Water Utilisation, Water Damage Prevention

# Irrigation aspects

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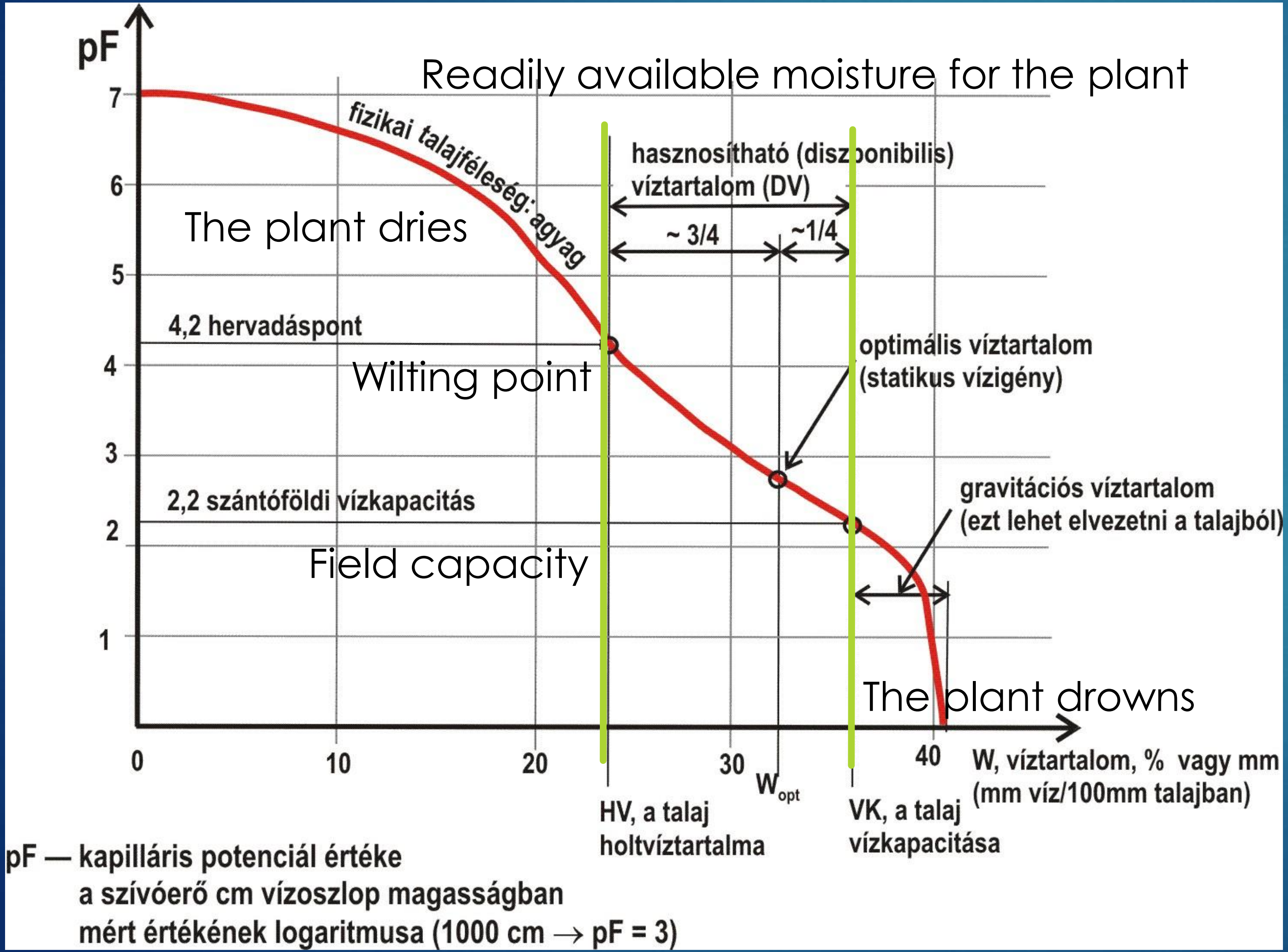
# Capillary potential – water content curve for a given soil (clay)

