IWMI International Water Management Institute

CGIAR

Water Accounting +:

WA + Fundamental Concepts - I (ET, Energy balance, Consumptive vrs non-consumptive and E, I, & T)

October 27, 2022 - Session II

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Objective

At the end of the 2 days, you will be able to

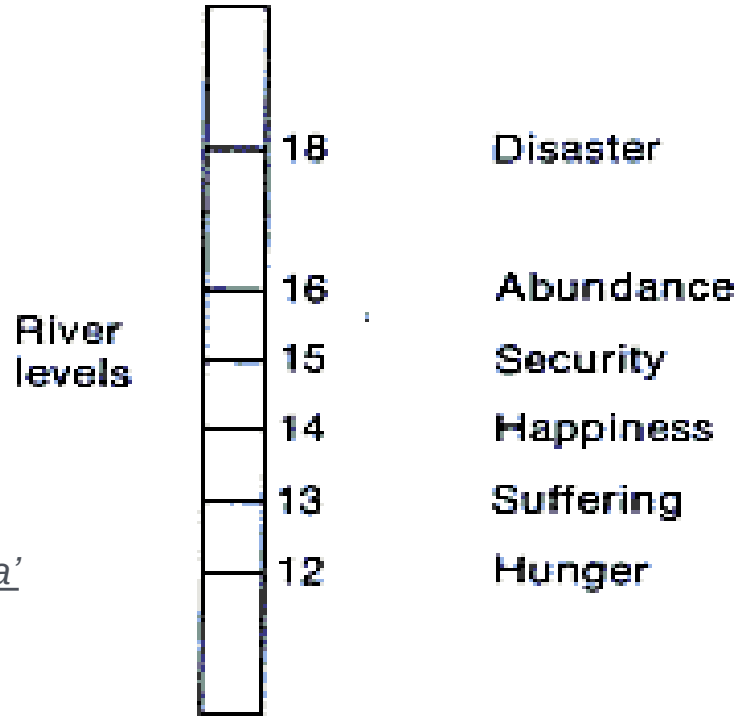
- **Explain the basic concepts of water accounting and WA+**
- Prepare spatial datasets for conducting water accounting assessment using python scripting
- Run WA+ model for a basin (Souss Massa basin)
- Understand and create resource base sheet for the Souss Massa basin
- Visualize and evaluate the results of the vertical water balance

Why is water accounting important?

- Established relationship between water availability - food security - livelihood

Pliny-the-elder, who wrote 'Naturalis Historia' in 23 AD came up with this classification

Pliny-the-elder's classification of river stages



Eagleson (1994)- Advances in Water Resources

Why is water accounting important?

⟩ Measuring water is one of the oldest fields of science

Nilometer, Egypt
Built in 715 AD.

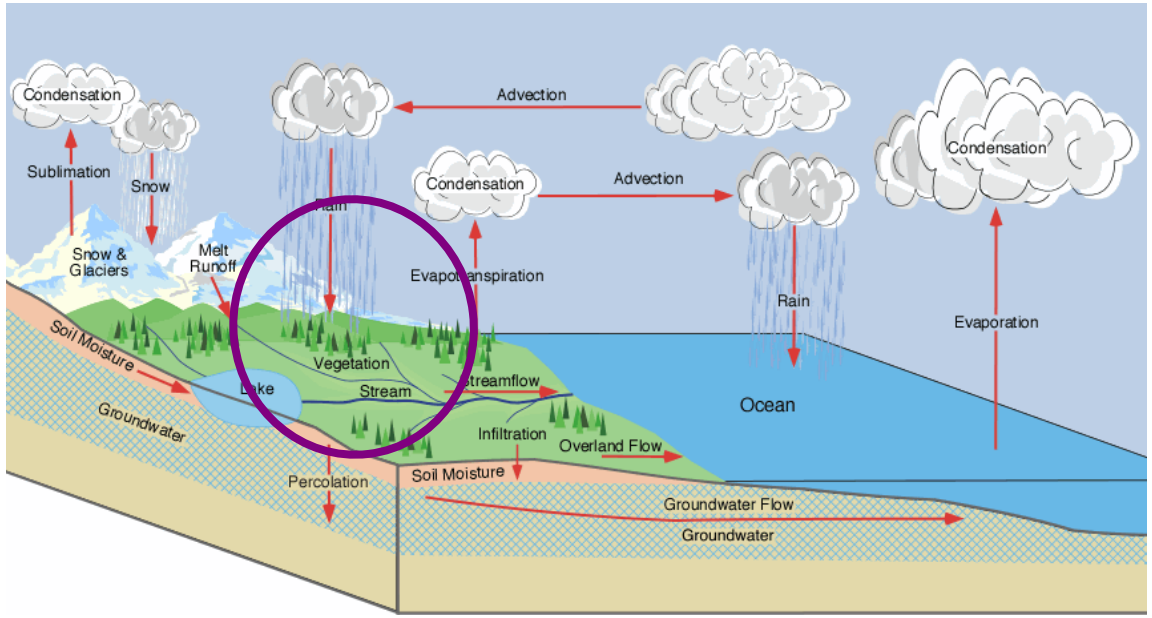
WA Fundamental concepts

1. Evapotranspiration
2. Energy balance
3. Consumptive water use
4. Beneficial and non-benificial water use
5. Separation of ET into E, I and T

