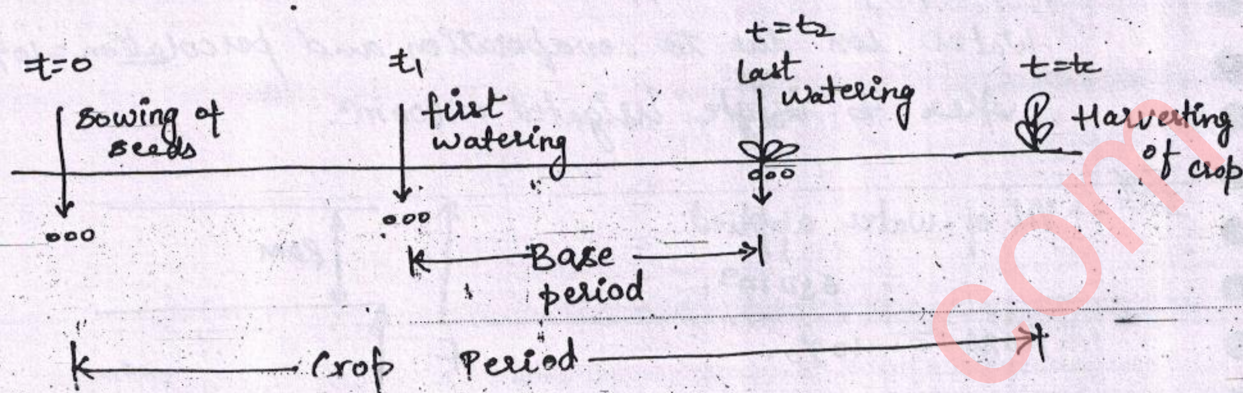
→ DUTY OF CROP :-

→ Duty of the crop is the area in hectare which can be irrigated by $1 m^3/s$ of discharge throughout the base period of the crop.



⊛ Base period < crop period.

⊛ But for all ~~po~~ practical calculation (BP = CP)

Base Period:-

→ It is the total period of irrigation during which water is applied to fields.

→ it starts from 1st watering after sowing of seeds upto last watering before harvesting of crop.

CROP PERIOD

→ Time period from the time of sowing to harvesting of crops.

NOTE :- ⊛ SUGARCANE — Largest Base period — 360 days

⇒ Perinial crop.

⇒ DELTA OF CROPS :- (Δ)

- It is the total water required by the crops for its complete growth during its entire Base period.

→ UNITS

Duty = hact./cumec

Delta (Δ) = cm.

⇒ DUTY & DELTA OF DIFFERENT CROPS:-

Type of Crop	D (hac/cumec)	Δ (cm).
✓RICE	775	120.
✓WHEAT	1800	30.
✓SUGARCANE	730	120.
VEGETABLE	1000	45
FODDER	2000	22.5

(*) In General, more is the duty, lesser is the Δ.

⇒ Relationship B/w Duty & Delta :-

Duty = Q = m^3/sec Δ = cm.

Base period = B days.

Vol. of water supplied during the entire base period @ $1 m^3/s$ = $1 \times B \times 24 \times 60 \times 60$

= $86400\ B\ m^3$.

Total area irrigated by above vol. (D) = $\frac{86400 B \times 10^{-4}}{\Delta \times 10^{-2}}$

(hact/cumecs) → $D = \frac{864 \times B}{\Delta}$ ← B in days, Δ in cm

In FPS system

$D = 864 \times \frac{B}{\Delta}$	$D = 8.64 \times \frac{B}{\Delta}$	$D = 2 \cdot \frac{B}{\Delta}$
B = days	B = days	B = days
Δ = cm	Δ = m	Area = $(feet)^3$
D = hact/cumec	D = hact/cumec	D = Acre/cusec
		Δ = ~~feet inch~~ feet

(i) 1 cusec = $(feet)^3$/sec

1 cumec = m^3/sec.

1 feet = 12 inch 1 inch = 2.54 cm.

$1 feet = 12 \times 2.54 \times 10^{-2}$

$1 feet = \frac{1}{3.28}$ m.