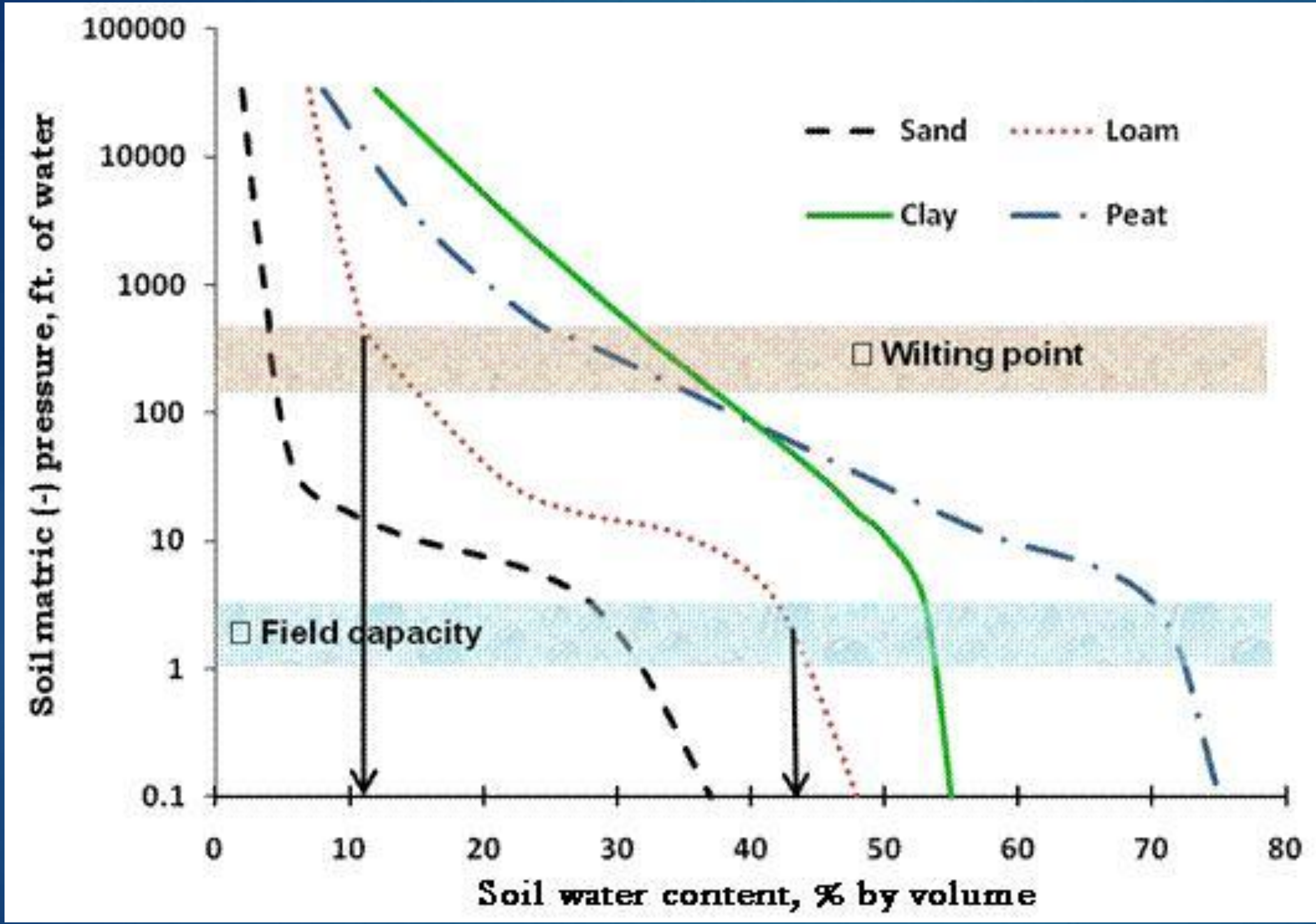



pF: capillary (force) potential in length (head) dimension, in logarithmic representation (1m → pF=3).

W: water content of the soil (percentage).

