Irrigation:-

It is a type of irrigation in which water required for the crop during the entire crop period is supplied b with the help of storage work such as reservoirs, dams, weirs and barrages to store the excess water during floods and release it crops when needed.

Inundation Irrigation:-

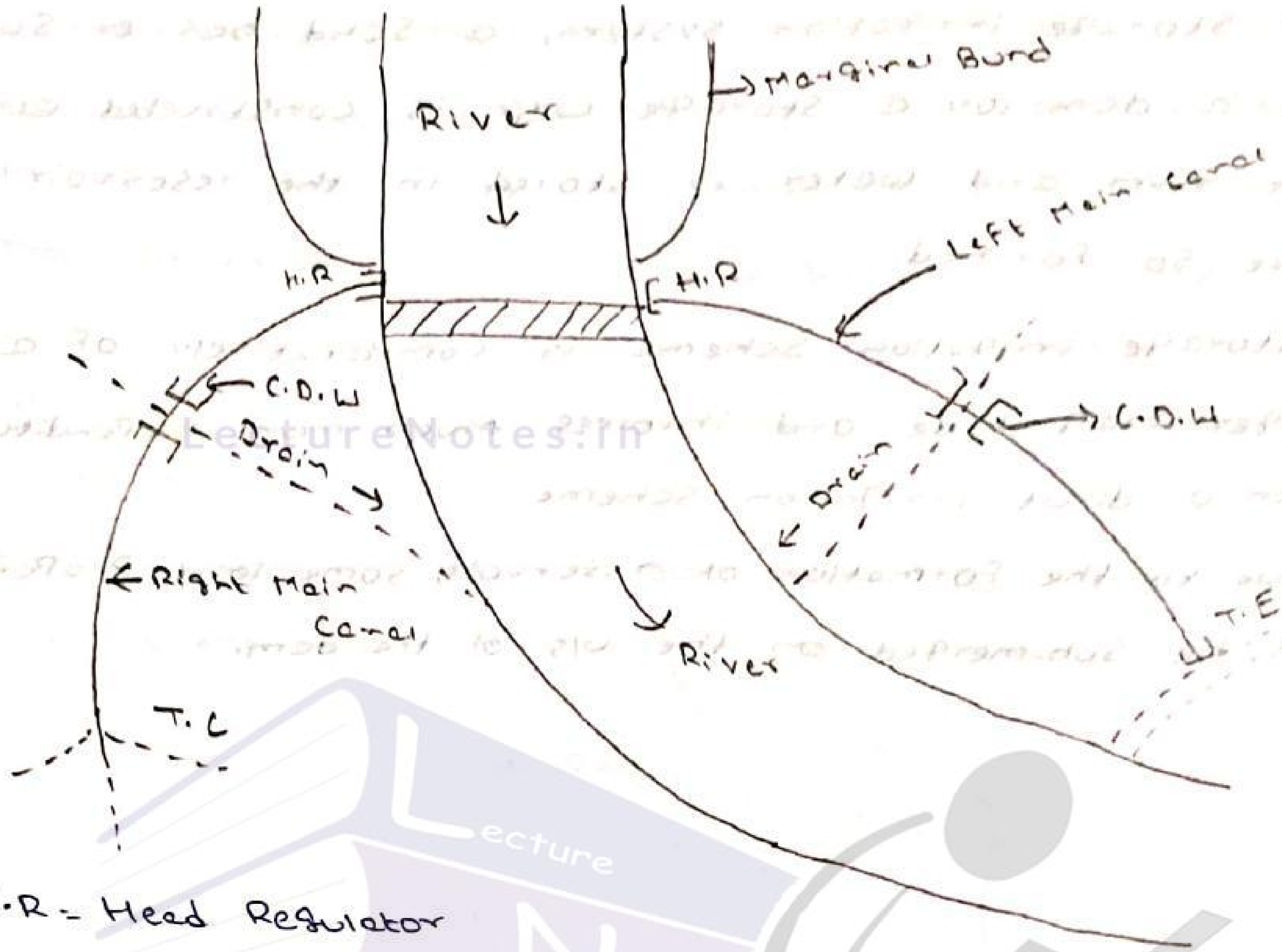
1. It is a type of irrigation in which large quantities of water flowing in a river during floods is allowed to inundate the land to be cultivated and there by saturating the soil.
2. The excess water is then drained off and the land is used for cultivation.
3. It is also common in areas near river deltas, when the slope of the river and land is small.

Classification of Flow Irrigation based on Source:-

Depending upon the source from which the water is drawn, flow irrigation can be further sub-divided into three types. They are:-

(i) Direct Irrigation (River Canal Irrigation): Diversion Scheme
(ii) Storage Irrigation (Reservoir (or) Tank Irrigation): Storage Scheme
(iii) Combined Storage and diversion Scheme.

Direct Irrigation (or) River canal Irrigation:



H.R - Head Regulator

C.D.W = cross- drainage works

T.C = Tail cluster

T.E = Tail Escape

Direct Irrigation or River canal Irrigation:

→ In this direct irrigation system, water is directly diverted from the river into canal by construction of diversion weir (or) barrage across the river without attempting to store water.

→ In a direct irrigation scheme, one or two main canals may take off directly from the river.

