TD 603
Water Resources

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Lecture 9: Water in Agriculture

Water in Agriculture

- **Historically: Biggest consumer of water**, in developed world, now industry is in first place.
- One cubic meter gives roughly 5 kg of rice, 10 kg of wheat, 3 kilos of sugar.
  - Though the source of water in all the three cases is usually different.
- Agriculture is also the biggest re-cycler of water through groundwater recharge.
- Indian agricultural under severe water stress-more so under global warming.
  - Depleting groundwater
  - Irregular rains
- Man-made Irrigation Systems and Agriculture now intimately connected. converge.
  - About 40 % of indian agricultural lands now under irrigation.
  - Remaining rain-fed.

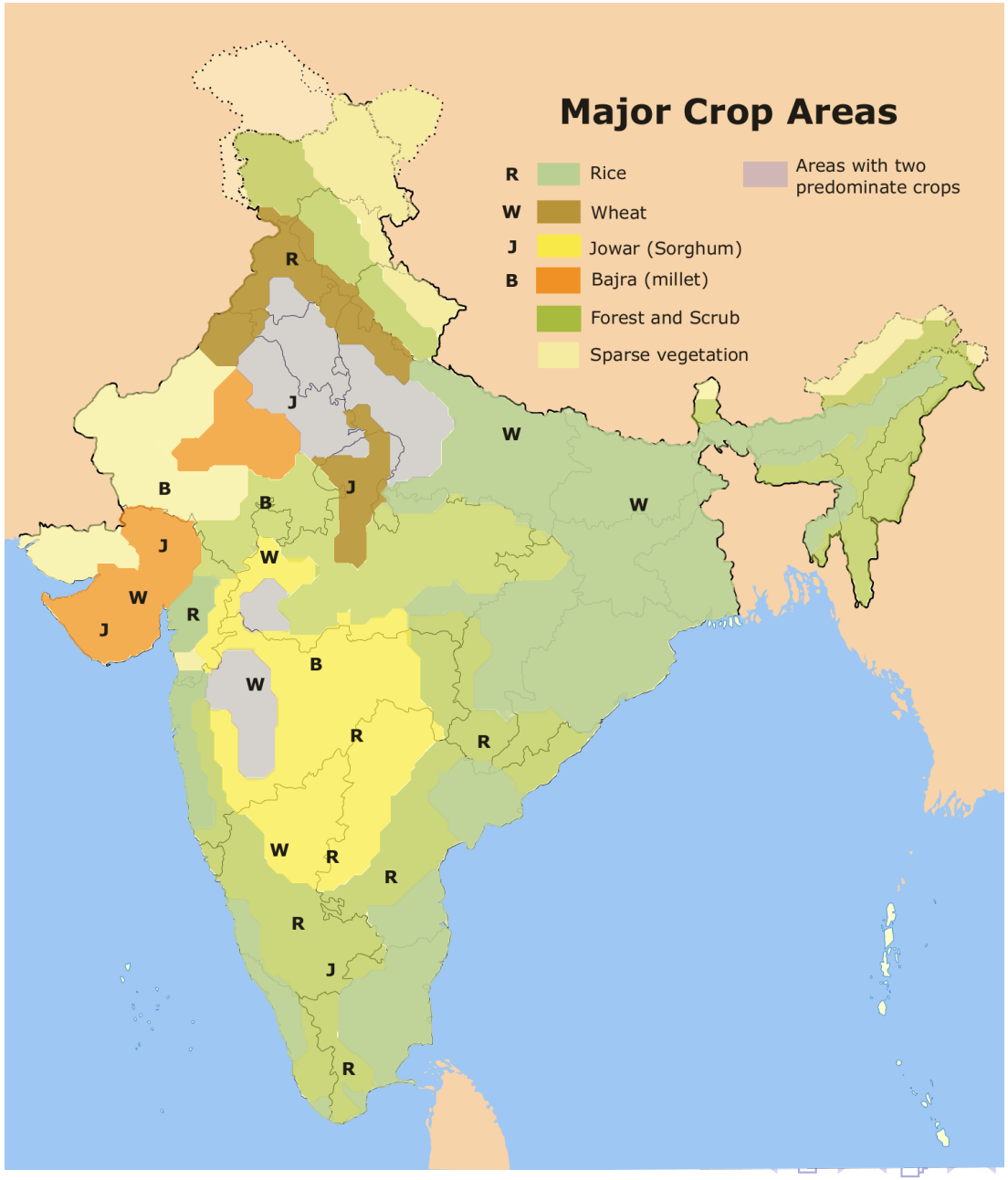
A single point where Ecology-Engineering-Economy, and of course Culture converge.