1 m = 3.28 feet

$1 cusec = \frac{(feet)^3}{sec} = \frac{(1/3.28)^3 \, m^3}{sec}$

1 cusec = 0.0283 cumec

1 Hac = 2.47 Acre

1 Acre/cusec = 14.30 Hact/cumec

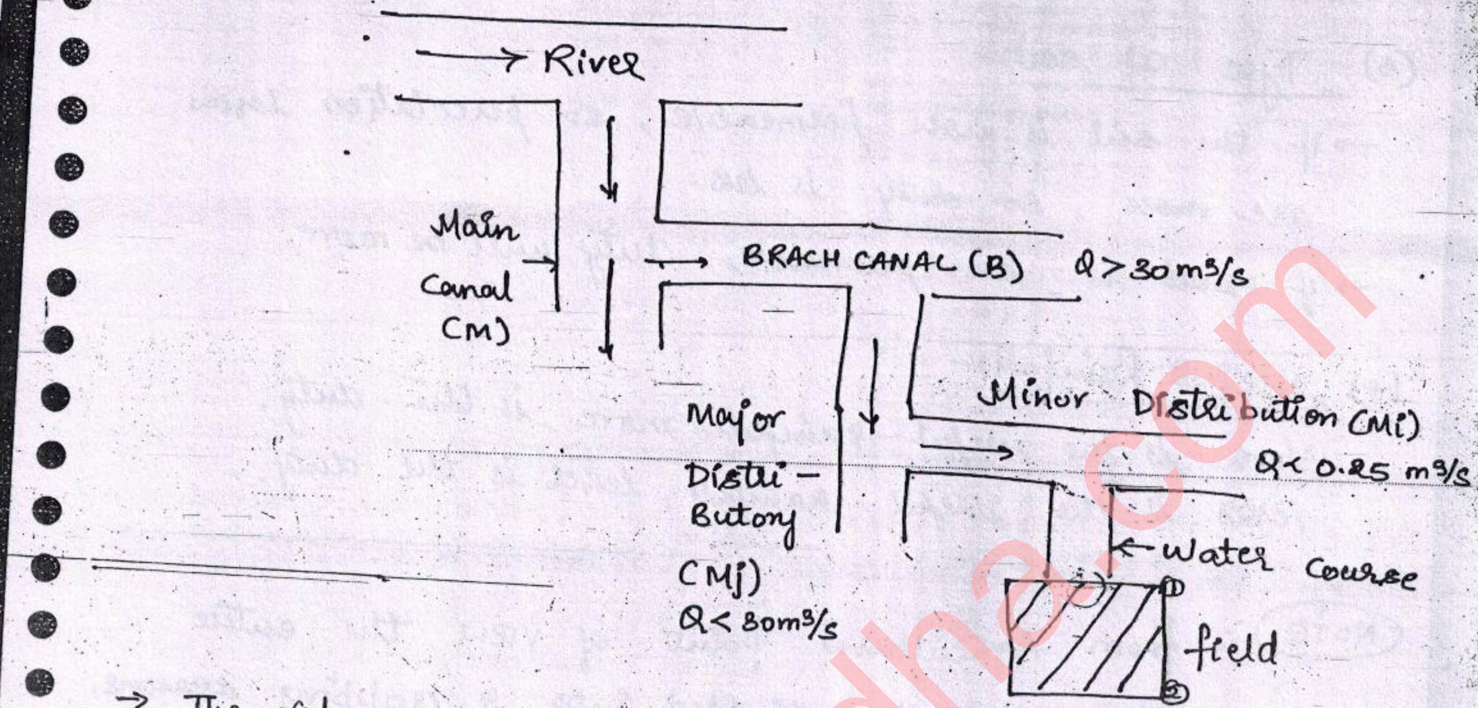
→ 1 Ha = 10^4 m^2

→ 1 Acre = 4046.85 m^2.

→ 1 Hac = 2.47 Acre

1 Acre = 0.4046 Ha.

→ The duty at the various points in the canal system is not constant.



→ The value of duty increase from River → water course

→ The value of duty decreases in the field from pt ① to pt ②. (As the total losses i.e evaporation & percolation loss increases) Hence the duty decreases as we move forward in field.

(NOTE)

→ Duty at the head of water course is known as "OUTLET DISCHARGE FACTOR"

⇒ **FACTORS AFFECTING THE DUTY OF CROP** :-

(1) Type of crop :- Crops which require more water have less duty & crops which require less water have more duty. as more area can be irrigated for the same discharge if water requirement is less.

(2) Climatic Condition:-

→ If the climate is warm, duty will be less as evaporation losses are more.

(3) Type of soil:-

→ If the soil is more permeable, so percolation losses are ~~more~~, so ~~duty~~ is less.

→ if soil is less permeable, duty will be more.

(4) Usefull Rainfall:-

More is the useful rainfall, more is the duty.
lesser is the useful rainfall, lesser is the duty.