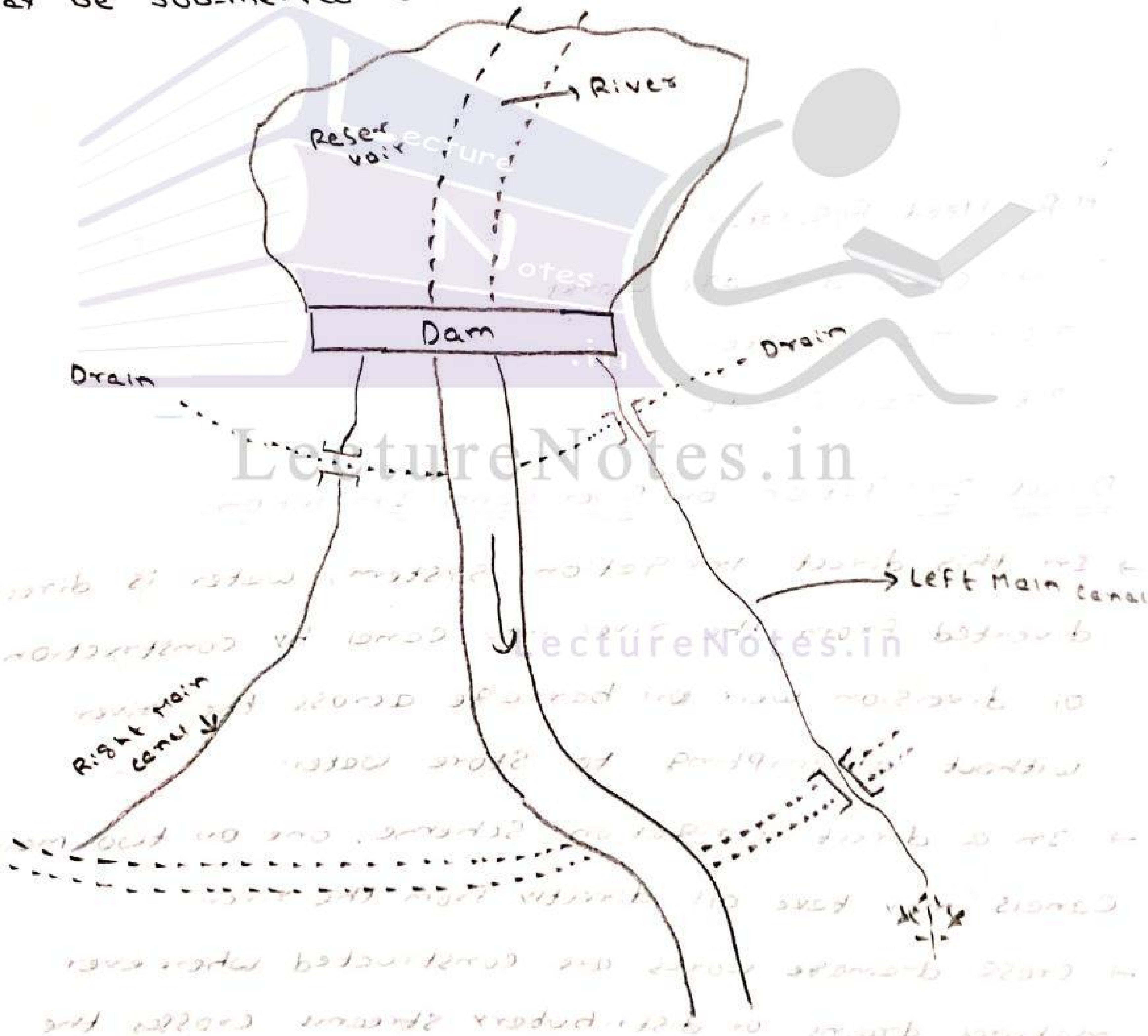
→ Cross drainage works are constructed whereever natural drains or distribubary streams crosses the canals

2. Storage Irrigation (or) Tank Irrigation:

→ In storage irrigation system, a solid barrier such as a dam (or) a storage weir is constructed across the river and water is stored in the reservoir (or) lake so formed.

→ Storage irrigation scheme is comparatively of a bigger magnitude and involves much more expenditure than a direct irrigation scheme.

→ Due to the formation of reservoir, some land property may be sub-merged on the u/s of the dam.