Agriclutural Land Summary

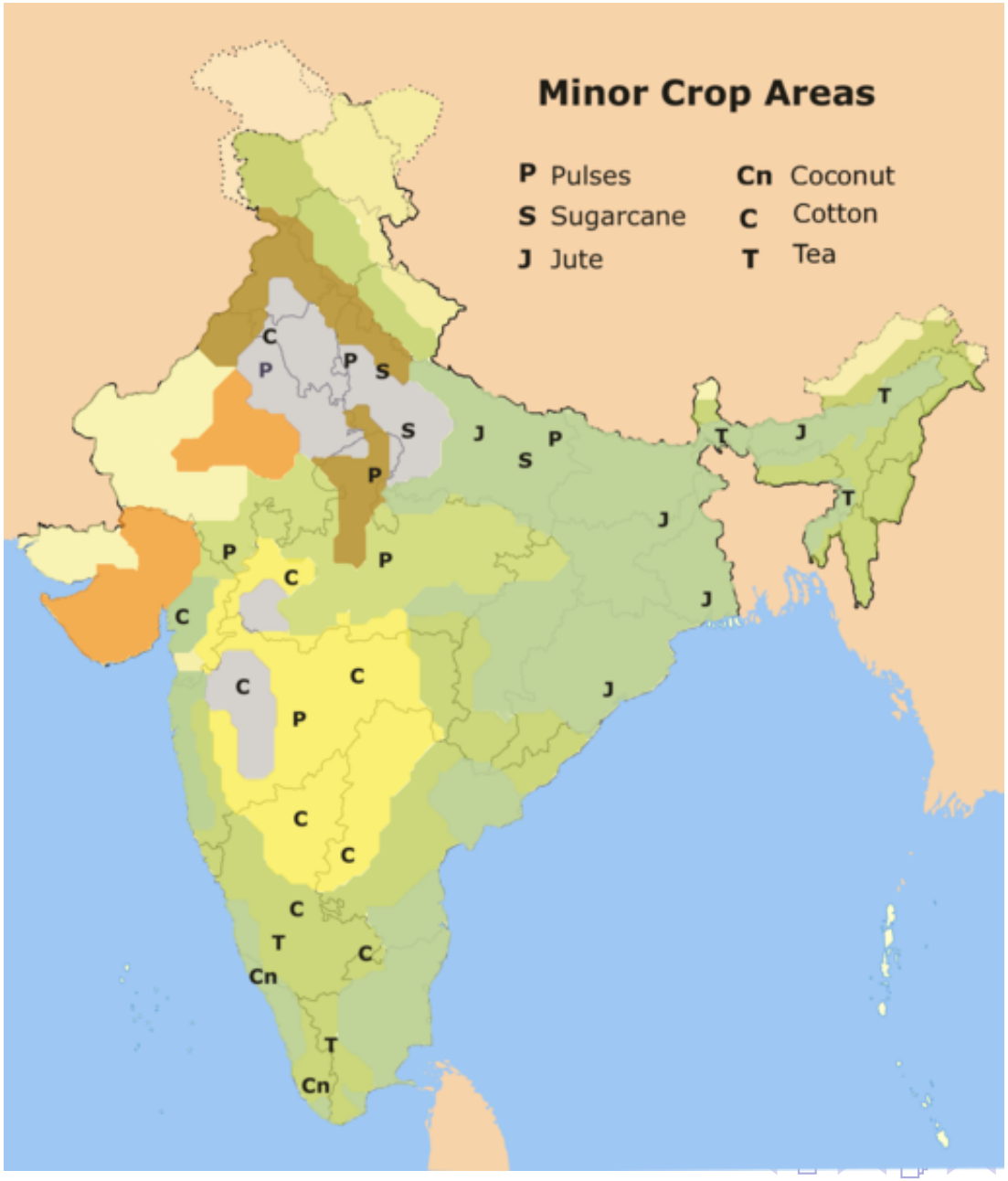
Year	1960-61	1997-98	2005-6
Land (MHa)	328.73	328.73	328.73
Net Cropped Area (MHa)	133.2	141.14	141.89
Total Cropped Area (MHa)	152.77	190.02	192.80
Cropping Intensity	114.7	133.9	135.9
Net Irrigated Area (MHa)	24.66	55.17	60.20
Total Irrigated Area (MHa)	27.98	75.42	82.63