NOTE :- from Agricultural point of view the entire year can be divided into 2 cropping seasons.

1) Kharif season → 1st Apr – 30th sept. (Summer),
2) Rabi season → 1st oct – 31st March. (winter).

Kharif Crops	Rabi Crops
RICE	WHEAT
Maize	BARLEY
JOWAR	GRAM
Bajara	LINSEED

NOTE :- KHARIF TO RABI Ratio:-
it is the ratio of Area irrigated under Kharif season to that in Rabi season.

$\frac{K}{R} = 0.5$ i.e. Area irrigated under Kharif $= \frac{1}{2} \times$ Area irrigated in Rabi

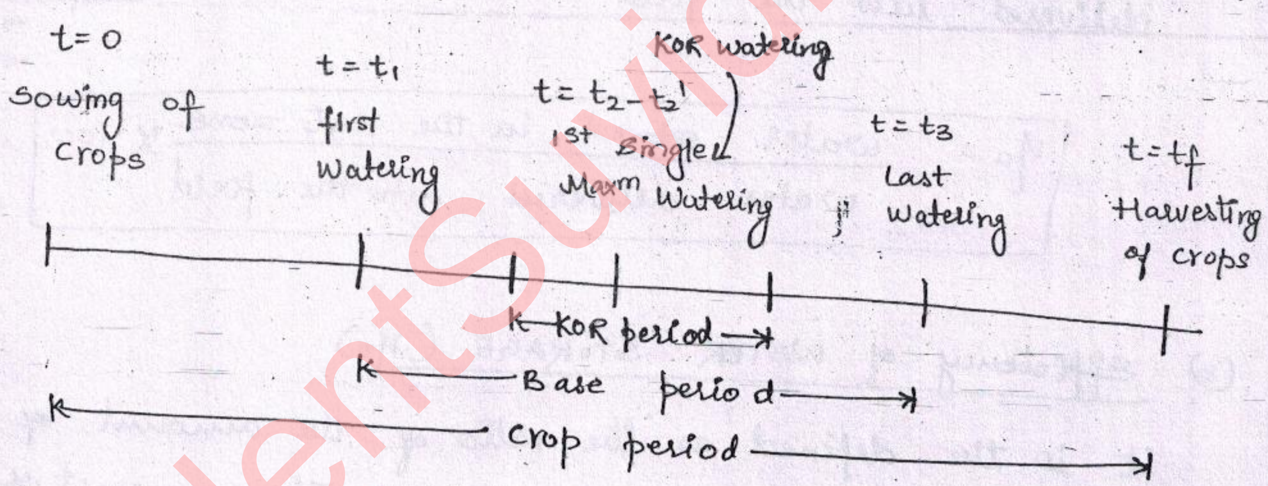
$\frac{K}{R} < 1$ always → as the duty in winter < duty in summer

→ PALEO IRRIGATION :-

— Sometimes in the intial stages before sowing of the crops water is applied to the field to bring back the moisture content upto its field capacity (as the moisture deficiency is very high) This is known as paleo irrigation.

— In summer the water content falls and hence in winter before sowing the water deficiency should be removed.
Hence, this is done before sowing of Rabi crops.

→ KOR WATERING & KOR PERIOD



→ KOR watering is the 1st watering given to crops when it is few centimeters high.

→ This is the maxm watering which is followed by the other watering of smaller magnitude.

→ The period for which the ~~core~~ Kor watering is done is known as Kor period.

	RICE	WHEAT	SUGARCANE
KOR DEPTH	19 cm	13-5 cm	16-5 cm
KOR WATERING	3-4 weeks	4-8 weeks	3-6 weeks

IMP → IRRIGATION EFFECIENCY :-

1) Efficiency of WATER CONVAYANCE (η_c):-

it is defined as the ratio of amount of water delivered into the field to the amount of water diverted into the canal.

Losses → Evap.
→ Infiltration

$$\eta_c = \frac{\text{water delivered into the field}}{\text{water diverted into the canal.}} \times 100$$

2) Efficiency of WATER Application (η_a)

it is defined as the ratio of amount of water stored in the root zone to the amount of water delivered into the field.