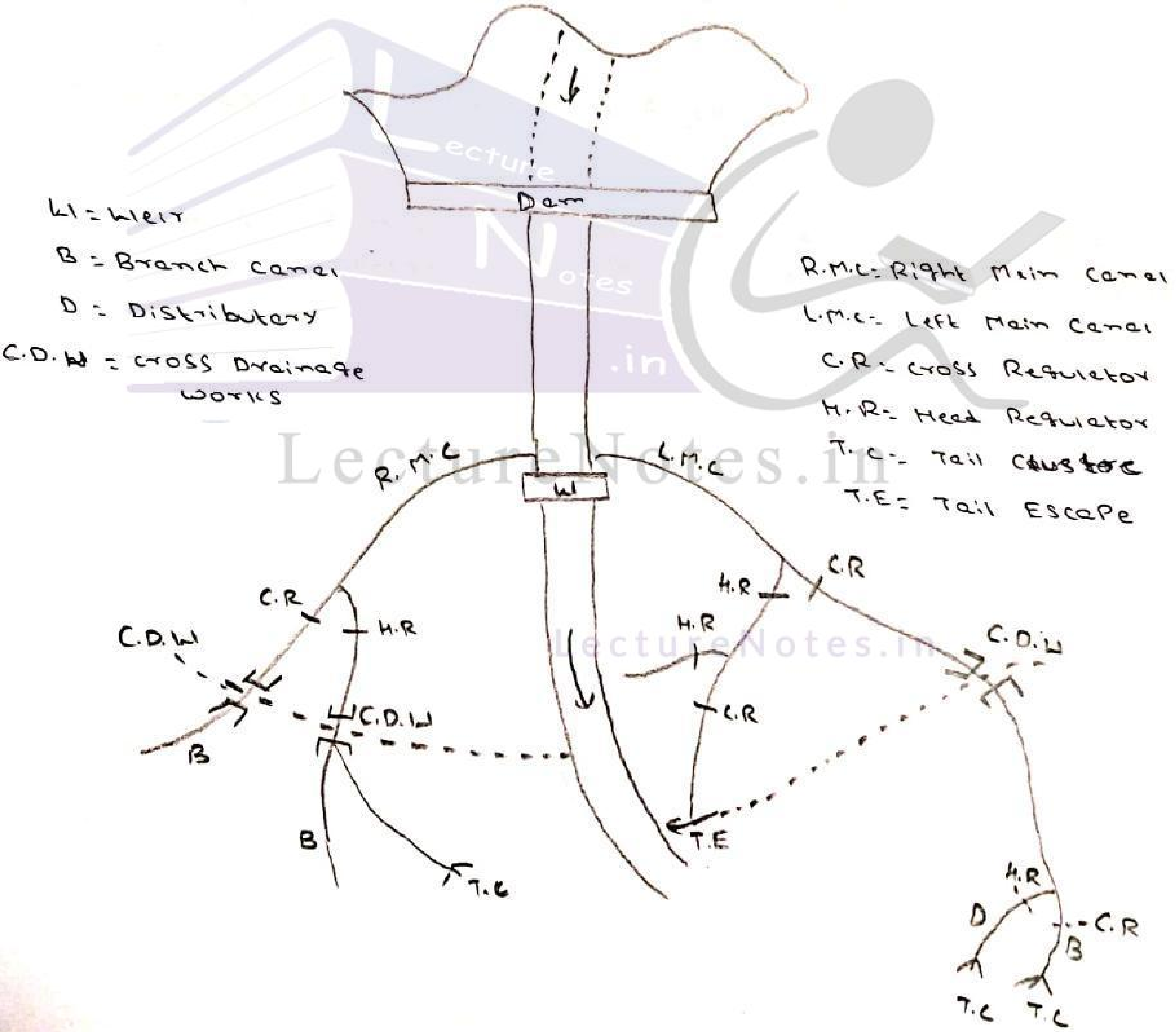


Combined System :- [Storage and diversion scheme]

→ In this System, the water is first stored in the reservoir formed at the upstream side of the dam and then this water is used for power generation.

→ The discharge from the power house is fed back into the river to the downstream side of the dam. Thus, sufficient quantity of water flow is again available in the river.

→ At a suitable location in downstream, weir is constructed which diverts water from river to the canal.



Principal Crops and Crop Seasons:-

Crops can be classified in the following ways:

1 Agricultural classification.

2. Classification based on crop seasons.

3. Classification based on irrigation requirement.

Agricultural Classification:-

1. **Field crops:-**

Wheat, Rice, Maize, Barley, oats, gram, Pulses, great millet, Spiked millet etc.

2. **Commercial crops:-**

Sugarcane, cotton, tobacco, hemp etc.

3. **Oil Seed Crops:-**

Mustard, ground nut, sesame, linseed, caster etc.

4. **Horticulture crops:-**

It consist of various fruit crops, various vegetable crops and flower crops.

5. **Plantation crops:-**

Tea, coffee, coconut, rubber etc.

6. **Forage crops:-**

Fodder, grass etc

7. **Miscellaneous crops:-**

Medicinal crops, aromatic crops, Sericulture crops and spices.

2. Classification based on crop seasons:-

(i) Rabi crops (or) Winter crops:-

These crops are sown in autumn (october) and are harvested in Spring (March). crops such as gram, wheat, barley, Peas, tobacco, linseed, Potato falls under this.

(ii) kharif crops (or) Monsoon crops:-

These crops are sown by the beginning of the south-west monsoon and are harvested in autumn. These consist of rice, maize, spiked millet, great millet, Pulses etc.

(iii) Perennial crops:-

These are the crops that require water for irrigation throughout the year. crops such as Sugarcane comes under this.

(iv) Eight months crops:-

crops such as cotton require irrigation water for 8 months.

3. Classification based on irrigation requirements:-

Based on irrigation requirements, crops are classified as:-

(i) Dry crops:-

Dry crops are the one which do not require water for irrigation i.e., only rain water is sufficient for their growth.

(ii) Wet crops:-

Wet crops are those which cannot grow without irrigation.

Garden crops:-

Garden crops require irrigation throughout the year.

Principal crops of India:- [Perennial & Eight month crop]

(i) kharif crops:-

1. These are also known as monsoon crops and these crops are growing during the monsoon (or) rainy season (June to October)

2. The crops are sown at the beginning of monsoon season and harvested at the end of monsoon season. (Sep-oct)

3. Major kharif crops are Rice, Maize, Bajra (spiked millet), Jowar (Great Millet), Pulses, ground nut etc.

4. The sowing time may vary in different states of India as it depends on the arrival of monsoon.

Ex:- Southern states like karnataka, Tamil Nadu crops are sown at the end of may and in Northern states like Punjab, Haryana seeds are sown in the month of June.

(ii) Rabi crops:- (or) Spring crops:-

1. Rabi crops are also known as winter crops and are sown in the winter season (october - November) and harvested (March - April)

2. Some of main rabi crops of India are wheat, gram, Oat, barley, Potato, mustard, tobacco, Peas etc.

Crop Ratio:-

It is the ratio of the area irrigated in rabi season to the area irrigated in kharif season

Over lap Allowance:-

The extent of water to be supplied for maturing a particular crop which extends from one season to another season is called over lap allowance.

Duty:-

Duty is the area of the land that can be irrigated with unit volume of irrigation water, flowing throughout the base period. It is denoted by letter 'D'.

Delta:-

It is the total depth of water required by a crop during the entire period of the crop. It is denoted by "Δ".

Crop Period:-

Crop period is the time in days that a crop takes from the instant of sowing to that of its harvesting.

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 ground for planting the crop to its last watering before harvesting.

Relation between duty and delta:-

Let D = Duty in hectares/cumec

Δ = Total depth of water supplied (m)

B = Base Period in days.

(i) Consider a field of an area "D" hectares in which 1 cumec of water running continuously for a Base Period of 'B' days. Water supplied to this field $= (1) \times B \times 24 \times 60 \times 60$ m^3

(ii) Amount of water supplied to 1 hectare of land with a depth of 'Δ' m = D Hec × 'Δ' m

$= (10^4) m^2 \times '\Delta' m \times D$

$$D \times 10^4 \times \Delta = 1 \times B \times 24 \times 60 \times 60$$

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

$$D = \frac{8.64 B}{\Delta} \Rightarrow \Delta = \frac{8.64 B}{D} \text{ metres}$$

1 Hectare = 10^4 m^2

1 cumec-day = 8.64 Hec-m

High and Low Duty:-

Duty is being referred to as being high (or) low according to the number of hectares/cumecs irrigated is large (or) small.