- Cropping Intensity: is the number of times the land is ploughed.
- Net Cropped, Net Irrigated : Doubly planted area counted once.
- Total Cropped, Total Irrigated : Multiply planted area counted as many times.
- Net-cropped area peaked in 2002 at 142.1, and has now stabilized.
- Average fertilizer use is 101 kg/Ha. (USA 50, China 80, Europe 150, Japan 300).

Major Crops source wikipedia



Minor Crops source wikipedia



Sowing Seasons

- *Kharif*: largely monsoon-fed.
  - Rice in Konkan, Jowar, Bajra in Marathwada
  - Rice in Tamil Nadu, Assam, Nachini in Konkan sloping lands.
  - Sugarcane in Pune, Cotton in Vidarbha, Oil seeds in Gujarat.
  - Tur, Makka, Til in UP (sloping or sandy lands), Rice, Wheat in A.P.
- *Rabbi*: Winter, either irrigation or existing soil moisture.
  - Pulses/fallow in Konkan, largely fallow in Marathwada
  - Vegetables, Grapes in Nasik, Turmeric, Ginger in Karnataka
  - Wheat in Pune, Chana in MP, Tur in A.P.
- *Summer*- largely highly irrigated.
  - Wheat in UP, Punjab, Potatoes in Uttaranchal.
  - Seasonal Fruits everywhere.
  - Yearlong crops such as Bananas, Coconut, Sugarcane.

Crucial Point : maintain soil moisture through-out the duration of the crop.

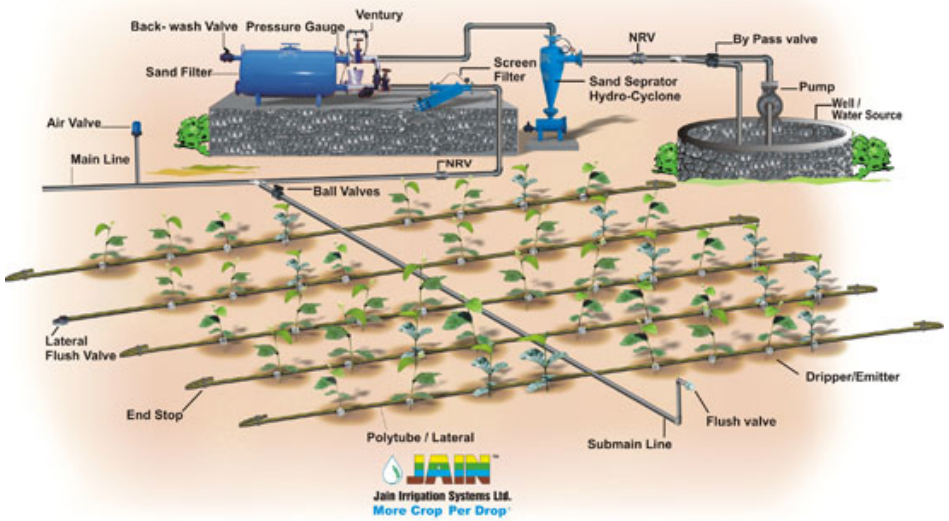
Water Requirements-Flood Irrigation

Crop	Period (days)	Each Wetting (mm)	Number	Rain/SM (mm)	Total (mm)
Kharif Paddy	100-120	50	4	600	800
Kharif Vegetable	90-110	25	8	250	450
Kharif Sugarcane	365+	75	12	400	1300
Kharif Jawar	120	1-2	50	200	350
Rabi Wheat	120	6	50	125	425
Rabi Cotton	170-190	50	6	400	700
Rabi Jawar	135	3	50	150	300
Rabi Vegetable	90-110	10	40	50	450
Summer Vegetable	90-110	15	40	0	600

Both crop duration and water requirements depend on the meterological conditions *intimately*.