Losses → Evap.
→ Infiltration
→ Runoff.

$$\eta_a = \frac{\text{water stored in the root zone}}{\text{water delivered into the field}} \times 100$$

(3) Efficiency of WATER STORAGE (η_s)

it is the defined as the ratio of the amount of water stored in the root zone to the amount of water required before irrigation.

$$\eta_s = \frac{\text{water stored in the root zone}}{\text{water required before irrigation}} \times 100$$

(4) Efficiency of Water Distribution (η_d)

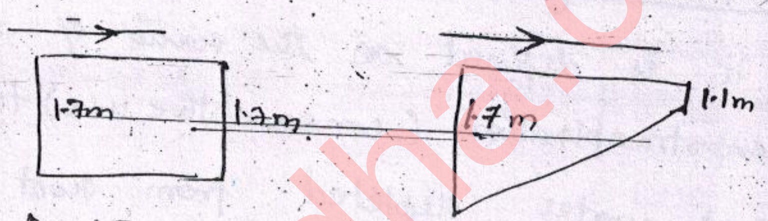
It indicates the degree of non uniformity of the water distribution throughout the field.

$$\text{Efficieny of water distribution} = \left(1 - \frac{d}{D}\right) \times 100$$

D = avg depth of water stored during irrigation

d = avg value of the absolute deviation from mean depth.

(*) It tells about the uniformity of application of water.



$D = 1.7$

$d = \frac{|1.7 - 1.7| + |1.7 - 1.7|}{2}$

$d = 0.$

$\eta_d = 100\%$

$D = \frac{1.7 + 1.1}{2} = 1.4m$

$d = \frac{|1.7 - 1.4| + |1.1 - 1.4|}{2}$

$d = 0.3$

$\eta_d = \left(1 - \frac{0.3}{1.4}\right) \times 100 = 78\%$.

(5) Efficiency of Water-Use (η_u) :-

→ Defined as the ratio of amount of water benificially used by the crops to the amount of water delivered into the field.

$$\eta_u = \frac{\text{water used beneficially by crop}}{\text{water delivered into the field}} \times 100$$

NOTE

Water which is beneficially used also includes leaching requirements.

→ Water delivered into the field = Surface runoff + Infiltration + Evaporation + Water stored in root zone + Leaching

(NOTE) — included in η_a

Water used beneficially by crops → {Water stored in root zone + Leaching}

⑥ Efficiency of consumptive use

it is defined as the ratio of water required for evapotranspiration (consumptive use) to the net amount of water depleted from root zone

$$\text{Efficiency of consumptive use} = \frac{\text{Consumptive use (P.E.T)}}{\text{Amount of water depleted from root zone}} \times 100$$

Q. A stream of 130 l/s was diverted from a canal and 100 l/s was delivered to the field and the area of 1.6 hectres was irrigated in 8 hrs. The effective depth of the root zone was 1.7m. The runoff loss in the field was 420 m³. The depth of water penetration varied from 1.6m at the head of the field to 1m at the tail linearly. Available moisture holding capacity of the soil is 20cm/m depth of the soil. It is required to determine water conveyance efficiency, η_a, η_s & η_d. Irrigation was started at the moisture extraction level of 50% of available moist...

Soln

$\eta_c = \frac{100}{130} \times 100 = 76.9\%$.

→ vol of water delivered into the field in 8 hr @ 100 l/sec.

$= 8 \times 60 \times 60 \times 100 \times 10^{-3} = 2880\ m^3$.

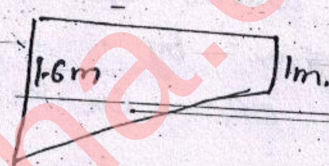
→ Runoff vol = 420 m³.

→ vol. of water stored in root zone = 2880 − 420 = 2460 m3.

$\eta_a = \frac{2460}{2880} \times 100 = 85.4\%$.

for η_d

$\eta_d = \left(1 - \frac{0.3}{1.3}\right) \times 100$



$D = \frac{1.6+1}{2} = 1.3m$.

$d = \frac{|1.6 - 1.3| + |1 - 1.3|}{2}$

$d = 0.3$.

$\eta_d =$ 76.9%

for η_s

→ moisture holding capacity $= 20 \times 1.7 = 34\ cm$

water reqd. before irrigation $= \frac{34}{2} \times 10^{-2} \times 1.6 \times 10^4$

$= 2720\ m3$

$\eta_s = \frac{2460}{2720} \times 100$

$\eta_s = 90.4\%$.

7-12-2012

⇒ CONSUMPTIVE IRRIGATION REQUIREMENT (CIR).

