Water and Environment Support
in the ENI Southern Neighbourhood region

Regional Training and Study Tour on optimal irrigation management Activity number/RW-7-REG/ST

Training module 2: Interfacing off- and on-farm irrigation systems: constraints and opportunities

14-June, Bari, Italy

Presented by: Dr Roula Khadra

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I'm…

ROULA KHADRA

A Ph D in ***collective irrigation systems*** design and performance analysis (Italy) with background in ***rural engineering*** (Lebanon)

A post doc in ***combined effects of water and salinity stress on crop production*** (USA)

and interest in ***decision analysis***, ***PIM***, and ***science policy***.

A **Senior Researcher/International Officer** at CIHEAM – Bari

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I've been told that…

you're coming from different countries…

From different institutions…

WHAT ELSE?…NEED TO KNOW MORE

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Water Supply in MENA

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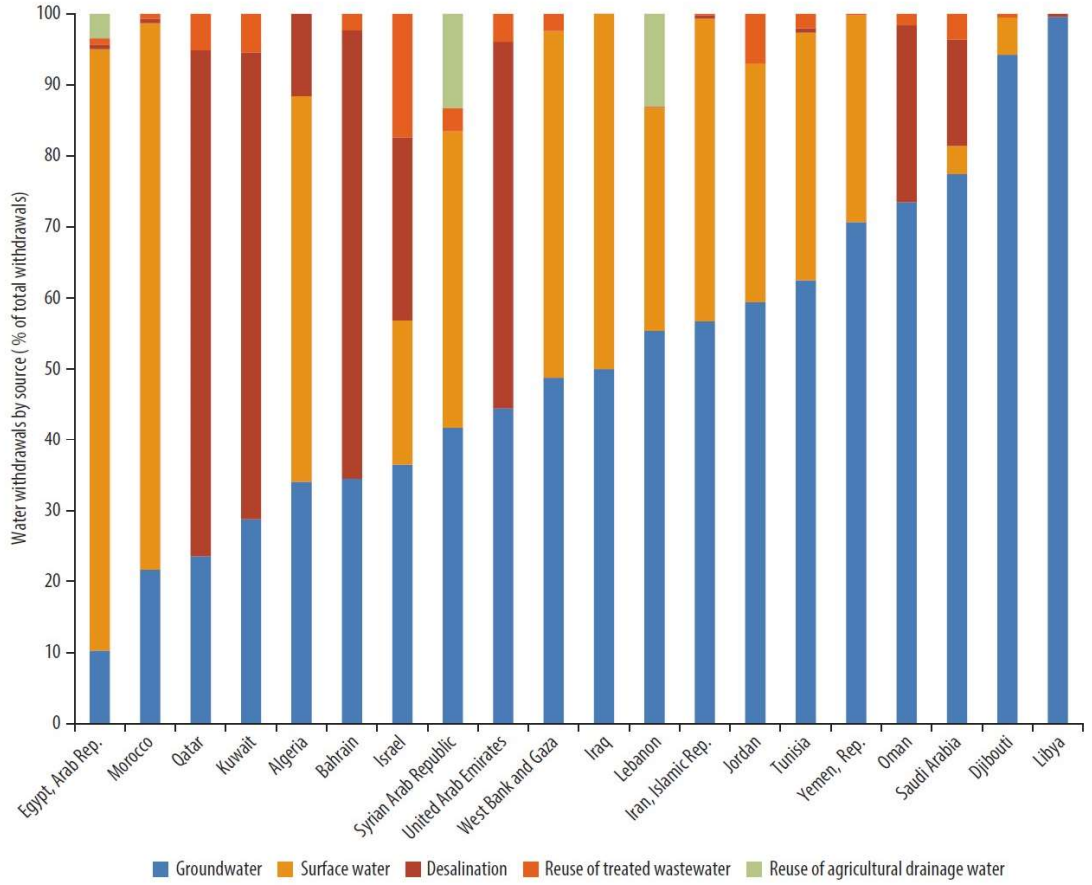
Water Withdrawals, by Source, as a Percentage of Total Withdrawals 2010



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Water Demand in MENA

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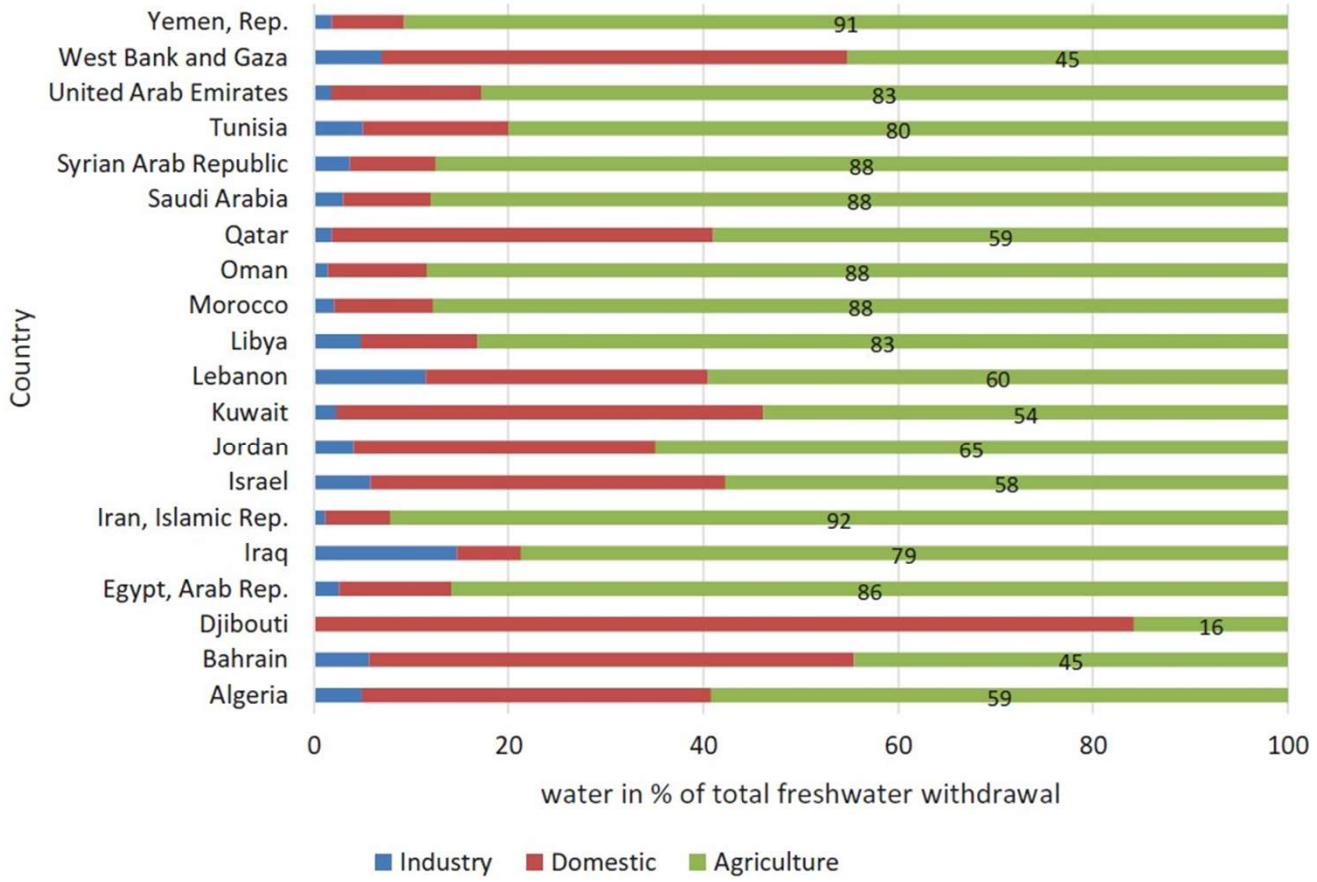
Percentage Freshwater Withdrawal by Sector in MENA in 2014