Gross command Area:- [G.C.A]

It is the total area lying between drainage boundaries which can be commanded or irrigated by a canal system.

Culturable command Area:- [C.C.A]

The gross commanded area also contains unfertile barren land, alkaline soil, local ponds, villages and other areas as habitation. These areas are known as unculturable areas.

The remaining area on which crops can be grown satisfactorily is known as "Culturable command Area".

G.C.A = C.C.A + unculturable Area

The culturable command area can further be classified as culturable cultivated area and culturable uncultivated area.

Culturable Cultivated Area:-

It is the area in which crop is grown at a particular time or crop season.

Culturable uncultivated Area:-

It is that area in which crop is not sown in a particular season.

Intensity of Irrigation:-

→ It is defined as the percentage of culturable commanded area proposed to be irrigated during either a crop season (or) during a year.

→ In simple words, it is the ratio of area under cultivation to the total culturable area.

→ If this intensity is more, more area is under cultivation, hence water requirement is more.

Q) If C.C.A of an field is 120 hectares, out of which 90 hectares of the land is cultivated during kharif season and 60 hectares of the land is cultivated during rabi season. Calculate Intensity of Irrigation.

Intensity of Irrigation during kharif season $= \frac{90}{120} \times 100$

$= 75\%$

Intensity of Irrigation during Rabi season $= \frac{60}{120} \times 100 = 50\%$

Yearly Intensity of Irrigation $= 75 + 50 = 125\%$

- Yearly Intensity of Irrigation can be more than 100%.

Factors affecting duty:-

1. Methods and system of irrigation
2. Mode of applying water to the crops
3. Method of cultivation.
4. Time and frequency of tilling.
5. Type of the crop.
6. Base period of the crop.

7. Climatic conditions of the area

8. Quality of water.

9. Method of assessment of irrigation method.

10. Canal conditions

11. Character of soil and sub-soil of the canal.

12. Character of soil and sub-soil of irrigation fields.

Methods and System of Irrigation:-

→ In the Perennial Irrigation System, soil is continuously kept moist and hence water required for initial saturation is less. Hence, the perennial irrigation system has more duty than the inundation irrigation.

Method of Cultivation:-

The old and conventional methods of cultivation gives less duty in comparison to the modern methods.

Type of Crop:-

The duty varies from crop to crop.

Base Period of the Crop:-

If the Base Period of the crop is more, the amount of water required will be high, hence duty will be low and vice-versa.

Climatic conditions of the area:-

→ The climatic conditions which affect the duty are:-

(i) Temperature
(ii) Wind
(iii) Humidity
(iv) Rainfall

→ Due to high temperature and wind, evaporation losses will be more and duty will be less.

→ Rainfall during the crop Period will reduce the irrigation - water requirement

Quality of water:-

→ If the harmful Salt content and alkalic content of the water is more, water will have to be applied liberally So that the salts are leached off. This will reduces the duty.

Method of assessment of water:-

→ Volumetric method of assessment always leads to a higher duty. This is because the farmer will use water economically.

→ If method of assessment is based on the area under cultivation, the farmer will have a tendency to use more water and the duty will be low.

Canal Conditions:-

→ In an earthern canal, the seepage and percolation losses will be high resulting in the low duty.

→ If the canal is lined, the losses will be less and duty will be more.

Character of Soil and Sub-soil of the canal:-

→ If the canal is unlined and if it flows through coarse grained, Permeable soils then the percolation and seepage losses will be high.

→ If the canal flows through fine grained soil, such losses will be less and the duty will be higher.

Character of Soil and Sub-Soil of the Irrigation Field:-

→ If the soil and sub-soil of the field is coarse-grained, percolation losses will be high and hence duty will be low.

Methods of Improving duty:-

1. Suitable method of applying water to the crops should be used.
2. The land should be properly ploughed and levelled before sowing the crop. It should be given good tilth.
3. The canals should be lined. This reduces seepage and percolation losses. Also water can be conveyed quickly, thus reducing evaporation losses.
4. The source of supply should be such that it gives good quality of water.
5. The rotation of crops must be practiced.
6. Volumetric method of assesment should be used.
7. The alignment of the canal either in sandy soil or in fissured rock should be avoided.

Kor-watering:-

→ The first watering given to the crops after when it has grown few centimeters is known as kor-watering. Crops require maximum water for this.

→ During the subsequent watering the quantity of water needed by crops gradually decreases and it is least when crop gains maturity.

Kor-Depth:-

The depth of water supplied during kor-watering is known as "kor-Depth".

Kor-Period:-

The portion of the base period in which kor-watering is needed is known as kor-period.

Note:-

→ While designing the capacity of a channel, kor-water must be taken into account since discharge in the canal has to be maximum during this time.

Paleo:-

The first watering before sowing the crop is known as "Paleo". It is done inorder to provide sufficient moisture to the unsaturated zone of the soil and it is required for the initial growth of the crop.

Outlet Factor:-

It is defined as the duty at the outlet.

Root zone Depth:-

Root zone depth is the maximum depth of soil strata in which the crop spreads its root system and derives water from the soil.

Open Discharge:-

It is the ratio of the number of cumec-days to the number of days the canal has actually been used for Irrigation.

Cumec-Day:-

The quantity of water flowing for one day at the rate of 1 cumec is known as cumec-day. It is equal to 8.64 hectare-metres.

Capacity Factor:-

This is the ratio of mean supply (discharge) to the full supply of a canal.

Time Factor:-

It is defined as the ratio of the number of days the canal has actually run to the number of days of Irrigation Period.

Ex:- Calculate time factor, if the number of days of irrigation period is 12 and the canal has run actually 5 days.

$$\text{Time Factor} = \frac{\text{No. of days canal has run actually}}{\text{No. of days of irrigation Period}} = \frac{5}{12}$$

Q) Find the delta for a crop if the duty for a base period of 110 days is 1400 hectares/cumec.