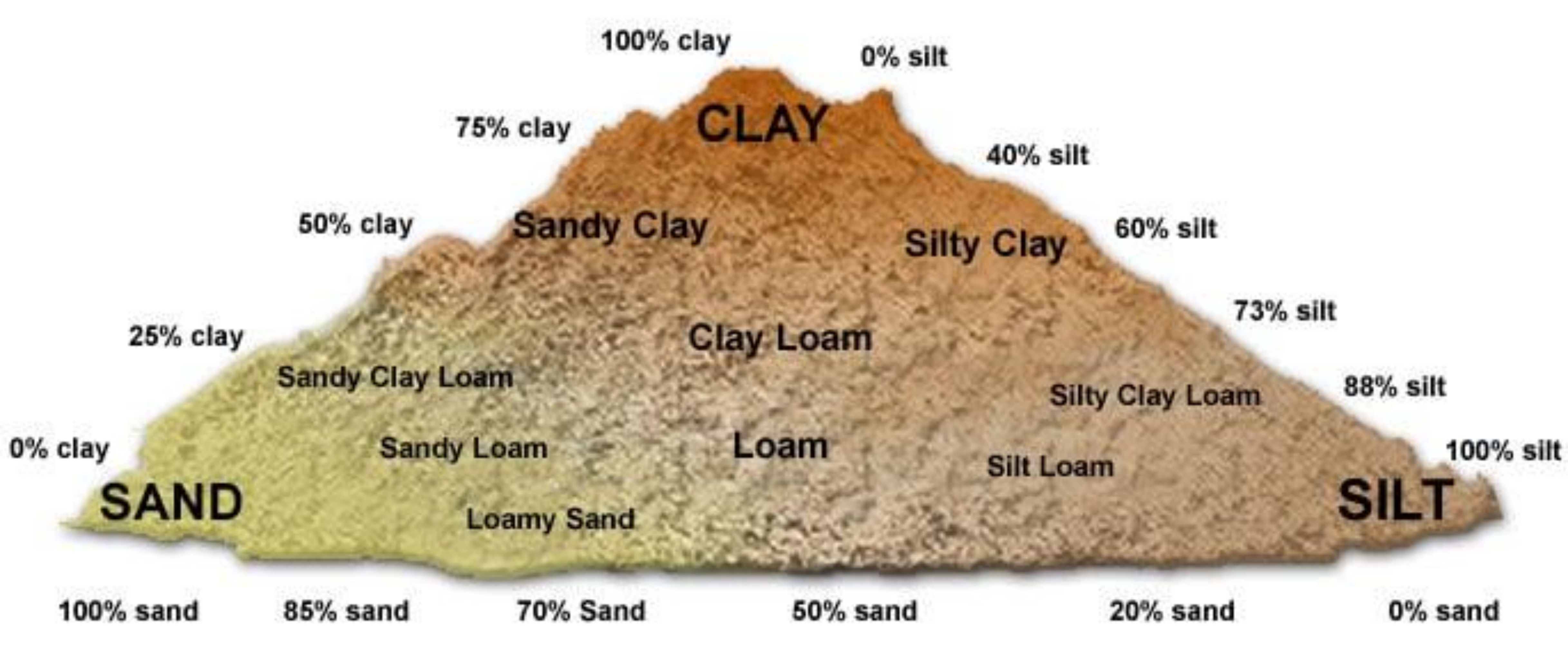
Optimal water content for a given plant.

Gravitational water content (that is drainable, or in other words that drops out if you lift up the soil from a pot).




pF curves for different soil types (source: Cornell University)