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Water Resources Management

Water Demand and Supply in the MENA region

Water Demand ↑

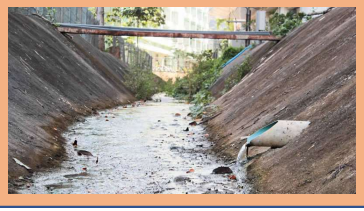
Water Supply ↓

Stressors

- Climate change

- Food security

- Water pollution



- Shared water resources

- Overexploitation of groundwater resources

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Water Resources Management

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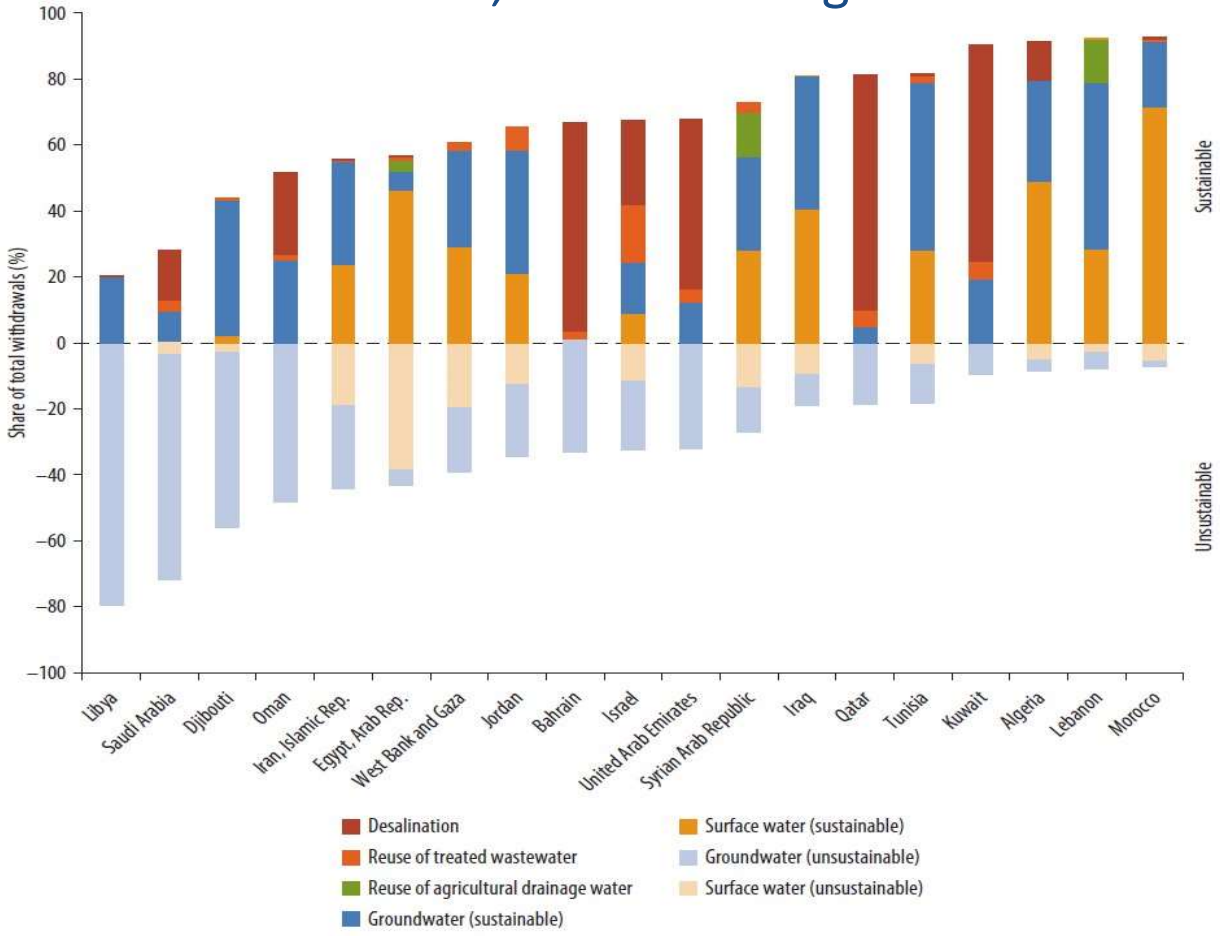
Sustainability of Water Withdrawals, as a Percentage Total Withdrawals



(World bank, 2018)

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What is Irrigation?

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Irrigation is an agronomic practice that relates to the artificial supply of water to soil and plants.

It is a **fundamental** mean to cultivate arid areas and to **optimize** crop production in cultivated areas

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Why we irrigate?

- **Wetting** irrigation aims at supplying water to soil and plants for their production (most commonly utilized).
- **Fertigation** is carried out to supply nutrients to plants through irrigation water.
- **Thermic irrigation** aims at modifying soil and plants temperature (irrigation to prevent plant **freezing** in California/Australia)
- **Leaching irrigation** is used to remove salts from top-layers of soils (if drainage is available. Australia).
- **Corrective irrigation** aims at modifying soil reaction **(pH)** (ex. acid soil sommersion – rice production)

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Irrigation Variables

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- **Seasonal irrigation volume** (m^3/ha) is the total amount of water to be supplied to a crop in order to satisfy its water needs for the whole irrigation season.
- **Watering volume** (m^3) is the amount of water that is supplied at each irrigation.
- **Irrigation interval** (days) is the time interval between two subsequent irrigations.
- **Irrigation time** (hours) is the time duration of every irrigation.
- **Water stream** (l/s) is the amount of water distributed to the field for any time unit.

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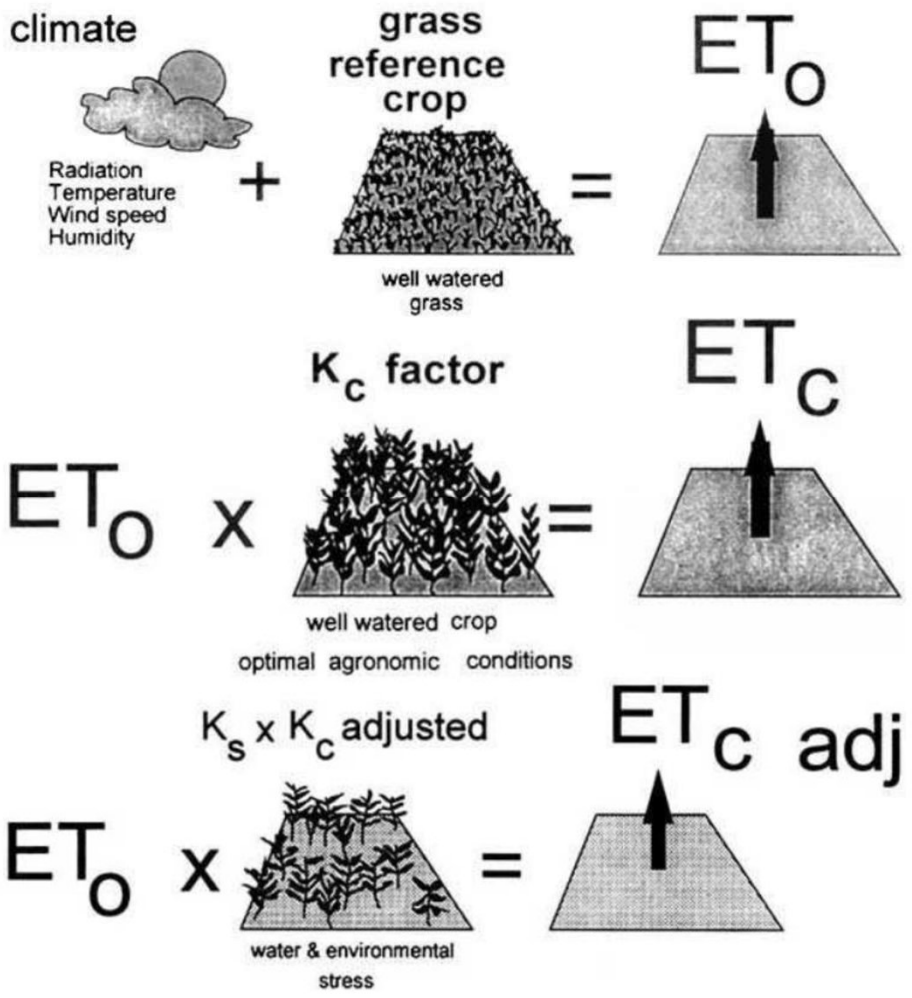
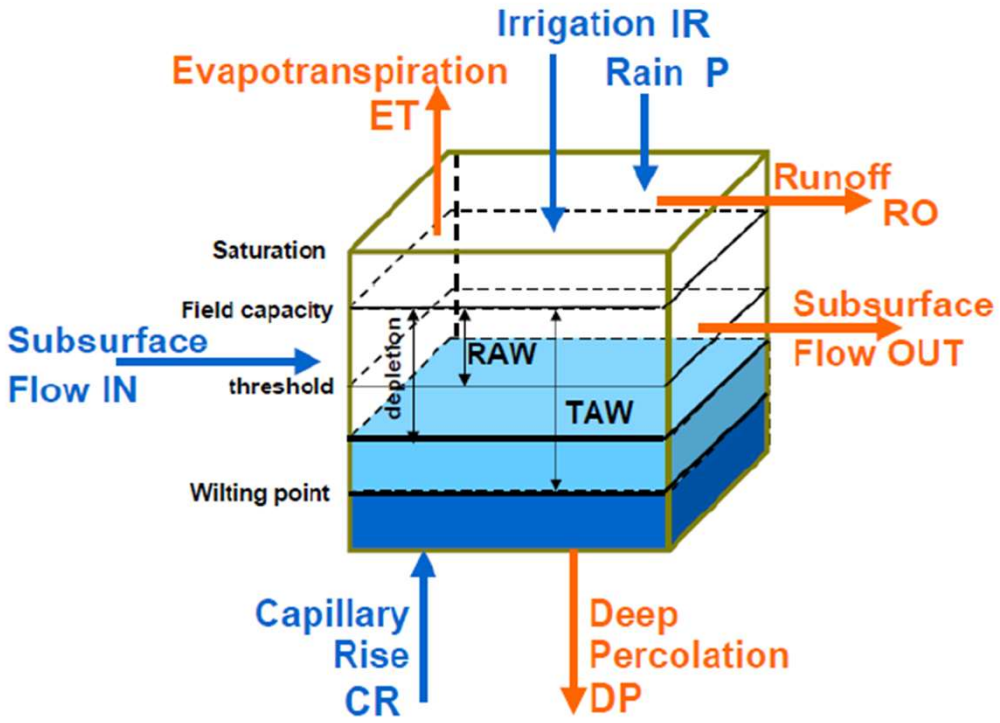
Potential and Actual Crop Evapotranspiration