Given,

Base Period = 110 days

Duty = 1400 hectares/cumec

$\Delta = ?$

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

$1400 = 8.64 \times \frac{110}{\Delta}$

$\boxed{\Delta = 0.68\,m}$

Q) A crop requires a total depth of 92 cm of water for a base period of 120 days. Find the duty of water.

Given,

$\Delta = 92\,cm = 0.92\,m$

Base Period, $B = 120$ days

Duty, $D = ?$

$D = 8.64 \frac{B}{\Delta} = 8.64 \times \frac{120}{0.92} = 1127$ hec/cumec

Q) An Irrigation canal has G.C.A of 80,000 hectares out of which 85% is culturable Irrigable. The intensity of irrigation for kharif season is 30% and for rabi season is 60%. Find the discharge required at the head of the canal if the duty at its head is 800 hectares/cumecs for kharif season and 1700 hectares/cumec for the rabi season.

Gross command area = 80,000 hectares

Culturable command area = 85% of G.C.A

$$= \frac{85}{100} \times 80,000$$

$$= 68,000 \text{ hectares}$$

Area under kharif season = 30% of G.C.A

$$= \frac{30}{100} \times 68,000$$

$$= 20,400 \text{ hectares}$$

Area under Rabi season = 60% of C.C.A

$$= \frac{60}{100} \times 68,000$$

$$= 40,800 \text{ hectares}$$

Water required at head of canal during kharif season $= \frac{20,400}{800} = 25.5 \ m^3/s$

Water required at head of canal during Rabi season $= \frac{40,800}{1800} = 24 \ m^3/s$

Q) A water course has culturable commanded area of 2600 hectares out of which the intensities of irrigation for perennial sugarcane and rice crops are 20% and 40% respectively. The duty for these crops at the head of water course are 750 hectares/cumec and 1800 hec/cumec. respectively. Find the discharge required at the head of water course if peak demand is 120% of the average requirement.

Given,

C.C.A = 2600 hectares

Intensity of Irrigation for Sugar-Cane = 20%.

Intensity of Irrigation for rice-crops = 40%.

Duty at head of water course for sugarcane = 750 hec/cumec

Duty at head of water course for rice-crops = 1800 hec/cumec

Area under sugarcane = 20% of CCA

$$= \frac{20}{100} \times 2600 = 520 \text{ hec}$$

Area under rice-crops = 40% of C.C.A

$$= \frac{40}{100} \times 2600 = 1040 \text{ hec}$$

Water required at head of canal for sugarcane $= \frac{520}{750}$

$= 0.694$ cumecs

Water required at head of canal for rice-crops $= \frac{1040}{1800}$

$= 0.578$ cumecs

Total water required $= 0.694 + 0.578 = 1.272$ cumecs

Discharge required $\simeq 1.2 \times 1.272 = 1.53$ cumecs

Q) The left branch canal carrying a discharge of 20 cumecs has culturable command area of 20,000 hectares. The intensity of Rabi crop is 80 percent & Base Period is 120 days. The right branch canal carrying discharge of 8 cumecs has C.C.A of 12,000 hectares, Intensity of irrigation of rabi crop is 50% and the base period is 120 days. Compare the efficiencies of two canal systems.

c) For left bank Canal

Area under Rabi crop = 80% of C.C.A

$$= \frac{80}{100} \times 20{,}000$$

$$= 16{,}000 \text{ hec}$$

Discharge = 20 cumecs

$$\text{Duty} = \frac{\text{Area under Rabi crop}}{\text{Discharge}} = \frac{16000}{20} = 800 \text{ hec/cumec}$$

b) For the right Canal

Area under rabi crop = 50% of C.C.A

$$= \frac{50}{100} \times 12{,}000$$

$$= 6000 \text{ hectares}$$

Discharge = 8 cumecs

$$\text{Duty} = \frac{\text{Area under Rabi crop}}{\text{Discharge}} = \frac{6000}{8} = 750 \text{ hec/cume}$$

∴ Left branch canal has high duty than right branch canal. Hence, left canal is efficient.

Q) A water course has a C.C.A of 1200 hectares. The intensity of irrigation for crop A is 40% and for B is 35%. both the crops being Rabi crops. Crop 'A' has a kor-period of 20 days and crop 'B' has kor period of 15 days. Calculate the discharge of the water course if the kor depth for crop 'A' is 10 cm and for 'B' it is 16 cm.

Crop A:-

Area under crop A = 40% of C.C.A

$$= \frac{40}{100} \times 1200 = 480 \text{ hec}$$

kor - Period = 20 days; kor depth = 10 cm = 0.10 m

$$\text{Duty} = \frac{8.64 B}{\Delta} = \frac{8.64 \times 20}{0.10} = 1728 \text{ hec/cumec}$$

$$\text{Discharge required} = \frac{\text{Area under irrigation}}{\text{outlet factor}}$$

$$= \frac{480}{1728}$$

$$= 0.278 \text{ cumecs}$$

Crop B:-

Area under crop B = 35% of C.C.A

$$= \frac{35}{100} \times 1200 = 420 \text{ hec}$$

kor - Period = 15 days ; kor - depth = 16 cm = 0.16 m

$$\text{Duty or outlet Factor} = \frac{8.64 B}{\Delta} = \frac{8.64 \times 15}{0.16} = 810 \text{ hec/cumec}$$

$$\text{Discharge required} = \frac{\text{Area under irrigation}}{\text{outlet Factor}}$$

$$= \frac{420}{810}$$

$$= 0.52 \text{ cumecs}$$

Design discharge of water course = 0.278 + 0.52 = 0.798

= 0.80 cumecs

Q) The G.C.A for a distributary is 10,000 hectares, 75% of which can be irrigated. The intensity of irrigation for Rabi season is 60% and that for kharif season is 30%. If the average duty at the head of the distributary is 2500 hec/cumec for Rabi season and 1000 hec/cumec for kharif season. Determine the discharge required at the head of the distributory from average demand consideration.