Drip Irrigation

- A network of pipes with nozzles exactly near the roots of the plants.
- As opposed to flood irrigation, water does not freely flow in the farm.
- Great savings in water (obvious) and increase in yields (due to better moisture control).
- Investment of Rs. 20-40,000 per Ha. depending on crop.
- Needs some amount of training.



- Initially used for fruit-tree saplings and vegetables, but now used in all soil conditions and on all crops.

FIM vs. DIM source: A. Narayanamoorthy

Crop	Water Use (mm)		Yield (q/Ha)		Benefits (%)	
	FIM	DIM	FIM	DIM	water	yield
Onion	602	451	9.3	12.2	25	31
Tomato	498	107	6.18	8.87	79	43
Potato	200	200	23.57	34.42	0	46
Banana	1760	970	57.5	87.5	45	52
Sugarcane	2150	940	128	170	65	33
Wheat	350	202	32.41	36.39	42	12
Bajri	177	78	6.97	8.33	56	19

- Mix of research station and farm-level data.
- The yield increase is primarily due to good moisture control.
- Even without subsidy, DIM pays back rapidly.
- DIM allows much lower input costs such a fertilizers and some pesticides.

Micro-Irrigation

- Micro-Irrigation : Includes Drip and Sprinkler and other related technologies.
- Sprinkler more suitable for narrow space crops (typically grains), while Drip for broad spaced crops (such as vegetables, fruits).
- Less than 1MHa under MI.
- Maharashtra, Karnataka, Tamil Nadu and AP leaders. 50 % in Maharashtra.
- Potential of atleast 70 M.Ha (of about 190 M.Ha of total cultivation).

Poor coverage due to

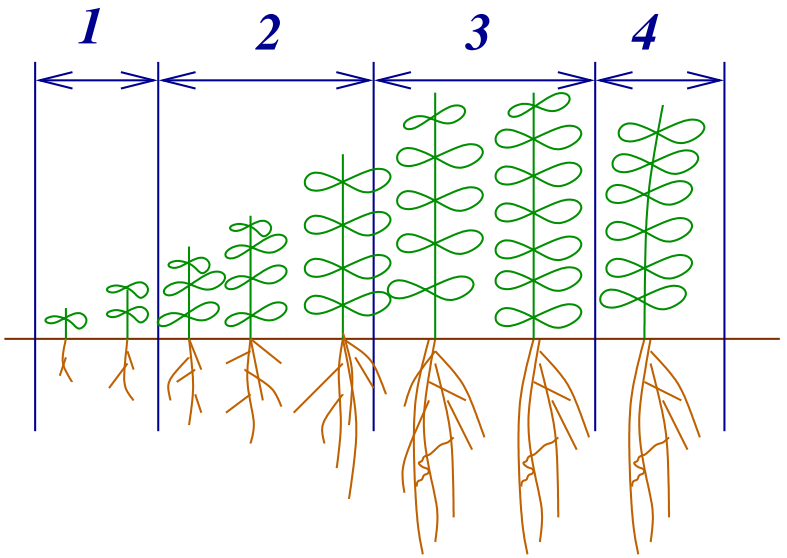
- Norms and standards have not percolated enough among farmers.
- Economic viability not well understood.
- Highly subsidised irrigation water!

Irrigation Systems

- Basic Parameters: Storage, Head-works, Canal works, Command area.
- Water Use: Sectoral and mechanics of lift.
- Costs: Capital and O&M.
- Tarrifs: Area-wise, crop-wise.