- **ETo** reference evapotranspiration
- **Kc** crop coefficient
- **ETc** Crop evapotranspiration under standard conditions
- **Ks** The stress coefficient



Soil Water Balance



D_r Depletion

i Day index

$$D_{r,i} = D_{r,i-1} - (P - RO)_i - IR_i - CR_i + ET_{c,i} + DP_i$$

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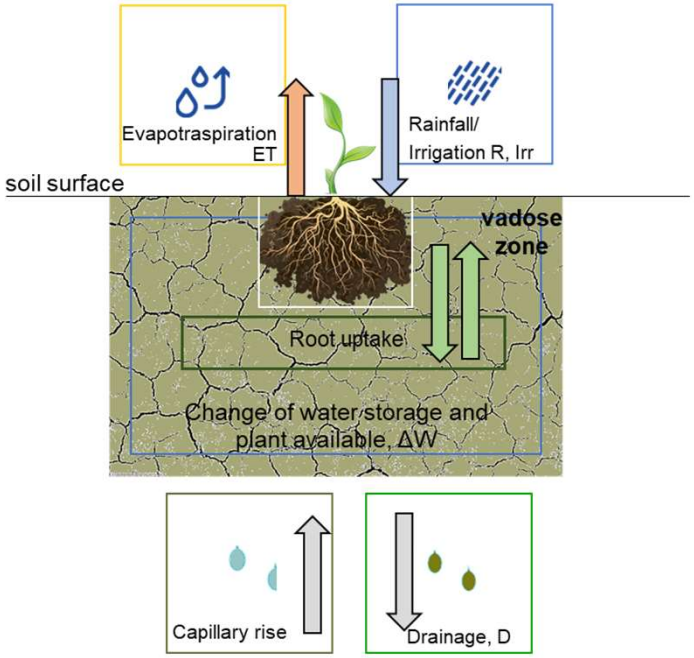
Soil Water Balance simplified



$$\Delta W = R + Irr - ET - D$$

Where R is the rainfall (mm), Irr, the irrigation volume (mm) and D drainage (mm), ET is the evapotranspiration (mm) and ΔW is the variation of water stored in the targeted soil zone (mm)

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Water availability in the soil

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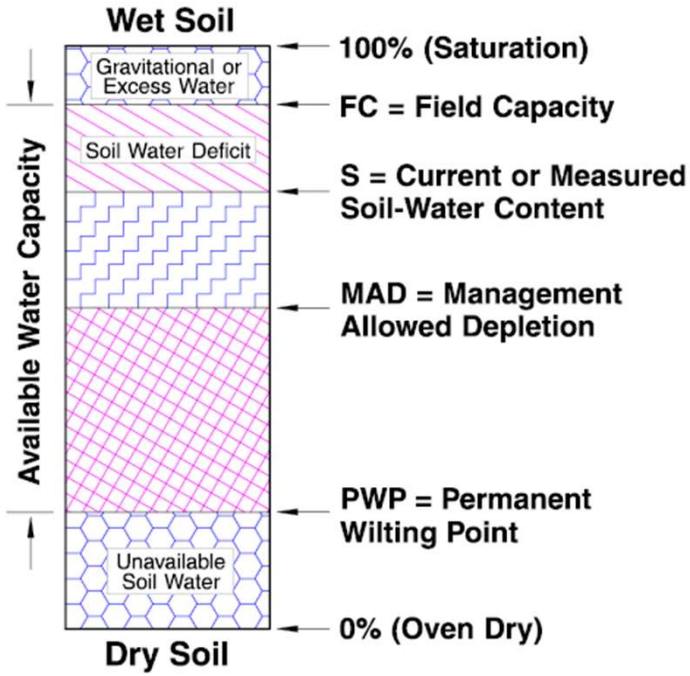
- **Field Capacity (θF)** is the maximum amount of water (measured in mm/m) that the soil can keep
- **Wilting Point (θWP)** is the amount of water (measured in mm/m) below which plants suffers a permanent water stress.
- **Available holding capacity (θA)** is the water (measured in mm/m) held in the soil between field capacity (θF) and the permanent Wilting Point (θWP).
- **Yield Threshold Depletion (YTD)** The water content where a crop is expected to start experiencing yield reducing water stress is called the yield threshold (YT) and the difference between FC and YT is called the yield threshold depletion and is often defined in terms of the Allowable Depletion (AD) which is the percentage of plant available water corresponding to the YTD.
- **Management Allowable Depletion (MAD)** is the soil water depletion value that is used to time irrigation events. The MAD is selected to fit with other management constraints, but it should always be smaller than the YTD to avoid yield reducing water stress



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Water availability in the soil