WA focuses on Consumptive use

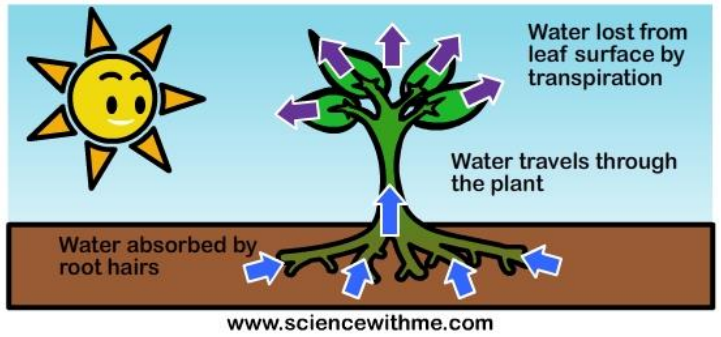
- Classical hydrological research is typically based on rainfall and streamflow measurements and quantification of ET processes is not give much attention.
  - Actual ET has a major impact on streamflow
  - Actual ET is a key component of the water balance, but cannot be measured easily using in situ devices.

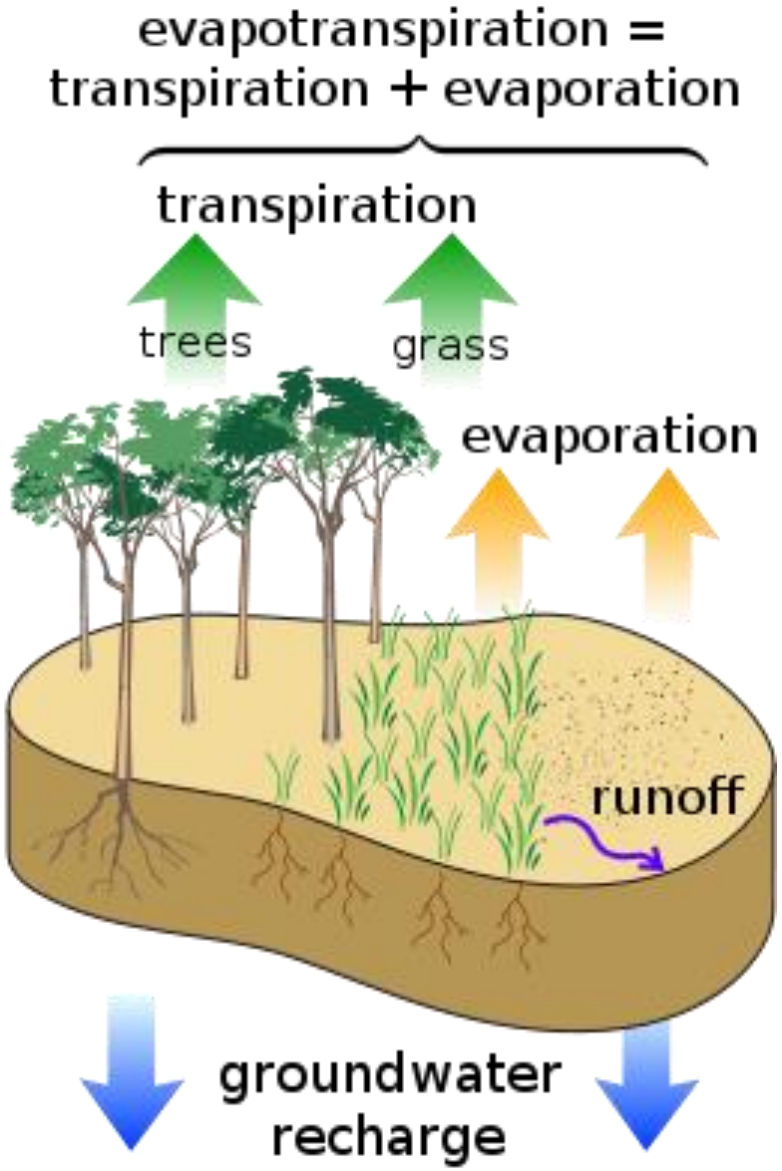
Evapotranspiration in WA+



Challenge with ET:

1) Gaseous state
2) Invisible
3) Only indirect measurement





Evapotranspiration in WA+

- It is a **RESPONSE** variable as opposed to precipitation (driver)
- It reflects the integrated effects of Energy/Aerodynamics, Soil Moisture, Vegetation and Environmental Stress