# Soil types




Source: civildigital.com

# Irrigation effects on the hydrological circle



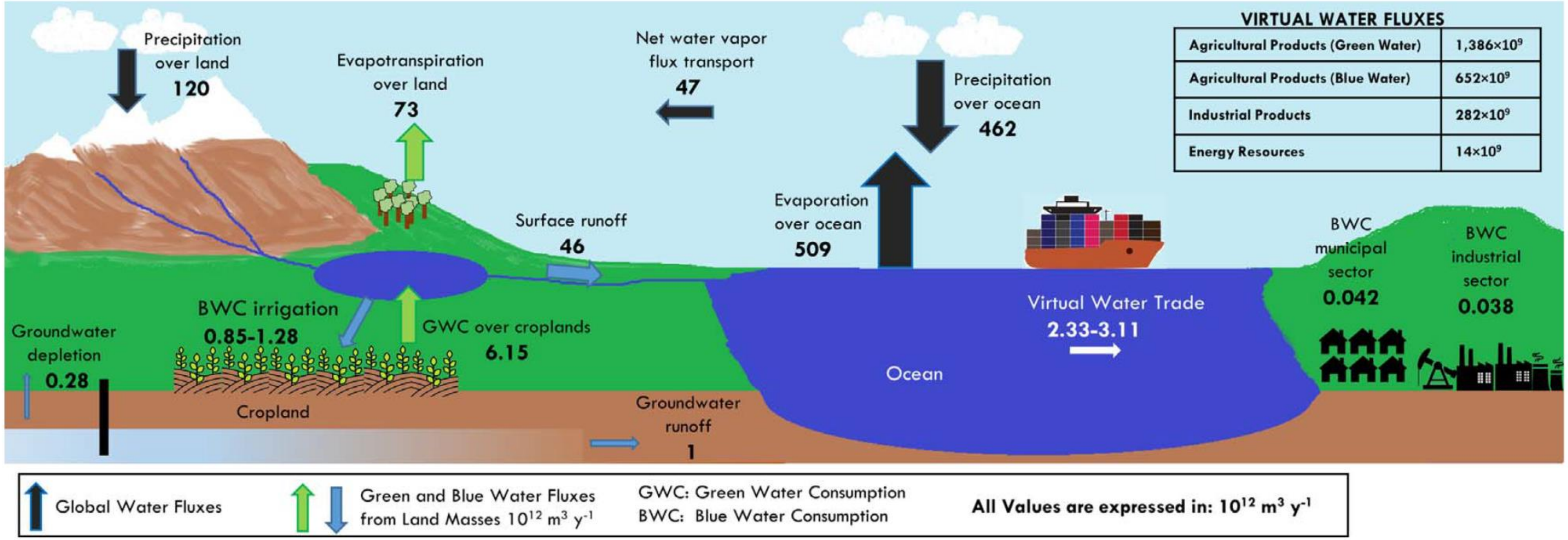



**Figure 11.** Comparison between physical and virtual water fluxes in integrative depiction of the global water cycle (based on data from table 4).