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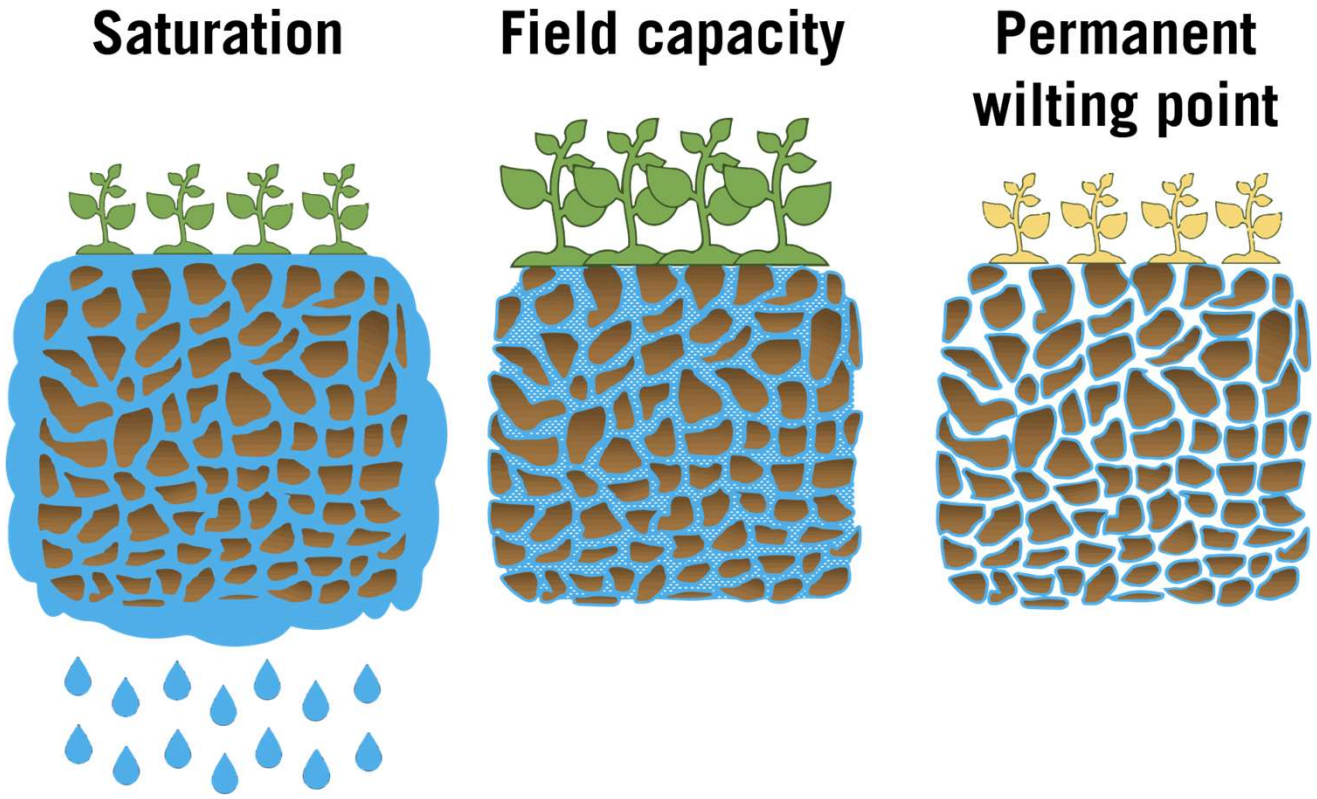

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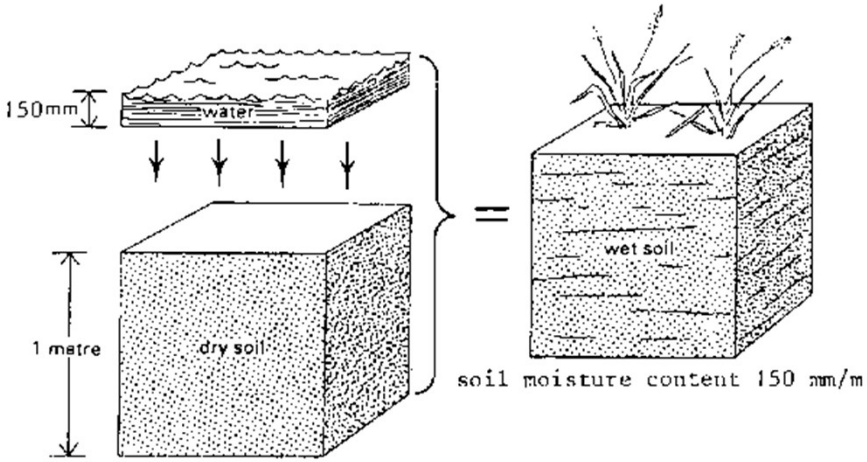
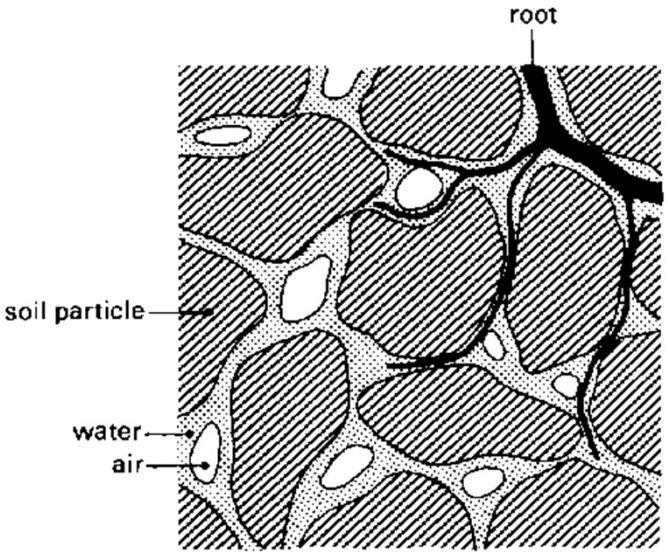
Soil water condition



How much water in the soil? (%)

Soil water content



In which holding tension? (kPa)

Soil water potential

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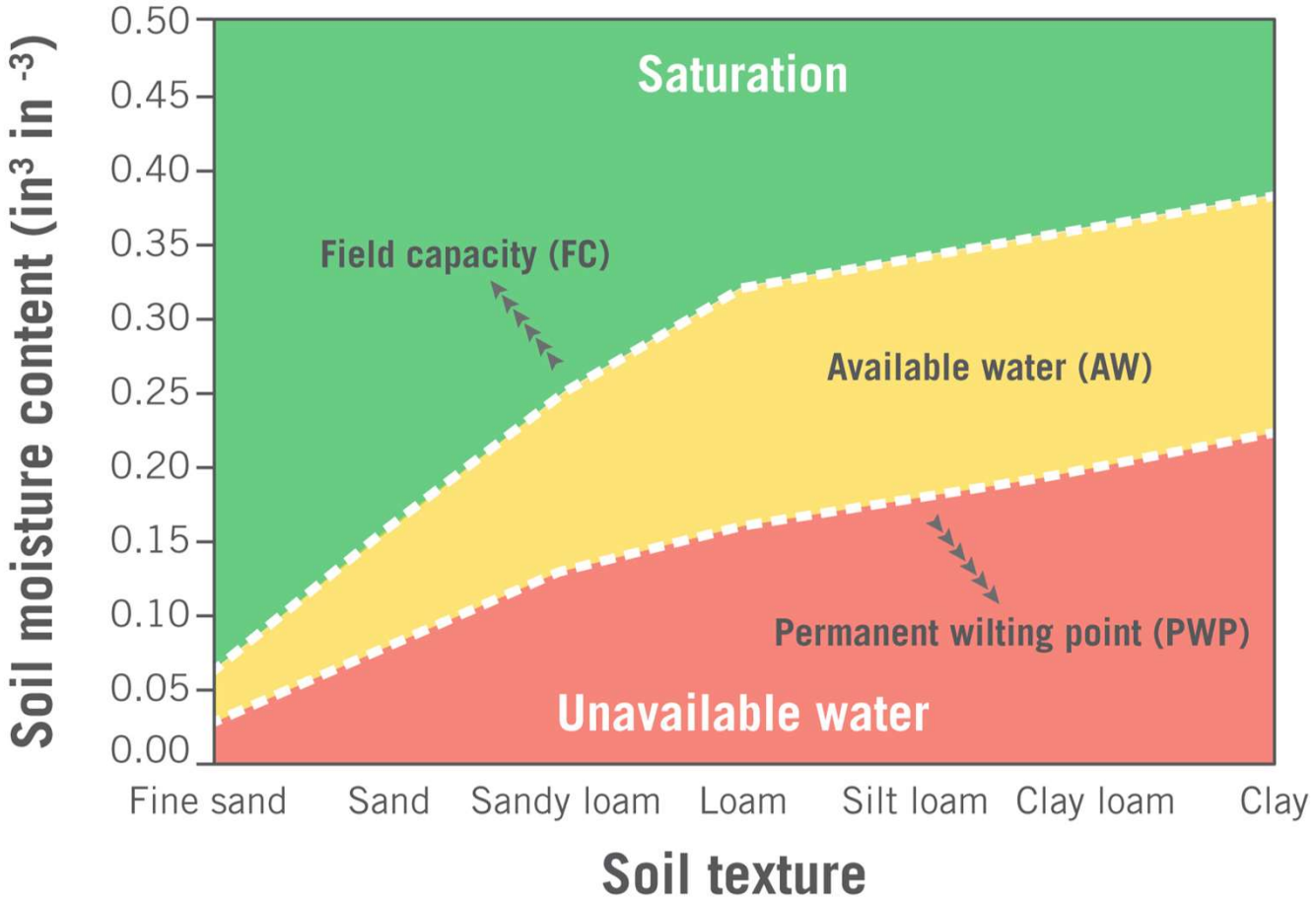
Soil Water capacity and soil texture