Potential

Energy

Wind/RH

Limitations

Moisture

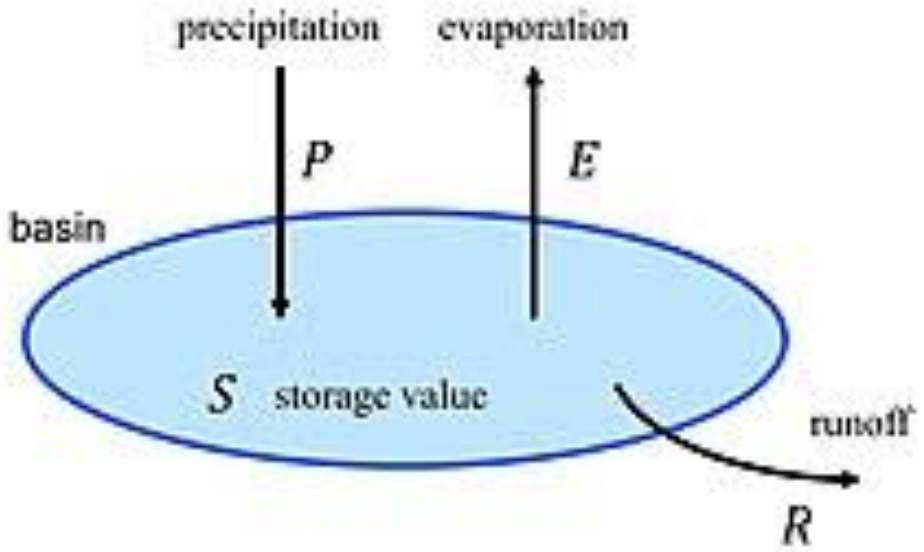
Vegetation

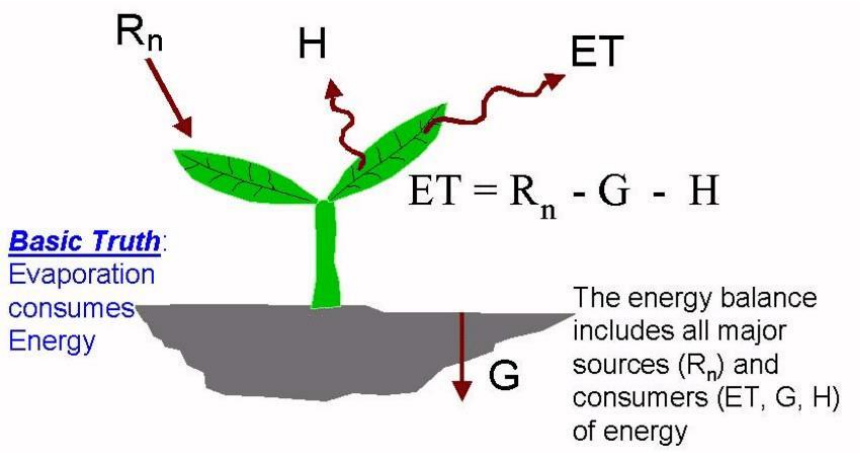
Env. Stress

Evapotranspiration in WA+

Two principles for ET estimation

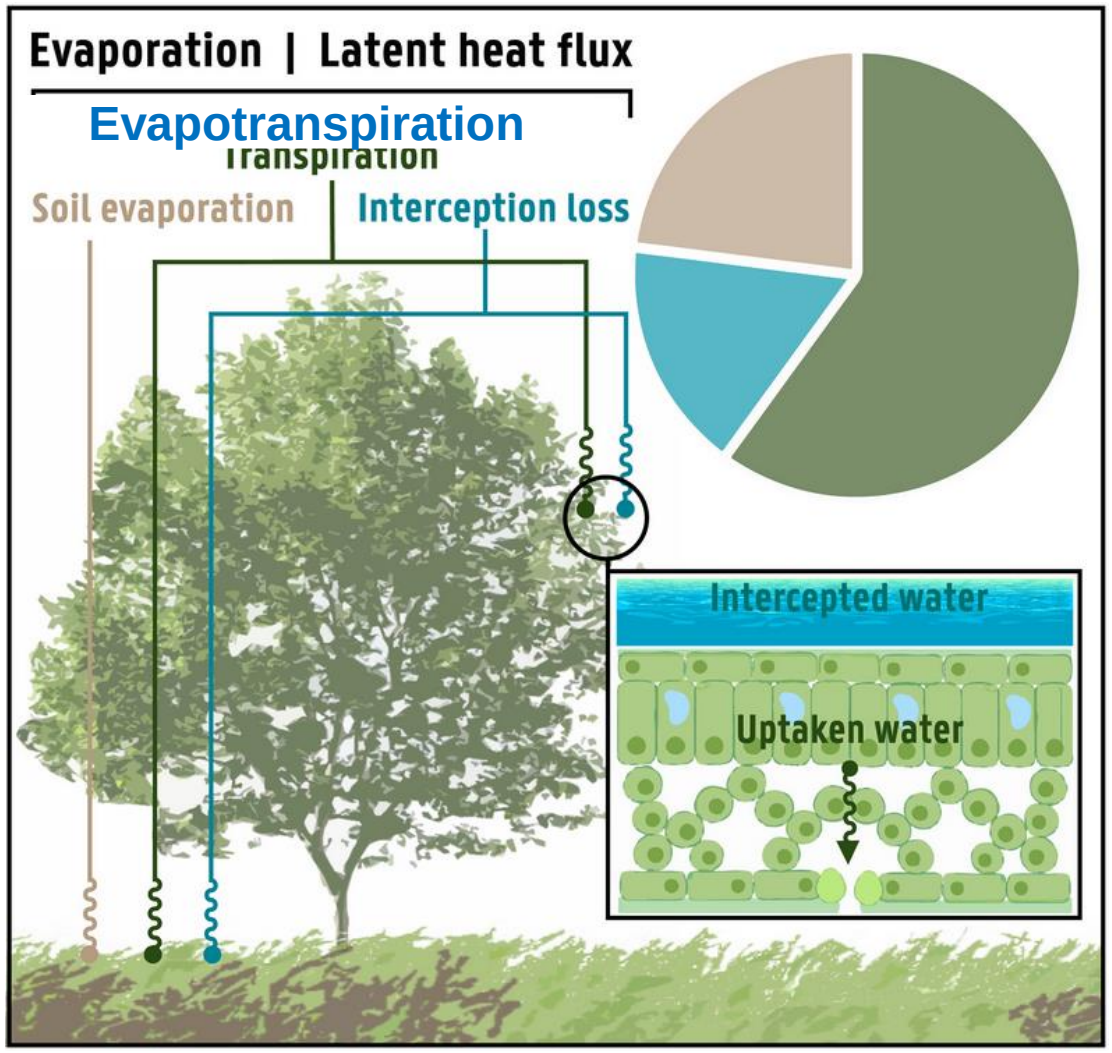
- Water Balance
  - driven by precipitation accounting
- Energy Balance
  - driven by Land Surface Temperature (LST





WA+ uses ET data produced using energy balance approach

Partitioning Evapotranspiration



$$ET = I + E + T$$

Source: Miralles et al., 2020

Partitioning Evapotranspiration

Estimating Interception losses

$$I_m = \left(1 - \frac{1}{1 + \frac{P_m}{n_m} * (1 - exp^{-0.5 * LAI_m}) * \frac{1}{LAI_m}}\right) * LAI_m * n_m$$

I = Interception [mm/month], P = precipitation [mm/month]