Crop growth and moisture

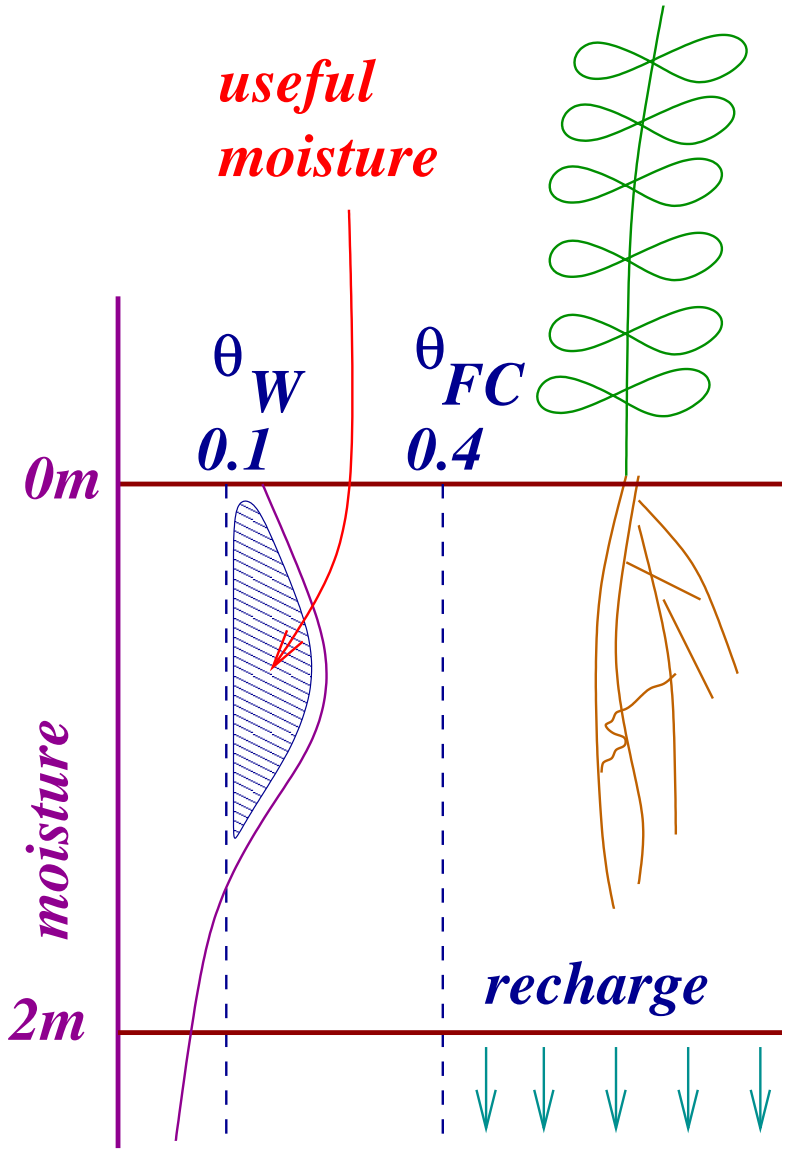
- Soil loses moisture through:
  - Evaporation: through surrounding soil.
  - Transpiration: through the plant.
- Fix (i) Crop, growth stage, (ii) Meterological conditions and (iii) soil and planting pattern.
- then, there is a defined rate of moisture loss called the total potential.
- This is the ideal rate at which a healthy crop demands water.