Gross command area = 10,000 hec

Culturable command area = 75% G.C.A

$= \frac{75}{100} \times 10{,}000 = 7500$ hec

Area under rabi = 60% C.C.A

$= \frac{60}{100} \times 7500 = 4500$ hec

Area under kharif = $\frac{30}{100} \times 7500 = 2250$ hec

Discharge for rabi = $\frac{4500}{2500} = 1.8\ m^3/s$

Discharge for kharif = $\frac{2250}{1000} = 2.25\ m^3/s$

Required discharge at head of distributory = $2.25\ m^3/s$

Q) A canal takes off a reservoir to irrigate the areas as shown in table. 40% of the water required for irrigation is assumed to be available directly from precipitation. Channel conveyance losses are 15%. Reservoir losses are 10%. What would be the capacity of the reservoir needed.

Crop	Base Period (Days)	Duty at Field (hec-cumec)	Area under crop (hec)
Wheat	120	1800	500
Sugarcane	320	800	600
Rice	120	900	300
Cotton	200	1400	1200
Bajra	100	1200	500

Crop	Base Period (Days)	Duty at Field (D) (hec/cumecs)	$\Delta = 8.64 \frac{B}{D}$ (m)	Area, A (hec)	Volume $= \Delta \times A$ hec-m
Wheat	120	1800	0.576	500	288
Sugarcane	320	800	3.456	600	2073.60
Rice	120	900	1.152	300	345.60
Cotton	200	1400	1.234	1200	1480.80
Bajra	100	1200	0.720	500	360

Total volume = 4548 hec-m

Channel conveyance losses = 15%.

Reservoir losses = 10%.

Capacity of reservoir $= 4548 \times \frac{1}{0.85} \times \frac{1}{0.90} \times 0.60 = 3568$ hec-m

Q) The base period, intensity of irrigation and duty of various crops under a canal system are given in the table below. Find the reservoir capacity if the canal losses are 20% and reservoir losses are 12%.

Crop	Base Period (Days)	Duty at the field (hec/cumecs)	Area under the crop (Hec)
Wheat	120	1800	4800
Sugar-cane	360	800	5600
Cotton	200	1400	2400
Rice	120	900	3200
Vegetables	120	700	1400

Crop	Base Period (Days)	Duty at Field (hec/cumecs)	$\Delta = 8.64 \frac{B}{D}$ (m)	Area under crop (hec)	Volume ($\Delta \times A$) hec-m
Wheat	120	1800	0.576	4800	2764.80
Sugarcane	360	800	3.888	5600	21772.80
Cotton	200	1400	1.234	2400	2961.60
Rice	120	900	1.152	3200	3686.40
Vegetables	120	700	1.481	1400	2073.40

Total volume = 33259 hec-m

Capacity of reservoir = $\frac{33259}{0.80 \times 0.88} = 47243$ hec-m

Q) The base period, intensity of irrigation & duty of water for various crops under the canal system are given. Determine the reservoir capacity if the culturable command area is 4000 hec, canal losses are 25% and reservoir losses are 15%.

Crop	Base Period (Days)	Duty at field (hec/cumec)	Intensity of Irrigation
Wheat	120	1800	20 %
Sugarcane	360	1700	20 %
Cotton	180	1400	10 %
Rice	120	800	15 %
Vegetable	120	700	15 %

Crop	Base Period (Days)	Duty at Field (hec/cumec)	$\Delta = 8.64\frac{B}{D}$ (m)	Area (hec)	Discharge required	Quantity of water hec-m
Wheat	120	1800	~~5.184~~ 0.576	8000		4608
Sugarcane	360	1700	1.829	8000		14632
Cotton	180	1400	1.110	4000		4440
Rice	120	800	1.296	6000		7776
Vegetable	120	700	1.481	6000		8886

Total volume = 40342 hec-m

$$\text{Reservoir capacity} = \frac{40342}{0.75 \times 0.85} = 63282 \text{ hec-m}$$

Irrigation Efficiencies:-

→ Efficient use of irrigation water is an obligation of each user as well as the planners.

→ In general, efficiency is defined as the ratio of the water output to the water input and is expressed as percentage.

1. Water Conveyance Efficiency:- (η_c)

It can be defined as the ratio of water delivered to the farm (or) irrigation plot to the water supplied (or) diverted from the river (or) reservoir.

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

η_c = water conveyance efficiency

W_f = water delivered to farm

W_r = water supplied (or) diverted from river (or) reservoir.

2. Water Application Efficiency (η_a)

It can be defined as the ratio of quantity of water stored into the root zone of the crops to the quantity of water delivered to the field.

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

η_a = water application efficiency

W_s = Water stored in root zone during irrigation

W_f = water delivered to the farm.

3. Water use Efficiency (η_u)

It can be defined as the ratio of water beneficially used, including leaching water to the quantity of water delivered.

$$\eta_u = \frac{W_u}{W_d} \times 100$$

η_u = Water use efficiency

W_u = Water used beneficially

W_d = Water delivered

4. Water Storage Efficiency (η_s)

$$\eta_s = \frac{W_s}{W_n} \times 100$$

η_s = Water storage efficiency

W_s = Water stored in root zone during irrigation.

W_n = Water needed in root zone prior to irrigation.

5. Water Distribution Efficiency (η_d)

→ It evaluates the degree to which water is uniformly distributed throughout the root zone.

$$\eta_d = 100\left[1 - \frac{y}{d}\right]$$

d = Average depth of water stored during irrigation

y = Average numerical deviation in depth of water stored from average depth stored during irrigation.

6. Consumptive Use Efficiency (η_{cu})

$$\eta_{cu} = \frac{W_{cu}}{W_d} \times 100$$

W_{cu} or C_u = Normal consumptive use of water.