- It is the amount of water (irrigation water) reqd. in order to meet the consumptive use of the crops for the given crop period.

$$CIR = Cu - Pe.$$

Cu = amount of water reqd for the growth of groups

Pe = eff. Rainfall

- If water ~~con~~ corresponding to available moisture is given by

$$CIR = Cu - Pe - Ma$$

⇒ NET IRRIGATION REQUIREMENT (NIR)

→ NIR is the amount of irrigation water required in order to meet the evapo-transpiration needs and also other needs such as leaching.

$$NIR = CIR + LR$$
$$= Cu - Pe + LR \text{ or } Cu - Pe - M_A + LR.$$

⇒ FIELD IRRIGATION REQUIREMENT (FIR)

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

$$FIR = NIR + SR + Ev + If$$

⇒ **GROSS IRRIGATION REQUIRED:-**

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

GIR = FIR + Losses in canal.

16/8/11 A sandy loam soil holds the water at 140 mm/m depth between the field capacity and PWP. The root depth = 30 cm. Allowable depletion of water is 35%. The daily water used by the crop is 5mm. and area to be irrigated is 60 ha and the water can be diverted at 28 l/s. The surface irrigation application efficiency is 40%. There is no rainfall and ground water contribution. Calculate (i) the allowable depletion depth between the irrigation.

(ii) frequency of irrigation.

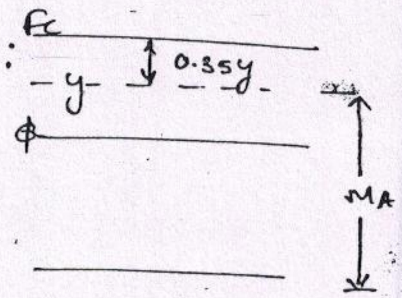
(iii) Net application depth of water.

(iv) Vol. of water req.

(v) Time to irrigate 4 ha of the plot. If the water lost in the field channel is 15% of outlet discharge calculate the quantity of water req. at the head of the canal.

Sol Moisture holding capacity $= \frac{140 \times 30}{1000 \times 10}$

$= 4.2$ cm



(i) allowable depletion depth

$= 0.35 \times 4.2 = 1.47$ cm.

(ii) frequency $= \frac{1.47 \times 10}{5} = 2.94 \approx 3$ days

(iii) $NIR = C_u - P_e - M/A + L/R = 3 \times 5 = 15mm$ ... $= \frac{15}{0.4} = 37.4$m.

(iv) Vol. of water = $\frac{37.5}{10^3} \times 60 \times 10^4 = 22500 m^3$

$\eta_a = (1 - \text{loss}\%)$

$= 1 - 0.15 = 0.85$

$FIR = \frac{15}{0.85} = 17.64\ mm$

time reqd $= \frac{V}{Q} = \frac{\frac{17.64}{10^3} \times 4 \times 10^4}{28 \times 10^{-3} \times 60 \times 60}$

time reqd =

time = $\frac{\text{Vol. corresponding to 4 ha}}{Q}$

$= \frac{\frac{37.5}{10^3} \times 4 \times 10^4}{28 \times 10^{-3} \times 60 \times 60}$

(v) time to irrigate 4 ha = 14.88 hrs.

(vi) $FIR = \frac{NIR}{1 - 0.15} = \frac{37.5}{0.85} = 44.11 mm$

⇒ MEASUREMENT OF CONSUMPTIVE USE :-

C_u (P.E.T.)

Direct Methods
- → field test
- → inflow - outflow
- → lysimeter

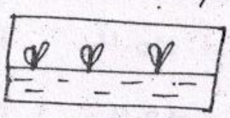
INDIRECT Method
- → BLAINEY CRIDDLE METHOD
- → Heagreaves — class-A — PAN - METHOD

⇒ DIRECT METHOD :-

1) LYSIMETER METHOD :-

- Lysimeter is a closed water tight tank which is used for the measurement of evapo-transpiration by creating the conditions similar to the field conditions.
- Lysimeter measures the actual evapotranspiration

Lysimeter — AET



2) INFLOW – OUTFLOW STUDIES :-

- Based on the water-Budget equation.

$$(Q + P_e)\Delta t - (C_u + IF + R + E_v)\Delta t = GR_2 - GR_1$$

⇒ INDIRECT METHOD :-

1) BLAINEY CRIDDLE METHOD :-

- According to this method consumptive use for 1 month is given by:-

$$\boxed{C_u = \frac{K.P.}{40}(1.8t + 32)} \rightarrow (cm/month)$$

K = crop factor or consumptive use factor depends upon the type of crop.

t = Mean monthly temperature in °C.

if temp is given in (°F) $\{ °F = 1.8\ °C + 32 \}$

$$C_u = \frac{K \cdot P \cdot t}{40}$$

P = monthly %age of annual day light hours for the given time (generally in days).