Tomato		
Stage	Dur. (days)	Req. mm/day
1	35	5
2	45	5.8
3	70	6.5
4	30	7.1

Wilt Point and Field Capacity

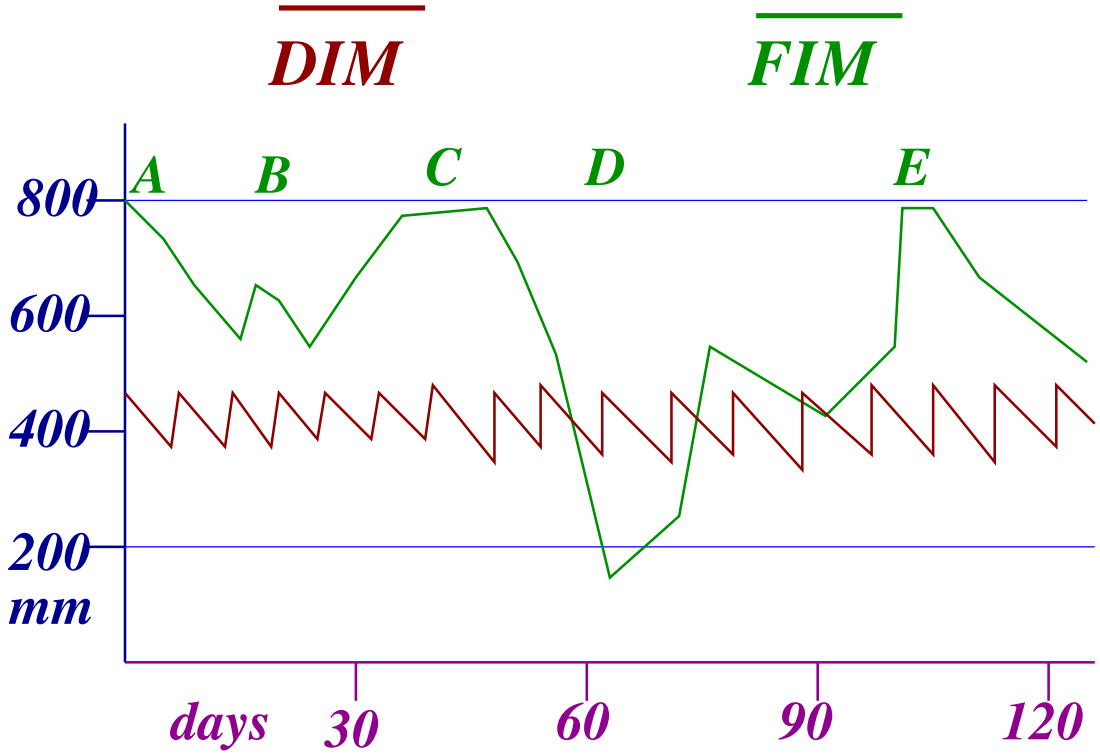
- Field Capacity θ_{FC}: is the maximum soil moisture (i.e., to saturation), e.g., 45 %.
- Wilt Point θ_W: Minimum moisture required for roots to absorb moisture.
- Depending on the crop, there is a depth (here 2m) beyong which moisture descends due to gravity.
- Above this depth, moisture is available to the root system.
- In that too, only that which is greater than θ_W.



Moisture Plots

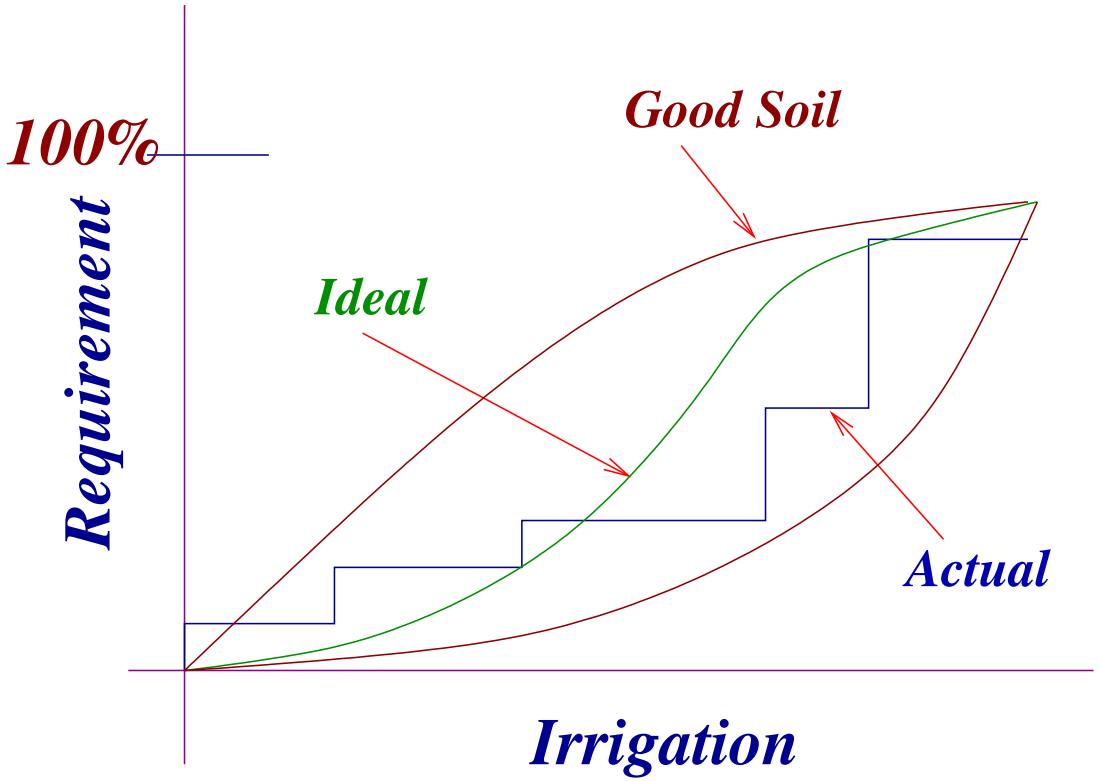
- Plot the water (in mm) in the cube of depth 2m.
- The maximum is $\theta_{FC} * 2000 = 800$mm.
- As the season progresses, we plot the moisture content in this cube.
- Swings below 200mm indicates stress.