n = number of rainy days [days/month], LAI = Leaf Area Index , m= month

veg cover

Source: Miralles et al., 2020

Partitioning Evapotranspiration

Estimating Transpiration based on NDM, ET and I

$$T_m = min \begin{cases} 0.95 * (ET_m - I_m) \\ \frac{NDM_m}{NDM_{max,m}} * 0.95 * (ET_m - I_m) \end{cases}$$

T = transpiration [mm/month]

NDM = Net Dry Matter [kg/ha/month]

NDM_{max} = maximum ,monthly averaged Net Dry Matter pixel value [kg/ha/month]

i, j is row, column

$$NDM_{max,m} = max(\overline{NDM}_{m,1,1}, \dots, \overline{NDM}_{m,i,j})$$

Dry matter Productivity (DMP) represents the overall growth rate or dry biomass increase of the vegetation

Source: Miralles et al., 2020

Partitioning Evapotranspiration

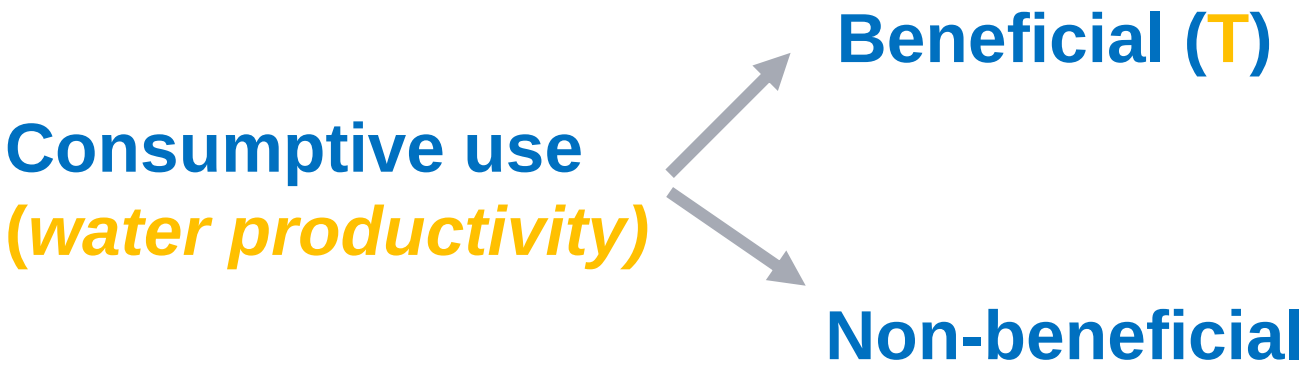
Calculate Evaporation (E)