Q Determine the value of water reqd to be diverted from the head works to irrigate 5000 ha using the data given below. Assume 80% of the effective precipitation to take of the consumptive use of the crop. Also assume 50% efficiency of water application in the field and 75% efficiency of water conveyance.

MONTH	TEMP (°F)	% hr of Sunshine	Rainfall (mm)	Crop factor (K)	$C_u = KPt/40$ (cm)
JUNE	70.8	9.9	75	0.8	14.01
JULY	70.4	10.2	108	0.85	16.12
AUG	72.8	9.6	130	0.85	14.85
SEP	71.3	8.4	115	0.6	8.98
OCT.	69.2	7.2	105	0.65	8.09
NOV.	55.8	7.6	25	0.7	7.42
DEC	47.4	6.5	0	0.68	5.23
JAN	48.6	8.2	0	0.7	6.97
FEB.	53.2	9.4	0	0.75	9.37
MAR	60.1	8.2	0	0.8	9.85
APR	62.5	8.3	0	0.7	9.07
MAY	67.5	9.3	0	0.82	12.84

$C_u = 125$ cm

$\Sigma R = 558\ mm = 55.8\ cm.$

$R_e = \frac{80}{100} \times R = 0.8 \times 55.8 = 44.6\ cm$

$CIR = Cu - Pe$

$= 122.8 - 44.6$

$= 78.16 \text{ cm}$

Since leaching requirement not given NIR = CIR

$\therefore FIR = \frac{NIR}{\eta_a} = \frac{78.16}{0.5} = 156.32 \text{ cm.}$

$GIR = \frac{FIR}{\eta_c} = \frac{156.32}{0.75} = 208.42 \text{ cm.}$

vol. of the water to be delivered in the canal $= 208.42 \times 10^{-2} \times 5000 \times 10^4$

$= 104.2 \times 10^6 \text{ m}^3.$

(2) HEAGREAVES – CLASS A PAN METHOD :-

$Cu = K_p \times \text{Pan evaporation}$

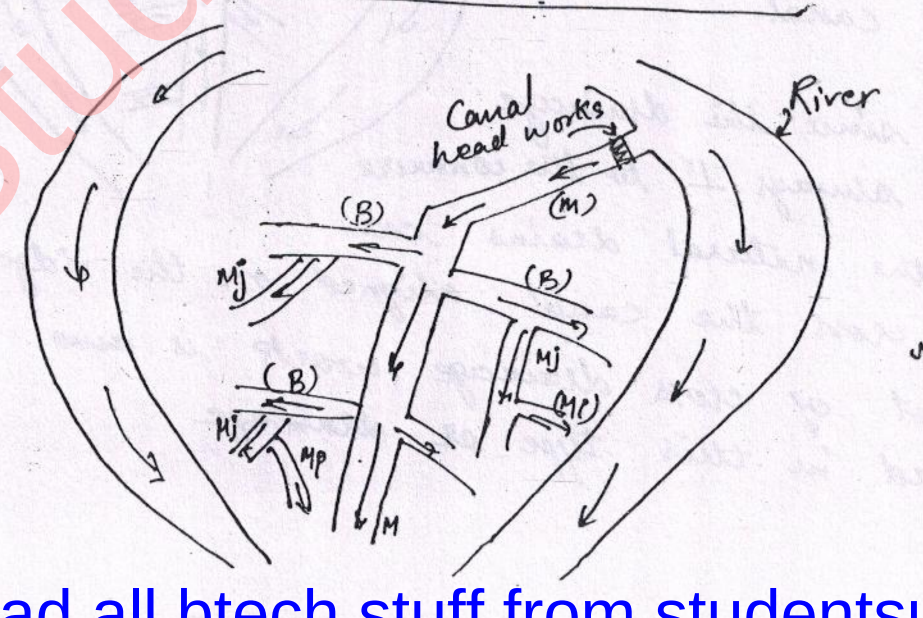
K_p = pan coefficient = 0.3 for wheat

= 0.8 – 0.9 for Rice

= 0.621 for sugarcane

→ pan coefficient is area specific.

⇒ CANAL IRRIGATION SYSTEM :-



M = main canal

Mj = Major Distributory

B = Branch Canal

Mi = Minor Distributory