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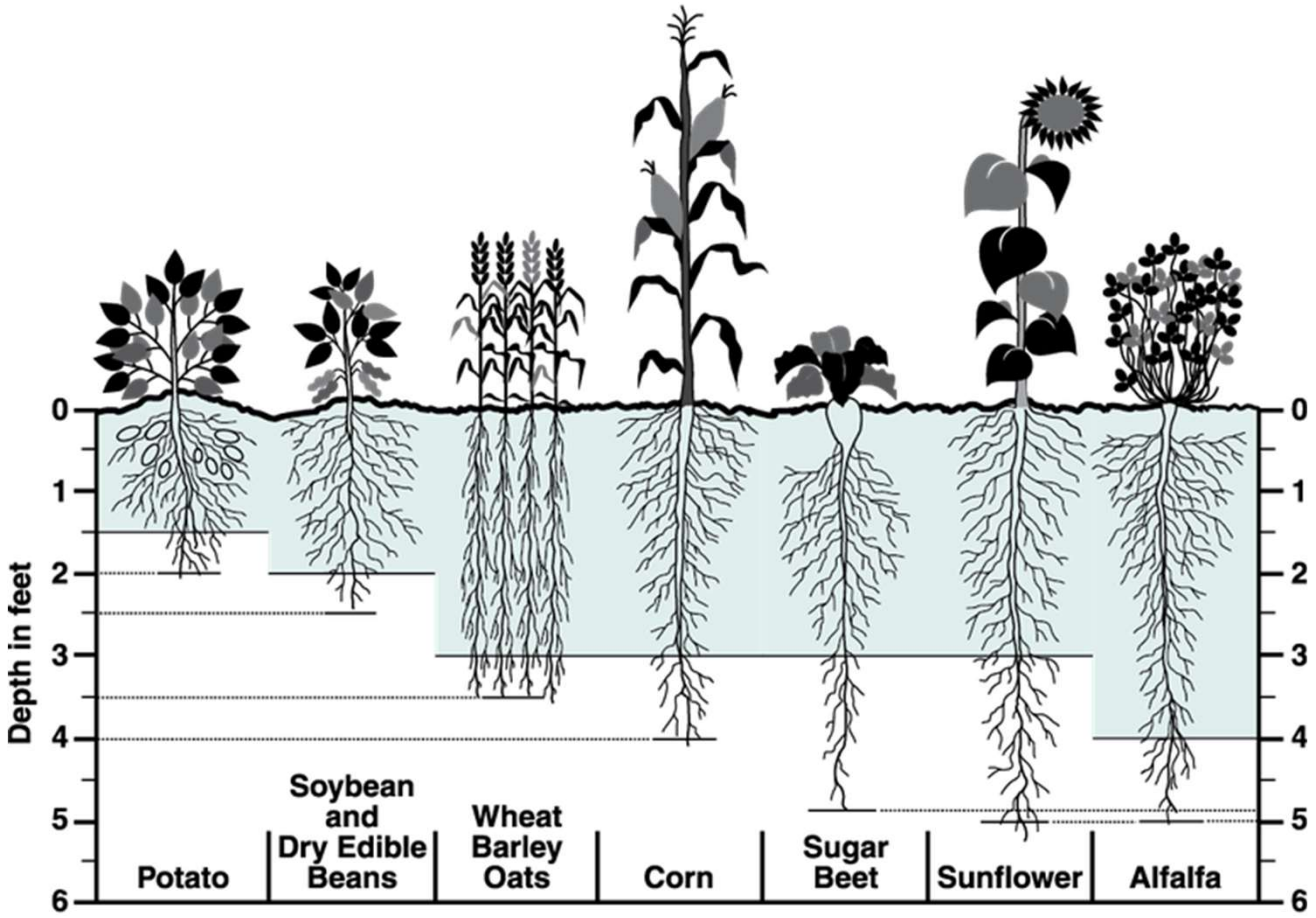
The Root zone



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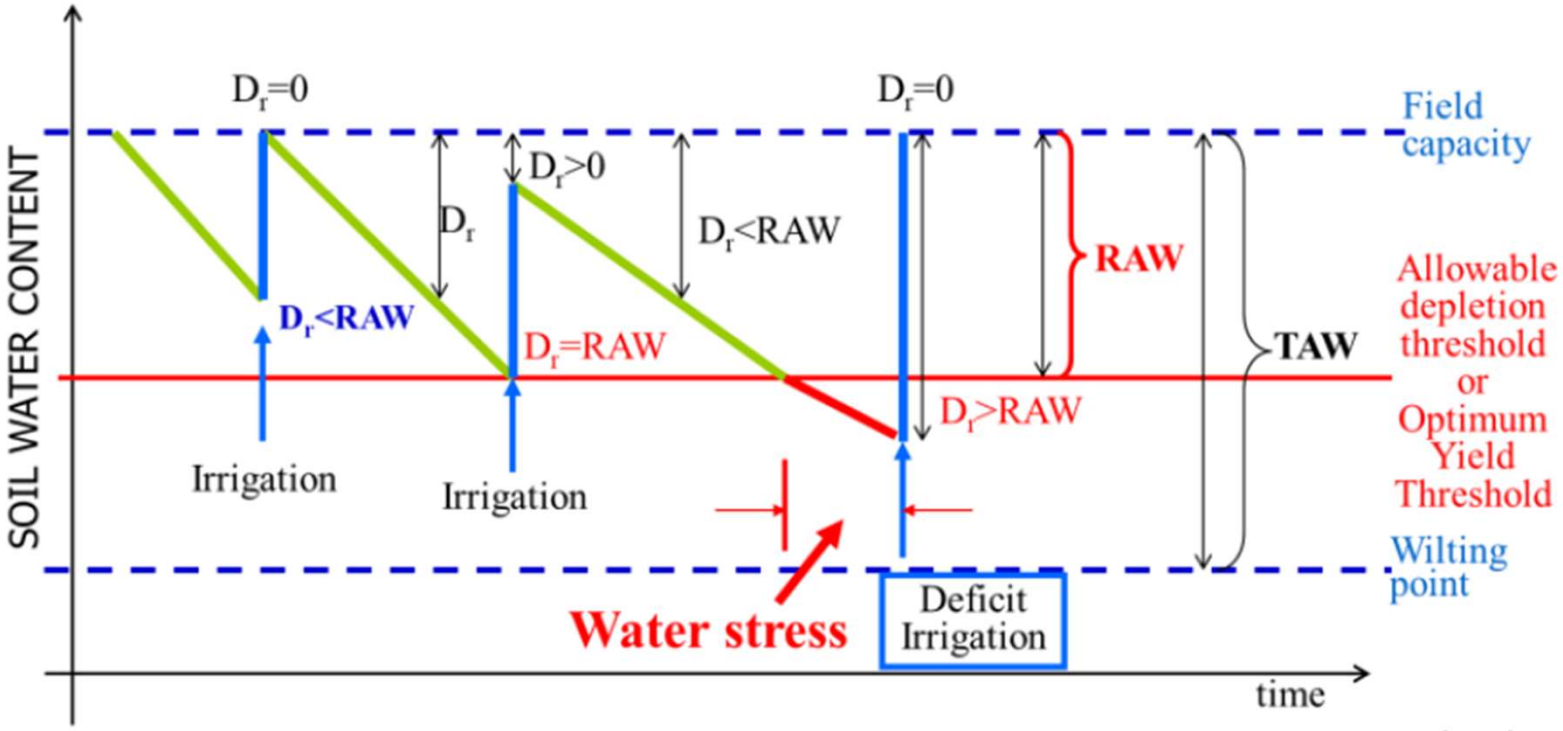
Irrigation scheduling



Question

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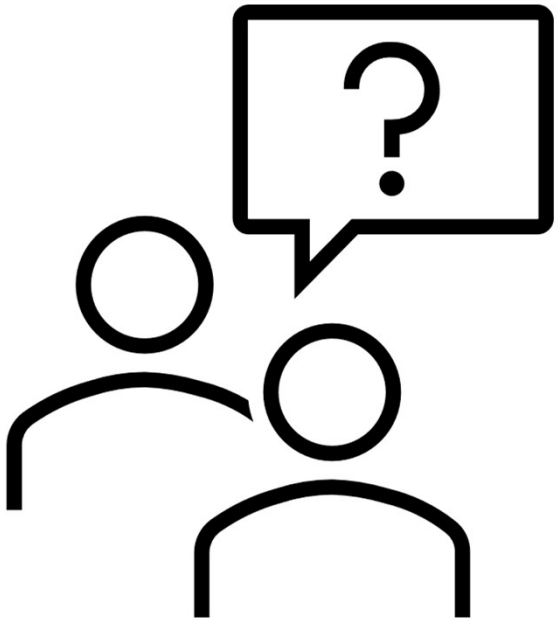
So, what is irrigation efficiency?