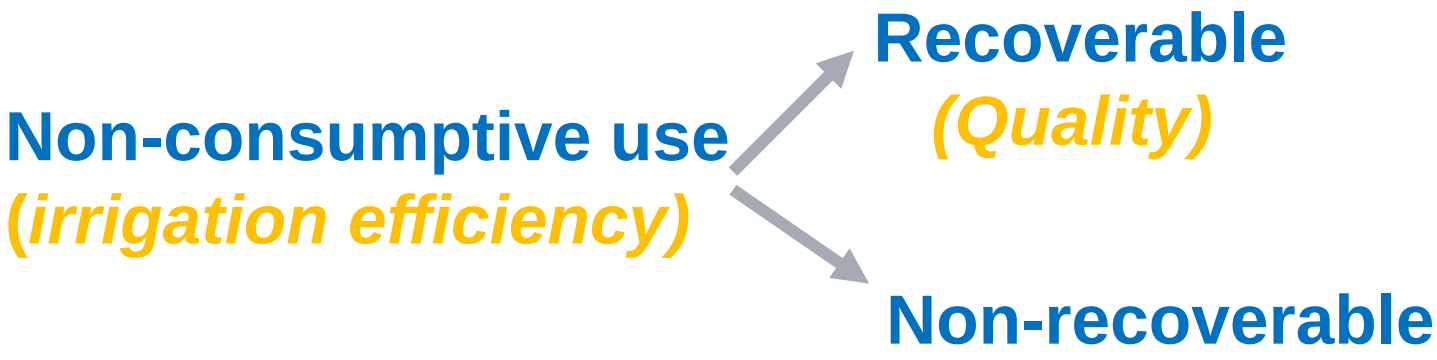
$$E_m = ET_m - T_m - I_m$$

E = Evaporation (mm/month)