A	planting
B	rain
C	RAIN
D	stress
E	wetting



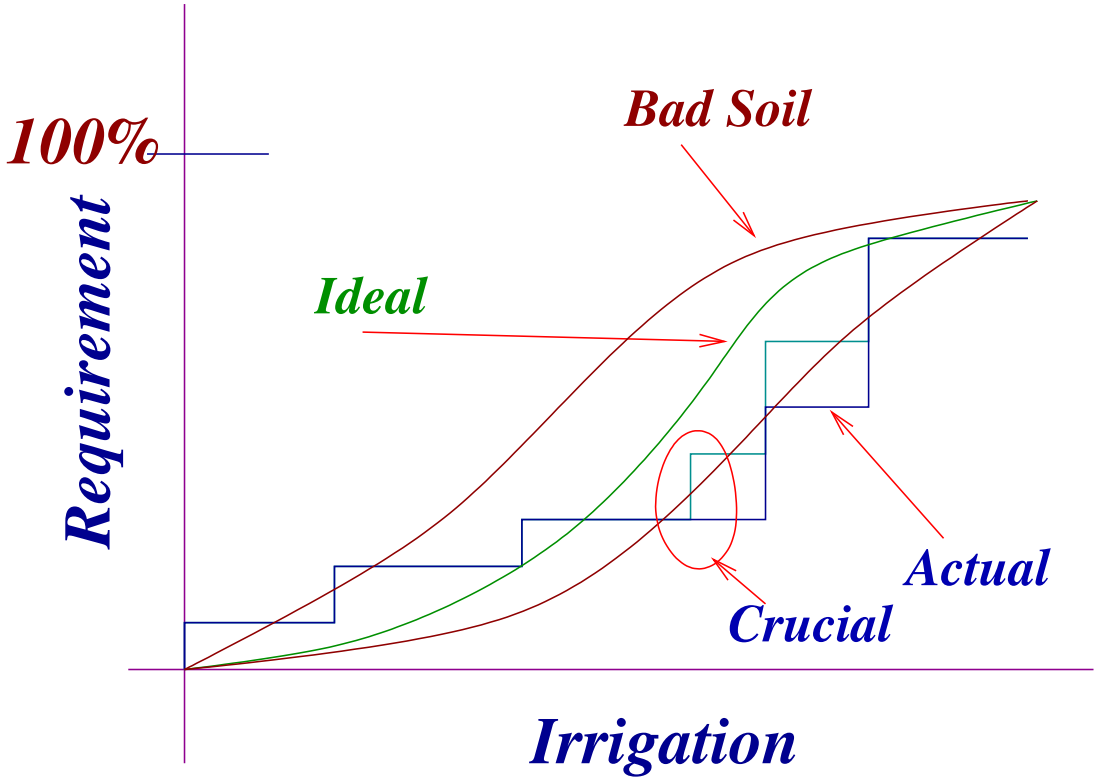
- Now compare the FIM and DIM lines.
- Moisture levels never reach stress levels
- Water content is low, since it is concentrated near the top and very little reaches the WT.