# Irrigation effects on the hydrological circle

*Environ. Res. Lett.* **14** (2019) 053001 P D'Odorico *et al*

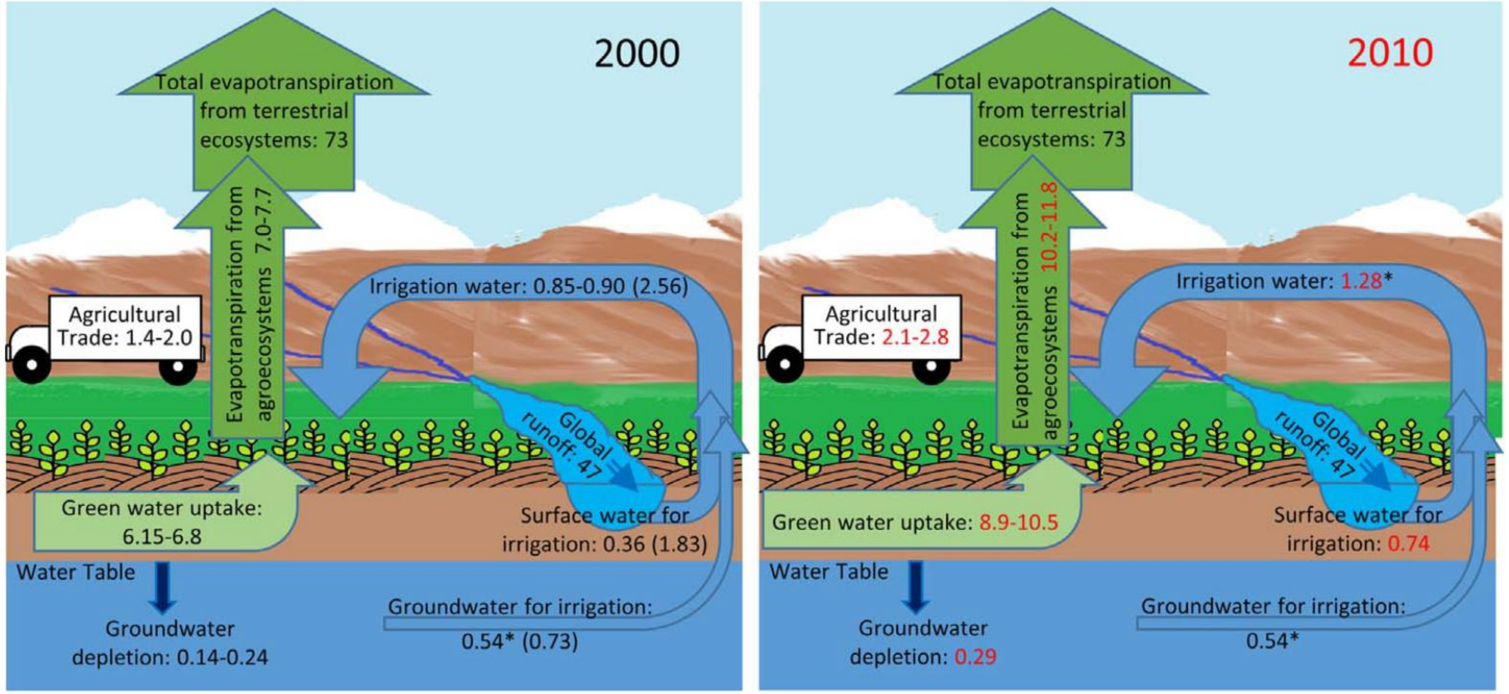


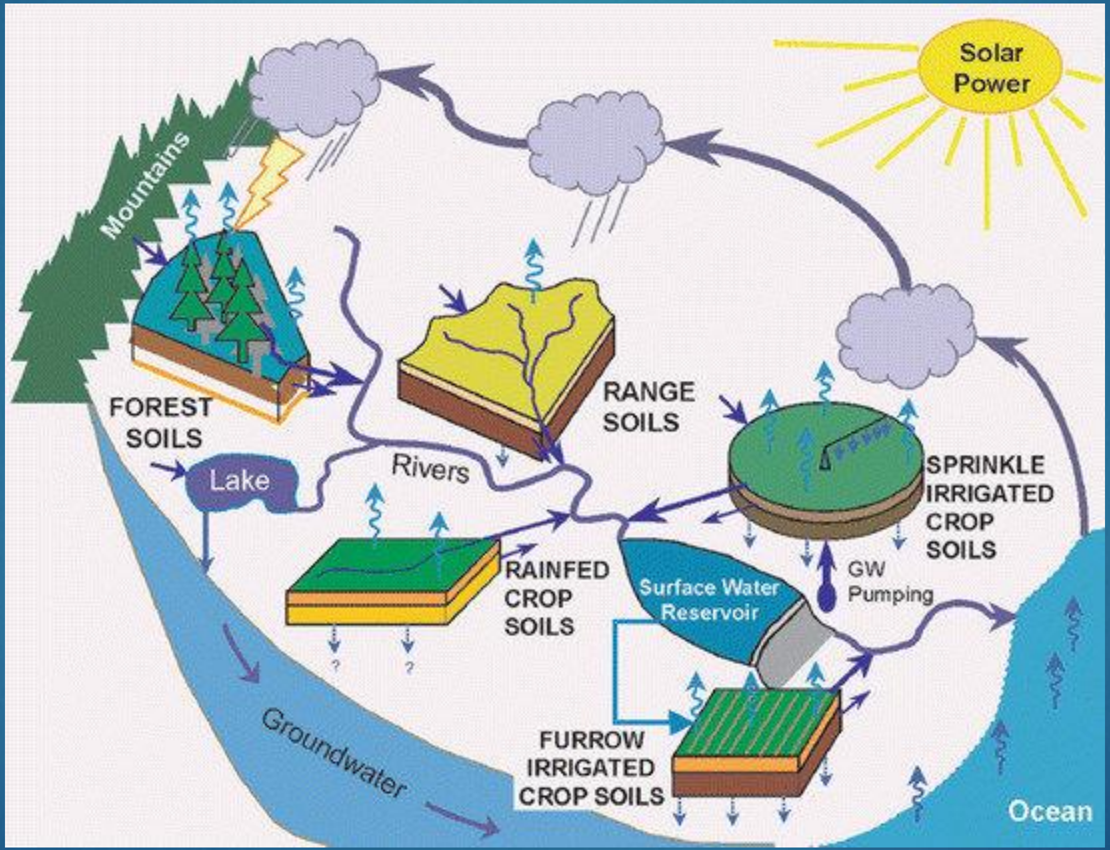

**Figure 12.** Global physical and virtual water fluxes in agriculture for the year 2000 (left) and 2010 (right) (source: tables 1 and 4, figure 4 and references cited in the text; all values are expressed in $10^{12}$ $m^3$ $yr^{-1}$). Blue water flows are reported both as consumptive uses and blue water withdrawals (between parentheses). The asterisk (*) denotes average values for 2000–2010. In red are values that have changed between 2000 and 2010.