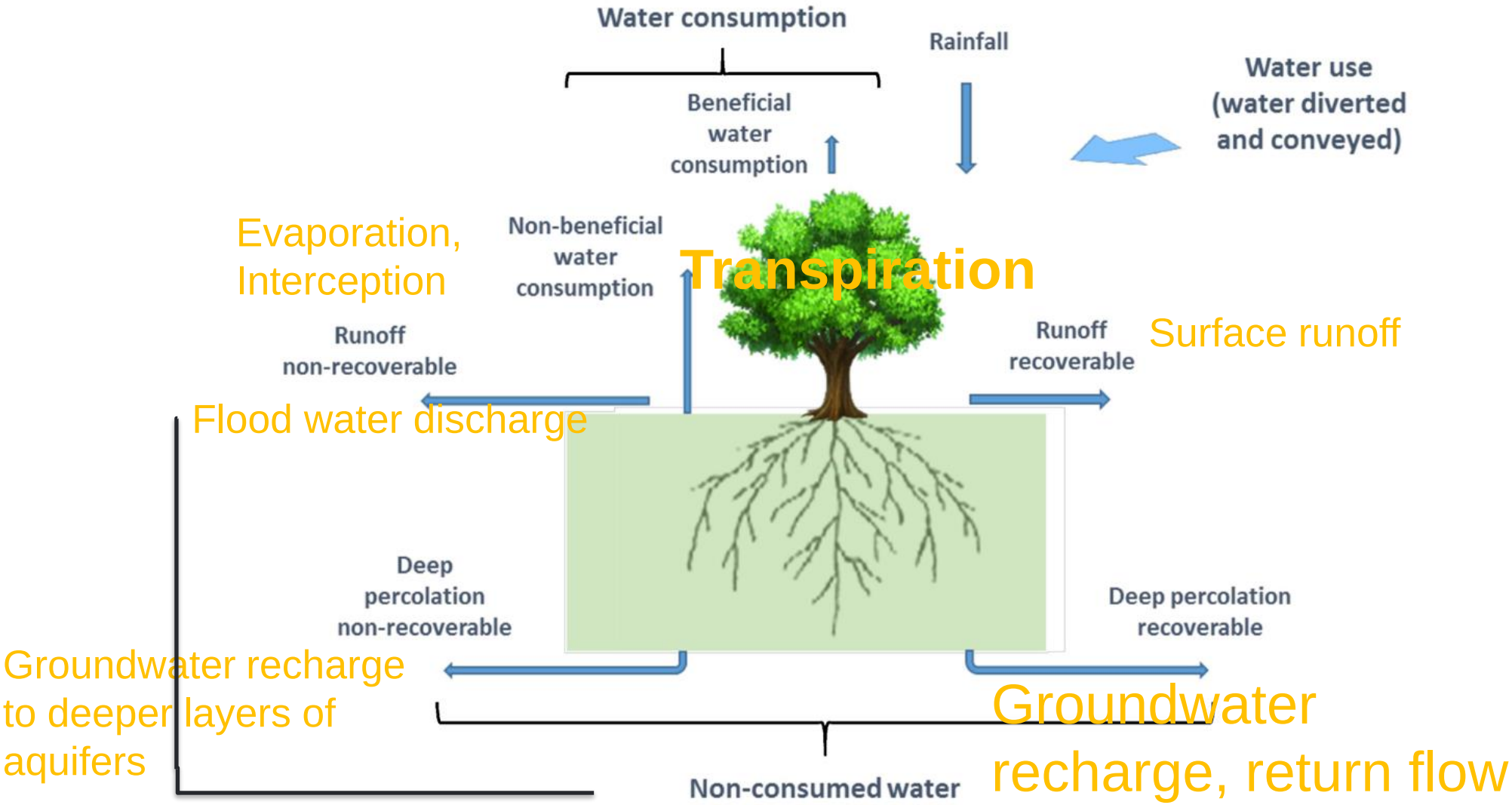
Source: Miralles et al., 2020

Water Accounting Fundamental Concepts



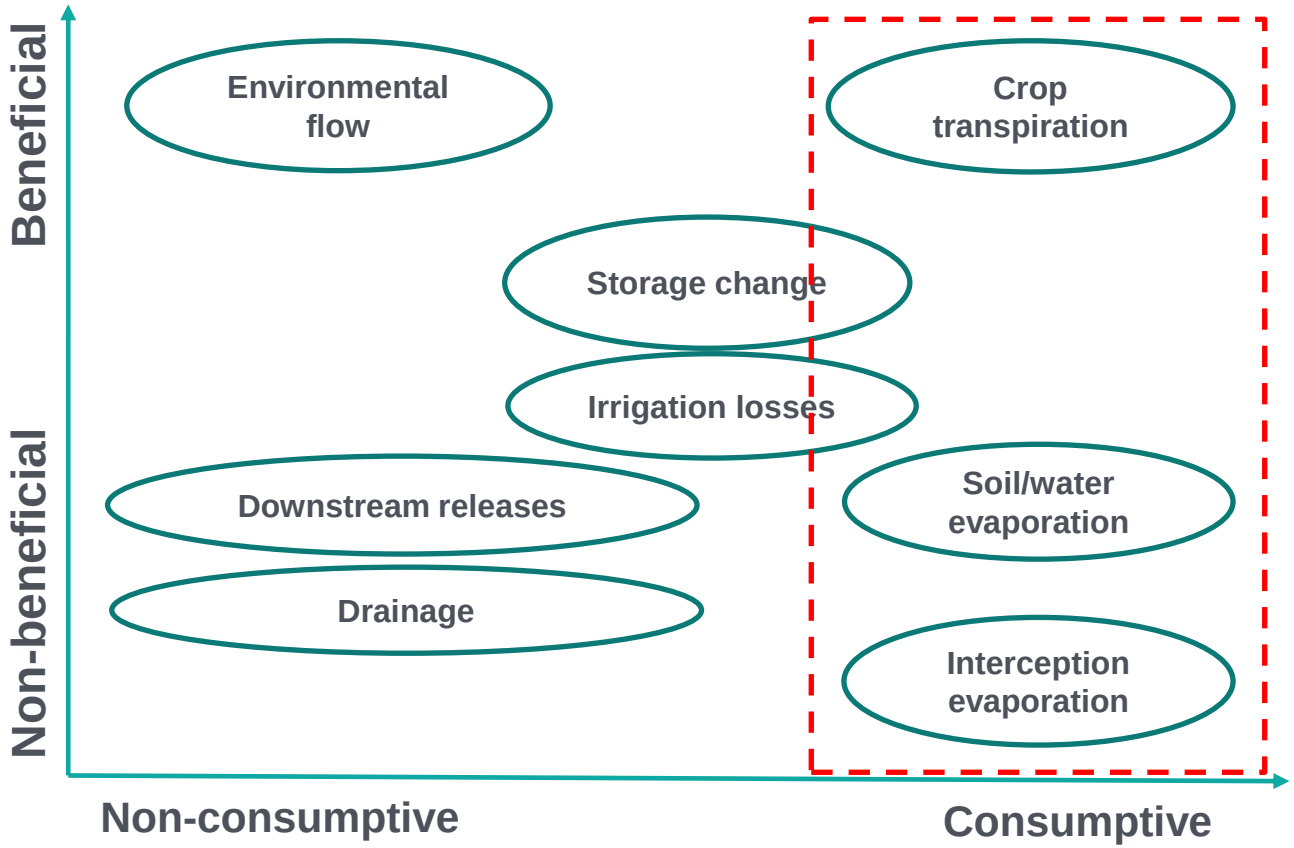


Consumptive vs. non-consumptive water use



Source: Jovanovic et al., 2020

Consumptive vs. non-consumptive water use



EXERCISE:
Separation of ET into E, I, T

https://github.com/iwmiwaplus/WA_Souss_Massa_Training/

Exercise: Partition of ET into E, I, T

Objective:

- To partition ET into Interception, Transpiration and Evaporation components.