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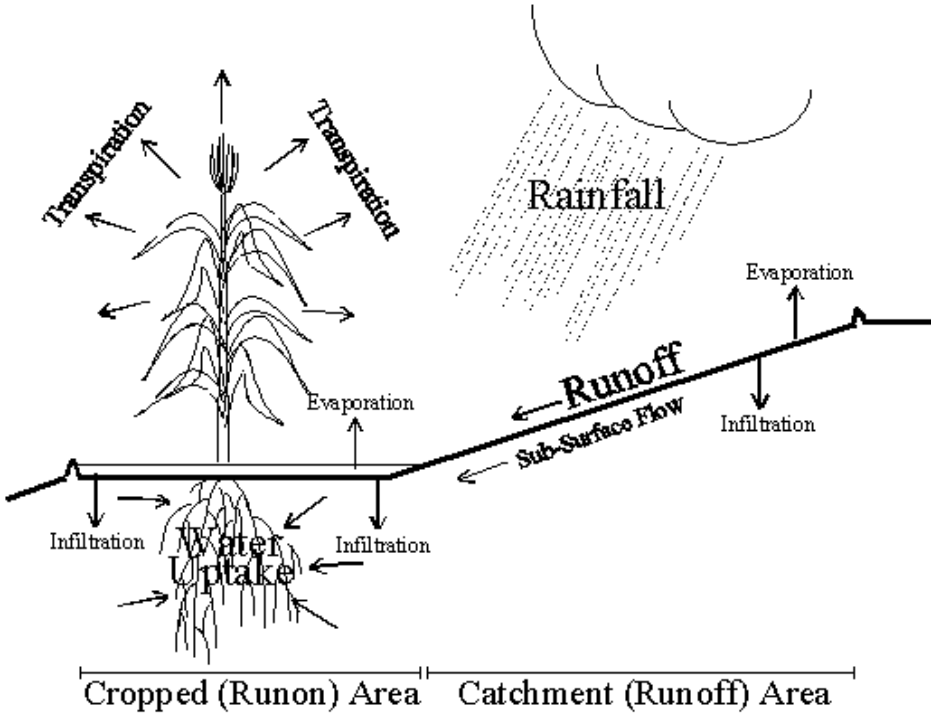
Irrigation efficiency



- **Application efficiency (AE)**

is a measure of how much of the water applied contributes to Crop Evapotranspiration Etc

- **Distribution Uniformity (DU)**

is a measure of how evenly water soaks in the field

For a well-drained field, if there is no runoff and if the Gross Application (GA) is equal to NA divided by the DU then AE is ± equal to the DU. The goals in good irrigation management are to apply and maintain the system with the highest DU possible.

PAST & CURRENT STRATEGY: The Supply Management

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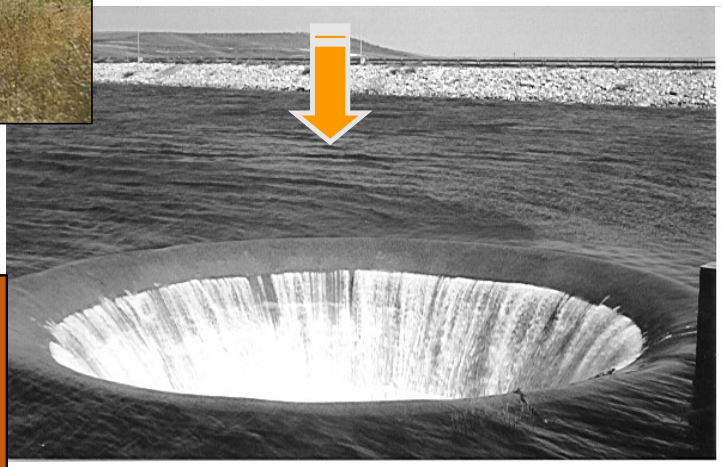
Most of national strategies in the water domain were and are still largely dominated by investments and efforts to increase water storage and conveyance by building large infrastructures & waterworks.



NOT ENOUGH ATTENTION IS GIVEN TO THE LARGE POTENTIAL FOR SAVING WATER AT DIFFERENT SCALES

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The PRESENT strategies by International Development Agencies & Donors suggests the alternative path of achieving greater efficiency in water management

This highlights the importance of improved Operation, Maintenance and Management activities (**WATER DEMAND MANAGEMENT**)

Viable approaches for more sustainable water management

Technical approaches

- Improving WUE along the whole chain of the system (minimizing losses)
- Application of Innovative Technologies
- Training & Capacity-building

Non-technical approaches

- IMT => PIM => SOM
- Transparent Tarification rules
- Enhancement of institutional organizations (modernization)

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The broader view: Efficiency Chain

$$\frac{W_{reservoir\ out}}{W_{reservoir\ in}} \times \frac{W_{farm\ gate}}{W_{reservoir\ out}} \times \frac{W_{field}}{W_{farm\ gate}} \times \frac{W_{root\ zone}}{W_{field}} = \frac{W_{root\ zone}}{W_{reservoir\ in}}$$

Storage efficiency	Conveyance efficiency	Farm efficiency	Application efficiency	Overall efficiency
0.90	x 0.85	x 0.72	x 0.75	= 0.413!!

Although the efficiency of each step is reasonably good, the overall efficiency is low
The efficiency effects are multiplicative, not just additive It follows that minor improvements in several efficiency steps would raise overall efficiency substantially

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Efficiency Chain

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improvement in each step

$$0.90 \quad x \quad 0.88 \quad x \quad 0.86 \quad x \quad 0.89 \quad = \quad 0.610!!$$

Much improvement





$$\frac{W_{reservoir\ out}}{W_{reservoir\ in}} \times \frac{W_{farm\ gate}}{W_{reservoir\ out}} \times \frac{W_{field}}{W_{farm\ gate}} \times \frac{W_{root\ zone}}{W_{field}} = \frac{W_{root\ zone}}{W_{reservoir\ in}}$$

Storage efficiency	Conveyance efficiency	Farm efficiency	Application efficiency	Overall efficiency

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PROBLEMS in the project area:

Food and income insecurity

inappropriate irrigation techniques

scarce water resources

high salt content of irrigation water

2003

2006

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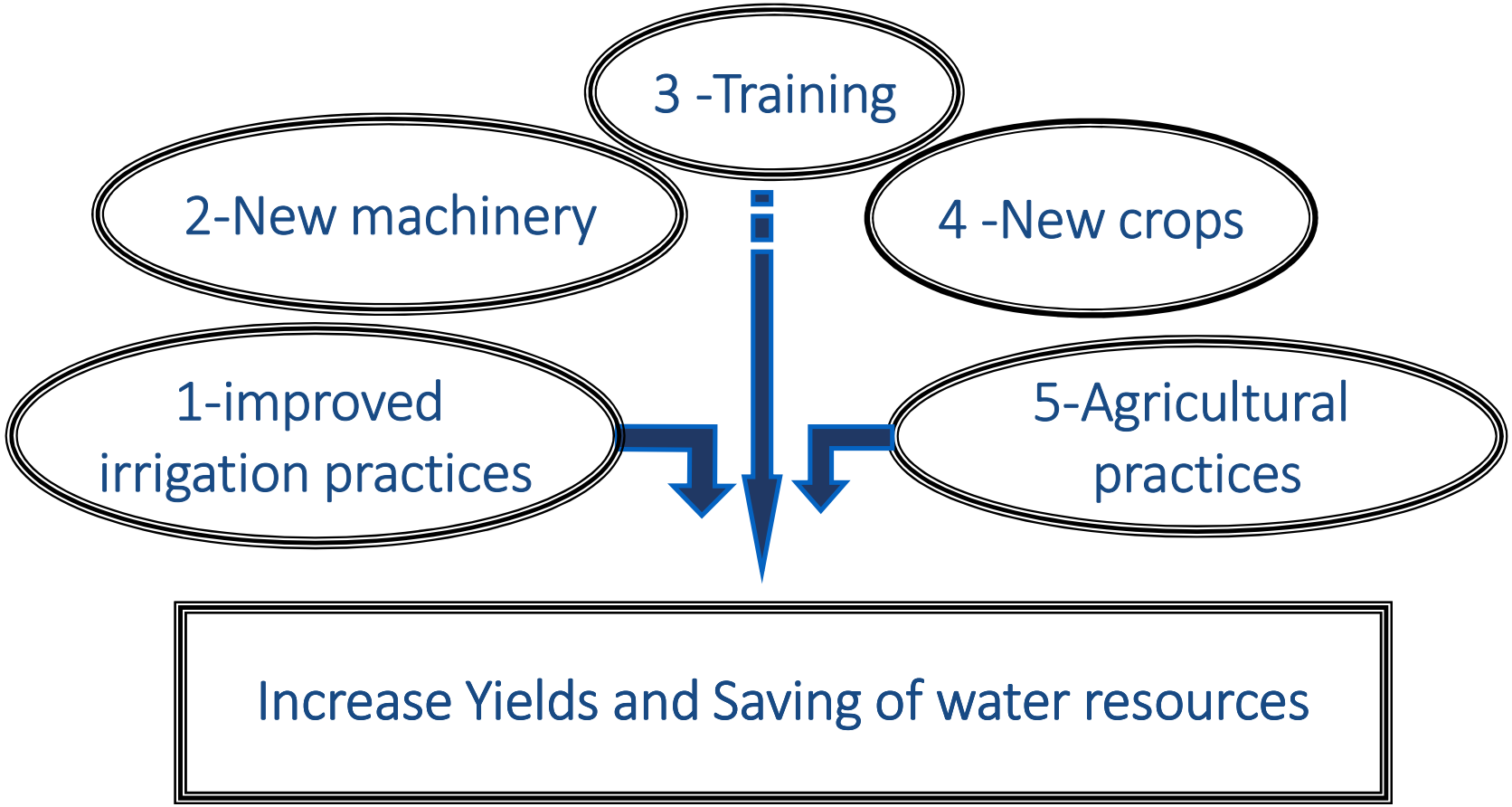

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90 % RELATIVE PRESSURE DEFICIT

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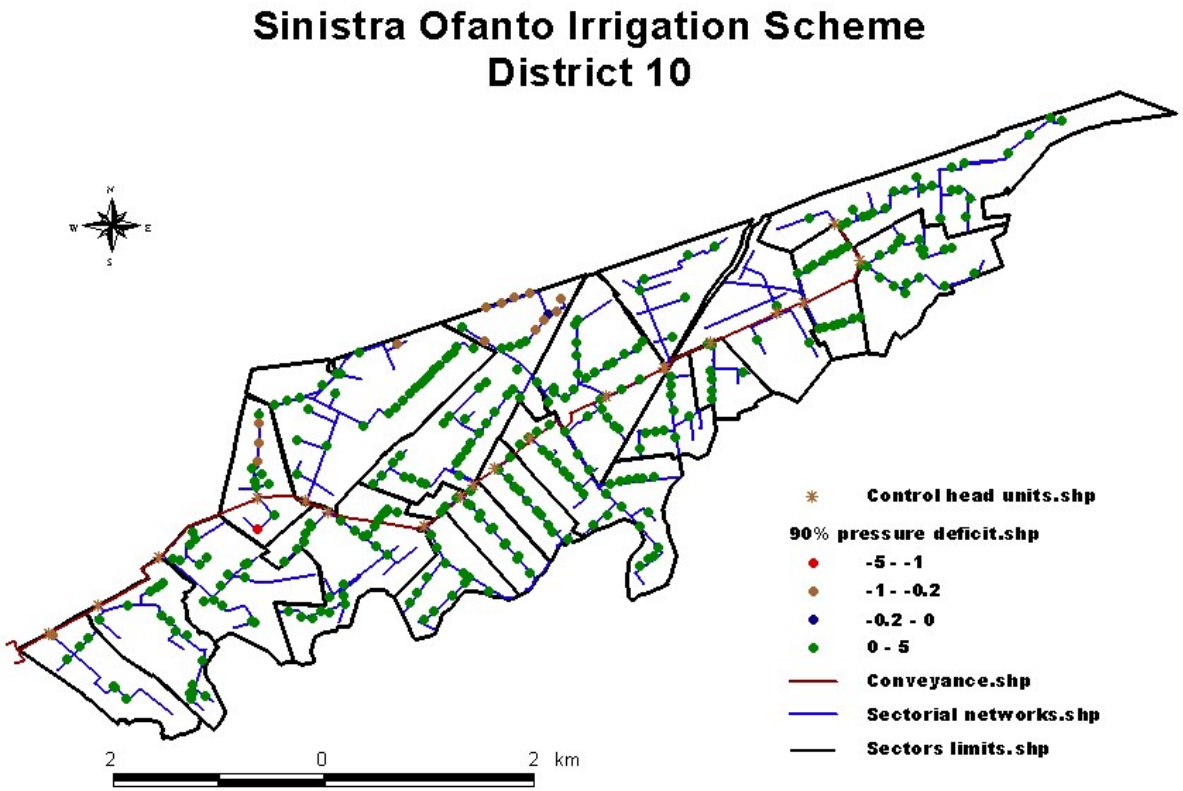

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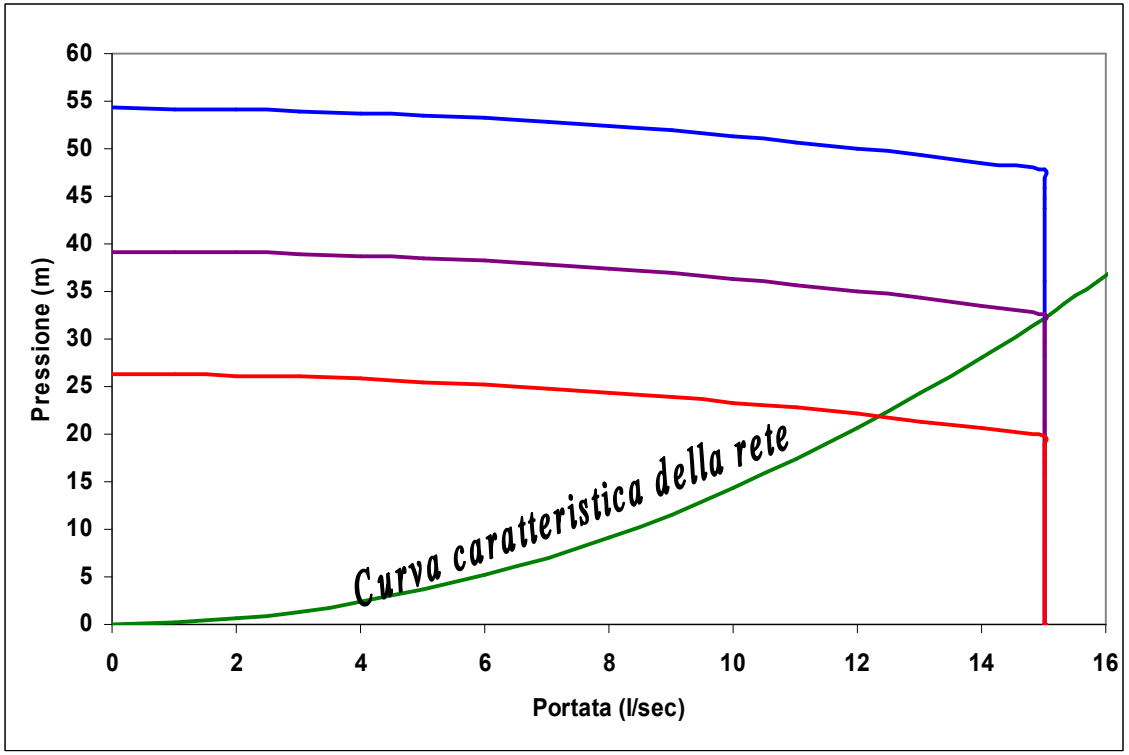
Working parameters of the on-farm network