W_d = Net amount of water depleted from root zone of soil

Determination of Irrigation requirement of crops:-

(i) Consumptive Irrigation Requirement (CIR):-

It is defined as the amount of irrigation water required to meet the evapo-transpiration needs of the crop during its full growth.

$$C.I.R = C_u - R_e$$

C_u = consumptive use : R_e = Rainfall Excess

Consumptive use:-

It is defined as the depth of water consumed by a crop for evaporation and transpiration during crop growth including water consumed by accompanying weed growth. It is also called as Evapo-Transpiration

Net Irrigation Requirement (N.I.R):-

It is defined as the amount of irrigation water required at the plot to meet the evapo-transpiration needs of a crop as well as other needs such as leaching etc.

N.I.R = Cu - Re + Water used for leaching.

Field Irrigation Requirement:- (F.I.R)

It is defined as the amount of water required to meet the needs of N.I.R and water lost in percolation in the field courses, field channels and in field application of water.

$$F.I.R = \frac{N.I.R}{\eta_a}$$

η_a = Water application efficiency

Gross Irrigation Requirement:- (G.I.R)

It is the sum of water required to satisfy the field irrigation requirement and the water lost as conveyance losses in distributeries upto the field.

$$G.I.R = \frac{F.I.R}{\eta_c}$$

η_c = Water conveyance Efficiency

Soil Fertility:-

A Soil is said to be fertile when it contains:-

(i) Ample supplies of organic materials.

(ii) The source of Nitrogen.

(iii) Sufficient soluble compounds of the mineral elements needed for the growth of food plants.

Methods to improve Soil fertility:-

1. By use of proper cultivation methods.
2. By spreading all the farmyard manure which supply organic materials as well as fertilising elements.
3. By crop rotation.
4. Application of carefully selected commercial fertilizers.
5. Suitable procedure for reducing or controlling erosions may constitute important role in maintaining fertility.
6. Irrigation with silty water.

Crop Rotation:-

It implies that nature of the crop sown in a particular field is changed year after year.

Necessity for crop rotation:-

1. The soil gradually looses its fertility if the same crop is sown every year. Hence, crop rotation is required to increase fertility of soil.

2. All crops require similar type of nutrients for their growth but all of them do not take in same quantities or proportions. Some crops favour certain plant nutrients and take them more than the others.

3. Thus, if a particular crop is grown year after year, the soil gets deficient in the plant food favoured by that crop.

4. If different crops are to be raised there would be more balanced fooding and soil deficient in one particular type of nutrient is allowed to recoupe.

5. If the same crop is grown continuously, crop diseases and insect pests will multiply at a faster rate. This can be eliminated by crop rotation.

6. A leguminous crop (such as gram) if introduced in rotation will increase nitrogen content of the soil and increasing its fertility.

The following crop rotation has given good result

1. Rice-Gram
2. Cotton-Wheat-Gram
3. Cotton-Wheat-Sugarcane
4. Cotton-great millet-gram
5. Wheat-great millet-gram

Gram is a leguminous crop which gives Nitrogen to the field.

Functions of Irrigation Water:

→ For any crop for its growth, water and nutrients are the two most important things to be required. The main functions of irrigation water are:-

1. Water acts as a solvent for the nutrients & the nutrients are absorbed ~~by~~ the plant roots.

2. The irrigation water supplies moisture which is essential for the
(i) Life of bacteria beneficial to plant growth.
(ii) chemical action within the plant leading to its growth.

3. Water cools the soil and atmosphere and makes more favourable environment for healthy plant growth.

4. Some salts present in soil react in the presence of water to produce nourishing food products.

5. It reduces the hazard of soil piping.

6. It softens the tillage pans.

Indian Agricultural Soils:-

Following are some of the Principal Indian Soils

1. Alluvial Soil:-

(i) These soils are found in Indo-Gangetic Plains

(ii) These soils are very fertile

(iii) These soils absorb fair percentage of rainfall and act as a good source of ground water reservoir.

(iv) These soils are formed by deposition under water.

2. Laterite Soil:-

(i) It is a residual soil formed from basalt.

(ii) They are usually porous and well drained but lack common nutrients.

3. Black cotton Soil:-

(i) It is formed due to chemical weathering and the parent rock is basalt.

(ii) It has high swelling & shrinkage but low shear strength

(iii) It contains high percentage of clay mineral called the montmorillonite.

4. Clayey Soils:-

They are potentially rich soils but lacks drainage.

5. Humus:

Partly decomposed organic matter.

6. Peat

7. Red soil

Preparation of land for Irrigation:-

1. Removal of thick jungle, bushes etc from the land. The roots of the trees should be extracted and burnt.

2. The land should be properly levelled. High patches are scrapped to fill the depressions.

3. The land should be provided with regular slope in the direction of the falling gradient.

4. Proper drainage measures should be adopted where the danger of water logging may become eminent after the introduction of canal irrigation.

5. The land should be divided into suitable plots by small leaves accordin to the method of irrigation practiced

Standard of Irrigation water:-

There should be some limits to the impurities present in the water so that yield of crop is not hampered. Various types of impurities are present in water.

a) Sediment concentration in water:-

(i) Sediment derived from eroded areas may reduce the fertility of soil.

(ii) Excessive suspended sediment may create trouble in canals and reservoir.

(iii) Very fine sediment when deposited on sandy soil increases the fertility of soil.

b) Concentration of Soluble Salts:-

→ Salts of Ca^{2+}, Mg^{2+}, Na^{+} and K^{+} may be injurious to crops if it exceeds the permissible limit

→ Excessive quantity of salts reduces the osmotic activities of the plants and may prevent adequate aeration causing injuries to plant growth.

c) Proportion of Sodium Ions to other Cations:-

→ Proportion of Sodium Ions present in the soils is generally measured by a factor called "Sodium Adsorption Ratio".

→ It represents the sodium hazards of water.

$$S.A.R = \frac{Na^{+}}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}} \quad \text{milli equivalent}$$

$0 < SAR < 10$ → Low Sodium water (S_1)

$10 < SAR < 18$ → Medium Sodium water (S_2)

$18 < SAR < 26$ → High Sodium water (S_3)

~~26 < SAR~~ $SAR > 26$ → very high sodium water (S_4)

d) Concentration of Potentially toxic elements:-

→ Elements like Boron, Selenium etc may be toxic to plants.