Instructions:

- Use the data provided in the excel

- **Step 1:** Compute Veg. cover for January using LAI

$$(1 - exp^{-0.5 * LAI_m})$$

Exercise: Partition of ET into E, I, T

Objective:

- To partition ET into Interception, Transpiration and Evaporation components.

❑**Instructions:**

- **Step 2:** Compute Interception for January using equation:

$$I_m = \left(1 - \frac{1}{1 + \frac{P_m}{n_m} * (1 - exp^{-0.5 * LAI_m}) * \frac{1}{LAI_m}}\right) * LAI_m * n_m$$

Exercise: Partition of ET into E, I, T

Objective:

- To partition ET into Interception, Transpiration and Evaporation components.

Instructions:

- Use the data provided in the excel
- **Step 3:** Compute Transpiration for January

$$T_m = min\begin{cases} 0.95 * (ET_m - I_m) \\ \frac{NDM_m}{NDM_{max,m}} * 0.95 * (ET_m - I_m) \end{cases}$$

Exercise: Partition of ET into E, I, T

Objective:

- To partition ET into Interception, Transpiration and Evaporation components.

Instructions:

- Use the data provided in the excel
- **Step 4:** Compute Evaporation for January

$$E_m = ET_m - T_m - I_m$$

Exercise: Partition of ET into E, I, T

Objective:

- To partition ET into Interception, Transpiration and Evaporation components.

Instructions:

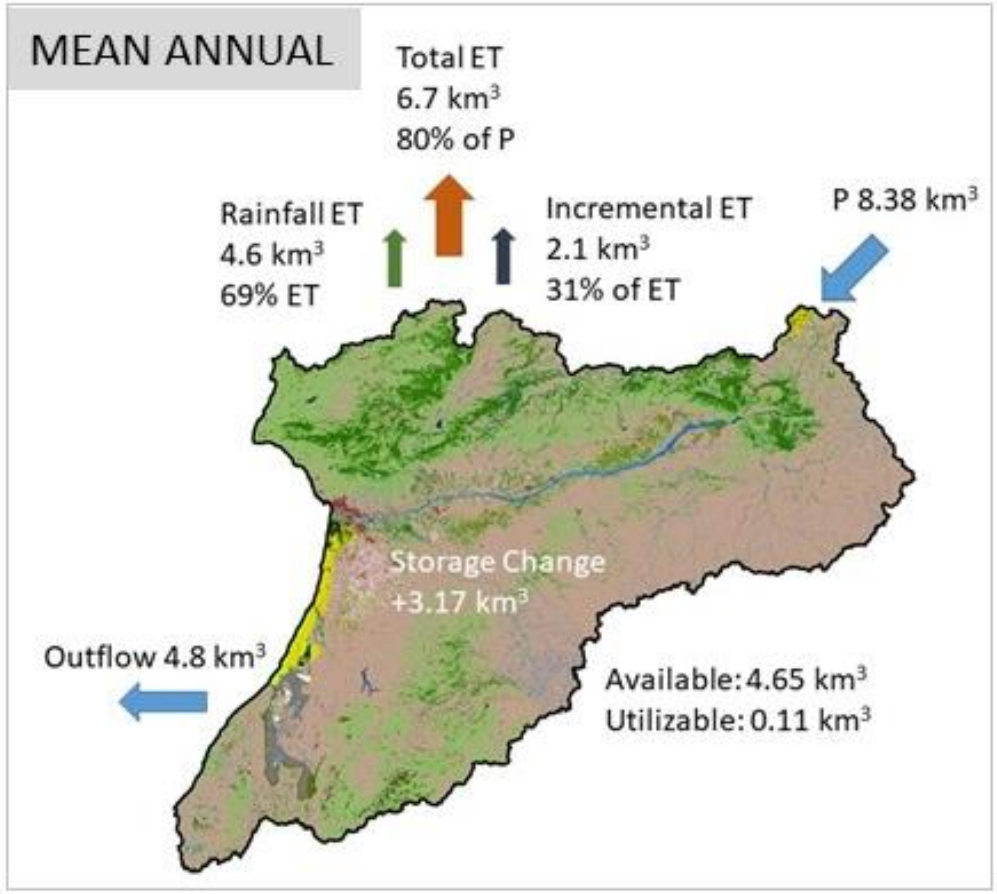
- Use the data provided in the excel
- **Step 5:** Compute I, T and ET fractions for January
- **Step 6:** Repeat Step 1 to Step 5 for all months