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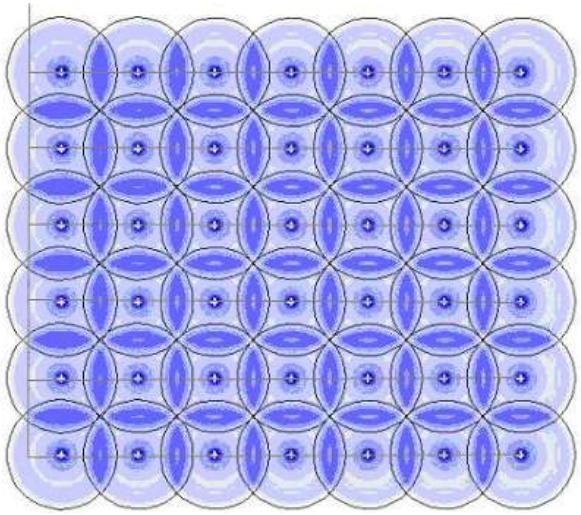
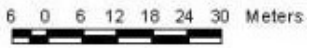
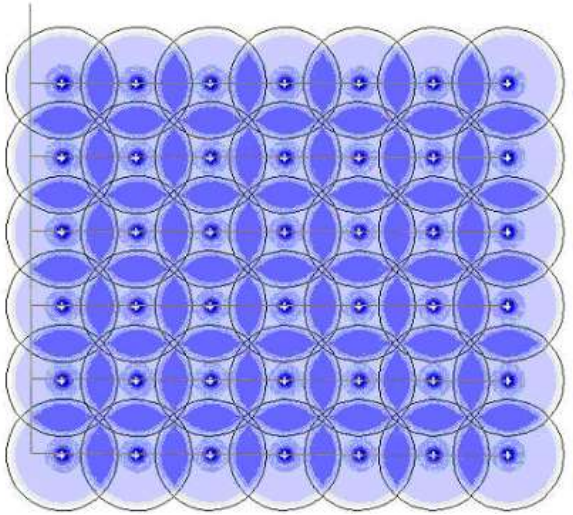


H = 21 m
CU = 63%
DU = 67%
DE_{90} = 60%
Dn_{90} = 3mm/h





H = 33 m
CU = 74%
DU = 80%
DE_{90} = 80%
Dn_{90} = 4.5mm/h

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SIMPLE CALCULATION

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CASE 1:

$E_{G,1} = 0.95 \times 0.60 = 0.57$

CASE 2:

$E_{G,2} = 0.95 \times 0.80 = 0.76$

$$DE = (0.76 - 0.57)/0.57 = 0.33 = +33\%$$

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Question

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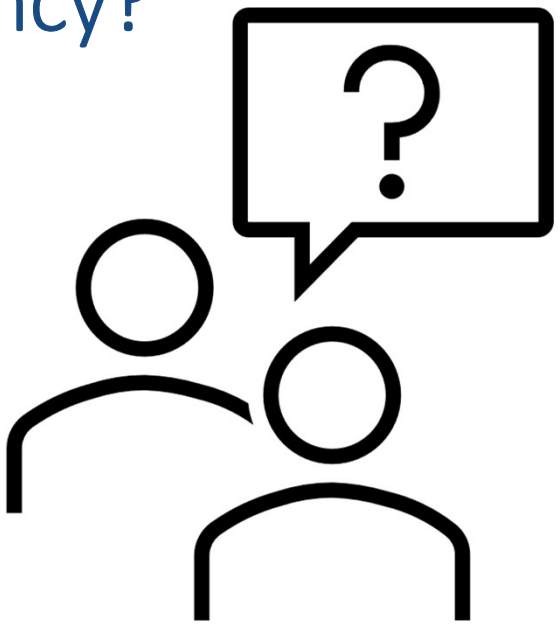
So now, what is irrigation efficiency?



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Irrigation Demand and Water Accounting

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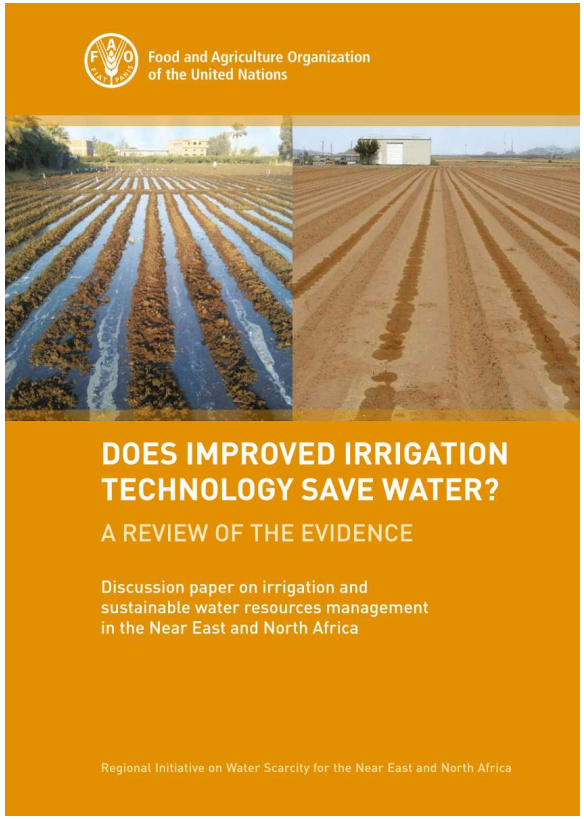
- Consumptive use
  - Beneficial consumption
  - Non-Beneficial consumption
- Non - Consumptive use
  - Recoverable flows
  - Non-Recoverable flows

Water accounting terms allow a clearer definition of the issues and options we face in irrigated agriculture. **50%** water savings through better technology invariably refer to **a narrow "local"** perspective of water applied to the field, failing to account for return flows that recharge aquifers or contribute to downstream river flows.

- What about the environmental services of excess water?
- What about energy consumption and carbon footprint?
- Which nutrients are produced from the irrigated crop?
- Should we include the water quality in the definition of efficiency?



https://www.fao.org/3/I7090EN/i7090en.pdf

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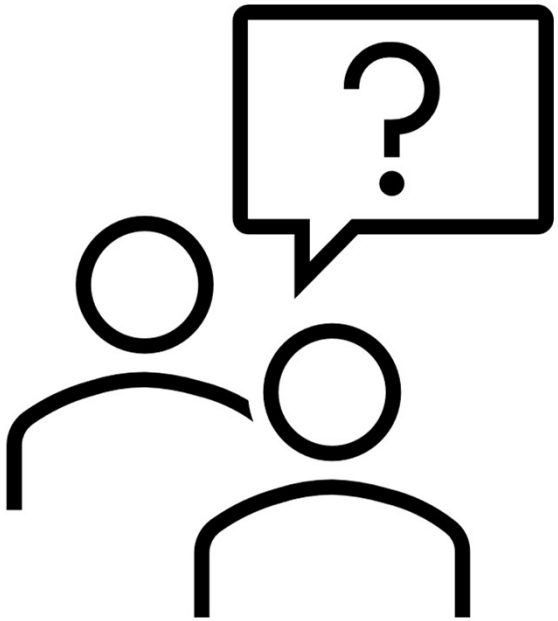
Question

Again, what is irrigation efficiency?



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Conclusion

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- We need to consider a holistic approach when designing and estimating the performance of on farm irrigation systems. It is a link in a chain. consideration: location, context, scale, objectives, …..etc. A generic or narrow definition will be misleading.

- A quantitative water accounting system could be an important step towards better understanding of physical water balance at large scale.

But How?

We will discuss that in our next session:
Innovative solutions towards enhanced on-farm management

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SALVADOR DALI
Persistence of Memory

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