→ Boron concentration $\ngtr$ 4 P.P.m

→ Selenium even in low concentration is toxic.

e) Bacteria concentration:

It is not a very serious problem.

Soil Water:-

→ Soil water (or) Soil moisture is the water added to the Soil mass during irrigation that gets held in the Pores of the Soil.

→ Soil Provides the necessary medium to the water through which the water gets used by the Plants (through their roots).

→ Factors responsible for growth of the crops

(i) rate at which water enter the Soil.

(ii) water retention in the Soil.

(iii) Availability of water to Plant roots.

Water holding Capacity of the Soil:-

→ It is one of the major factor influencing irrigation.

→ Water holding capacity of a Soil mainly depends on its Porosity.

$$\text{Porosity, } n = \frac{\text{Volume of Pores in Soil}}{\text{Total volume of Soil}}$$

Capillary & Non-Capillary Pores:-

Capillary Pores	Non-capillary Pores
1. Small Pores	1. Large Pores
2. Holds large amount of water against gravity.	2. Do not hold water tightly. Large amount of water drains against gravity.
3. Clayey Soil Possesses Capillary Pores.	3. Sandy Soil Possesses non-capillary Pores.
4. Result into Poor drainage & aeration.	4. Result into better drainage & aeration.

→ An ideal soil for irrigation has pore spaces equally divided into capillary and non-capillary pores.

Classification of Soil Water:-

Soil water may be classified as gravitational water, capillary water and hygroscopic water.

Gravitational Water:-

1. It is the free water which is not held by the soil as this water drains out freely under the action of gravity. It is found in macropores of soil.
2. A very little gravitational water is available to the plants as it drains out rapidly.

Capillary Water:-

1. It is present in the micro-pores of the soil
2. It is that water which is retained in the soil after the gravitational water gets drained off.
3. Water is held in the soil by surface tension force against the gravitational force.
4. It is the most beneficial for plant growth.
5. It is also called as "Available Water".

Hygroscopic Water:-

1. When an oven dried sample is exposed to atmosphere it absorbs some amount of moisture from the atmosphere this water is called "Hygroscopic Water".

2. Hygroscopic water cannot be removed easily from the soil particles.

3. Hygroscopic water is not available for plant use.

4. Hygroscopic water can be removed only at very high temperature.

Soil Moisture Tension:-

→ It can be defined as "Force per unit area that must be exerted by plant roots in order to extract water from the soil".

→ Soil moisture tension is also called as "Capillary Tension" soil pull, capillary potential & force of suction.

Leaching:-

It is the phenomena of application of excess irrigation water in order to avoid building up of salinity in soil.

Soil Moisture Constants:-

1. Saturation Capacity:-

(i) It is defined as the total water content of a soil when 100% of the pores of soil are filled with water.

(ii) It denotes the maximum water holdin capacity of soil.

2. Field Capacity:-

(i) It is defined as the amount of water held in the soil after excess water gets drained off due to the gravity.

(ii) It is expressed in percentage

(iii) F.C of soil = wt. of maximum amount of moisture held by soil against gravity / unit wt. of dry soil

3. Permanent Wilting Point :- (PWP)

(i) It is the water content at which Plants can no longer able to extract water from the Soil for its growth.

(ii) P.W.P = wt. of moisture held by Soil when Plant gets Permanently wilted / wt. of dry Soil

4. Available Moisture:-

It is defined as the difference in water content of the Soil between Field Capacity and Permanent wiltin Point.

5. Readily available moisture:-

(i) It is that Portion of available water which can be readily extracted by the Plants.

(ii) In general, readily available moisture is 75% of the available moisture.

Water Logging:

→ It is a Phenomena in which Productivity of land gets affected due to rise in water table, thus leading to the flooding of root zone of the Plants.

→ In this Process, the Productivity of land is affected by rise in water table.

Causes of Water Logging:

Main factors Causing water logging are as follows.

1. Inadequate Surface drainage:-

(i) When the Surface drainage is not adequate, heavy Precipitation is not drained off quickly and the rain water remains Stagnant over the area for considerable time.

2. Over-irrigation of fields:-

When the irrigation water applied to the field is in excess of the requirement of the crop, deep Percolation takes Place which is retained in the intermediate zone augmenting the ground water Storage.

3. Obstruction of natural drainage:

If a natural drainage is obstructed by irrigation channel, rail (or) road embankment it will not be able to Pass the rain water of catchment. There will be flooding of land and consequent water logging.

4. Obliteration of natural drainage:

Sometimes the cultivators plough up and obliterate an existing natural drainage. This results in stoppage of storm water flow, consequent flooding & water-logging.

5. Construction of a water reservoir:

Seepage from the reservoir augments the water-table and may cause water-logging.

6. Natural obstruction to the flow of ground water:

Sometimes sub-soil doesnot permit free flow of sub-soil water due to some natural obstruction. This may rise to the process of raisin the water table.

7. Seepage from canal system

8. Inadequate capacity for arterial drainage.

Effects of waterlogging:-

1. Fall in soil temperature:

A water logged soil warms up slowly and due to lower temperature, action of soil bacteria is sluggish and plant food available is less

2. Growth of wild flora:

In waterlogged soils, natural flora such as water hyacinth grows rapidly. This reduces the crop yield. A cultivator has to waste money and time both for clearing it out

3. Delay in Cultivation operations:-

In water-logged areas, cultivation operations such as Ploughing and mulching are either impossible or difficult and in any case they are delayed. Sowing of crops and their growth are also delayed. Crop yield is Poor and it arrives late in market causing loss to cultivators.

4. Defective air circulation:-

→ When the water-table is high, the drainage becomes impossible and the carbon-dioxide liberated by the Plant roots cannot be dissolved and taken away.

→ Consequently fresh air containing oxygen is not drawn and activity of soil bacteria and plant growth suffers.