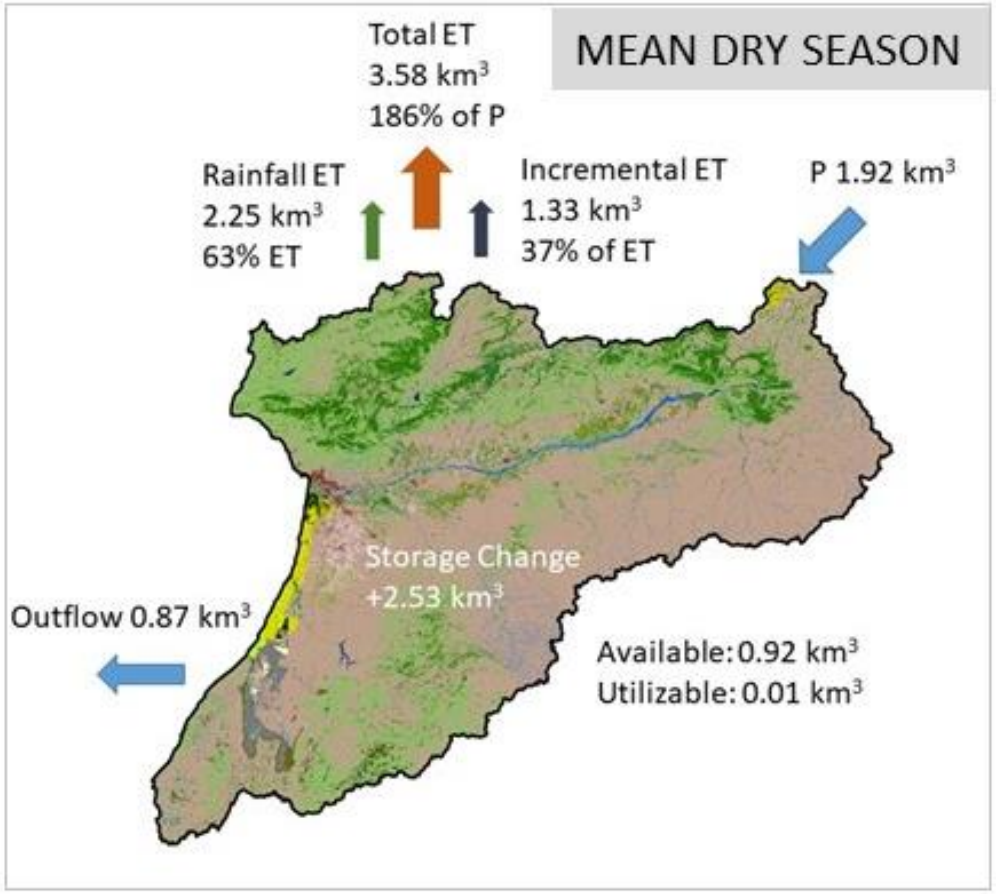
Partition of ET into E, I, T

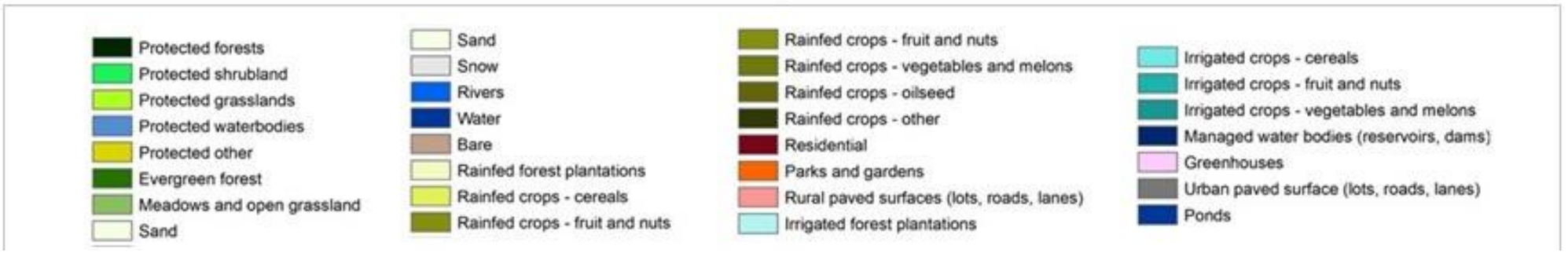
Questions for discussion:

- Based on the results obtained, which land cover classes has the highest interception?
- Based on the results obtained, which land cover classes has the highest Transpiration?
- Based on the results obtained, which land cover classes has the highest Evaporation losses?
- Looking at the three different plots (case 1, 2, and 3), identify the months with highest E, T and I and how do they change with respect to P?

Land use in Souss Massa







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THANK YOU FOR YOUR ATTENTION

Questions/Comments:

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