Graphing it out



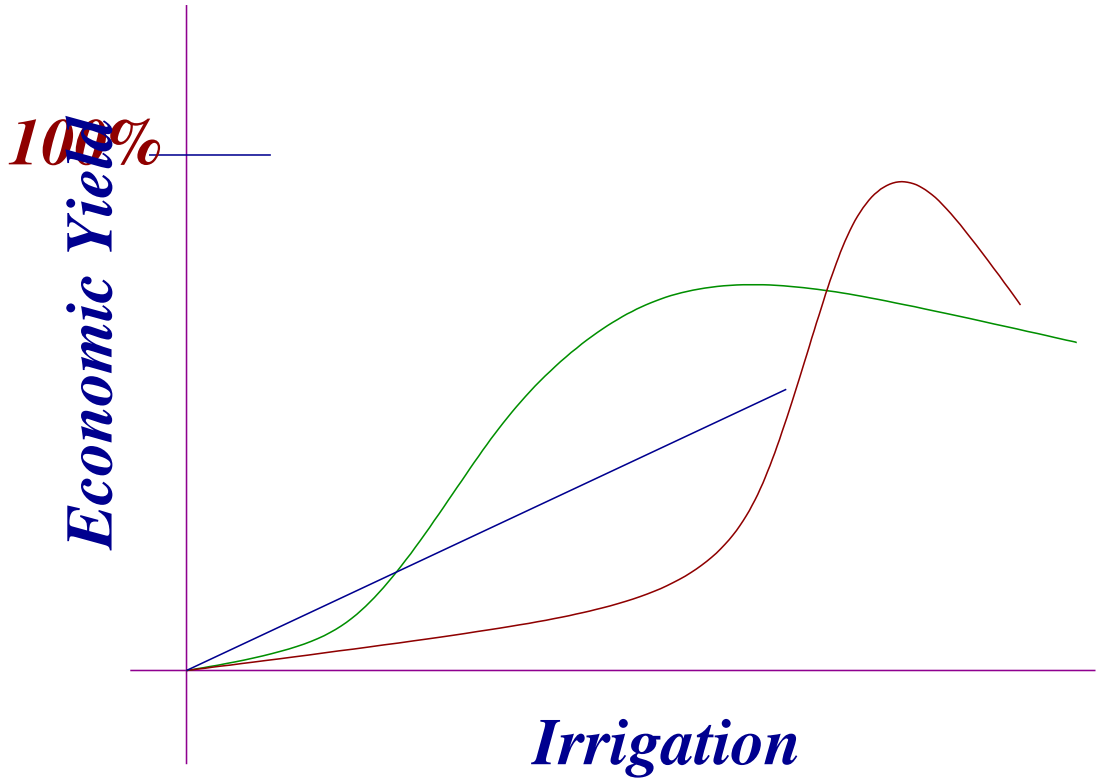
- Ideal requirements: slop is mm/day requirement.
- Actual irrigationis by rain or by flood/drip and is step-wise.
- The steps are small and regulated for drip.
- Important. Soil is like a bank. It stores excess moisture and makes it available when required.

Poor soils and dry-spells



- The soil-envelope is thinner for poor soils.
- The extra irrigation becomes critical.
- Rabbi. What is the source.
- How to even out rotation?

Economic Returns



- Different crops have different quantity and quality curves. Qaulity is many times by perception.
- Ideal crop is of course linear.
- Cash crops are frequently highly sensitive.
- Important. The operating point and the slope at that point.

Managing Water Stress

Kharif

- Measure dry-spells and their impact.
- Try and improve availability of water during dry spells.
- Increase soil-moisture retention through area treatment.
- Farm-ponds, nalla etc., wells as possible storage regions.
- Match Run-off with deficit.

Rabi

- Understand water balance. Community should sow accordingly.
- Select crops which match water availability.
- Manage groundwater. Reduce competitive access.
- Nuture fallow lands and increase infiltration.
- Look for community and shared infrastructure.

Discussion

1. Looking at the Net and Total agricultural areas, estimate the irrigation water requirements for a year for the whole of India. Mumbai city requires 3000 mega-liters per day. How many Mumbais may be supplied by this water?
2. Fertlizers are typically explosives. What is the calorific value of fertilizers as explosives? Compare this with the calorific value of the crops which are produced. Is this a fair comparison?
3. Darcy's law remains valid in the unsaturated regions as well. Discuss what modifications need to be done.
4. What are the disadvantages of DIM if any? What additional reasons do you think are responsible for its unpopularity?
5. The moisture plots do not quite relate total potential to moisture. How should this be done?
6. How do you think h varies with depth and what is the direction of moisture flow?
7. Much of the agriclutural data was obtained from the Planning Commission site. Explore the data at this site: `www.planningcommission.gov.in`.