Decreased groundwater level and increased evaporation.

The vapoured water can fall back into another watershed.

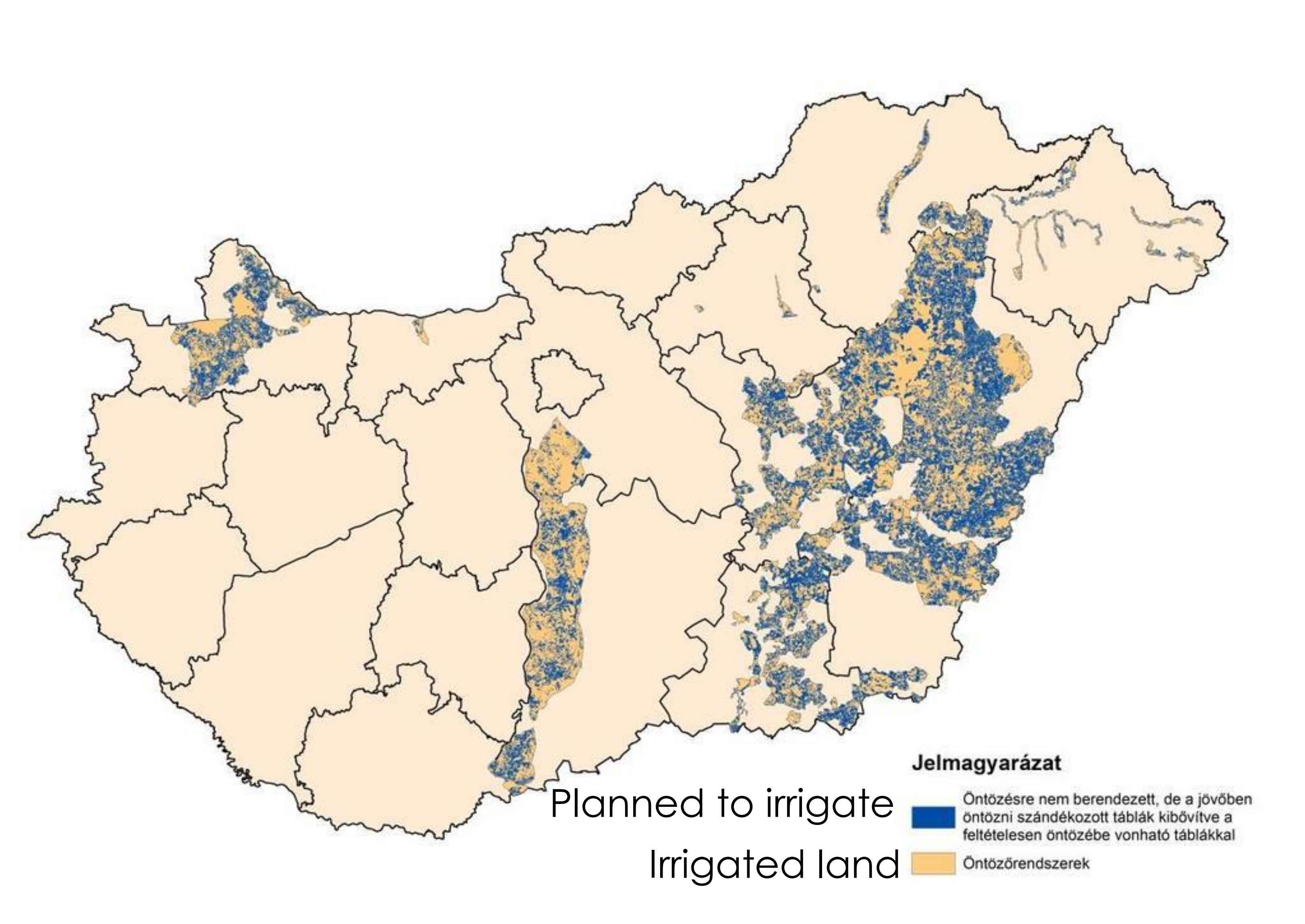
A deficit appears in the water budget of the irrigated watershed.

- The proper choice of the way of irrigation and the water amount irrigated is highly important.
- Not only for the optimal needs of plants but also for the fragility of the local hydrological cycle.




Green and van Schilfgaarde 2006

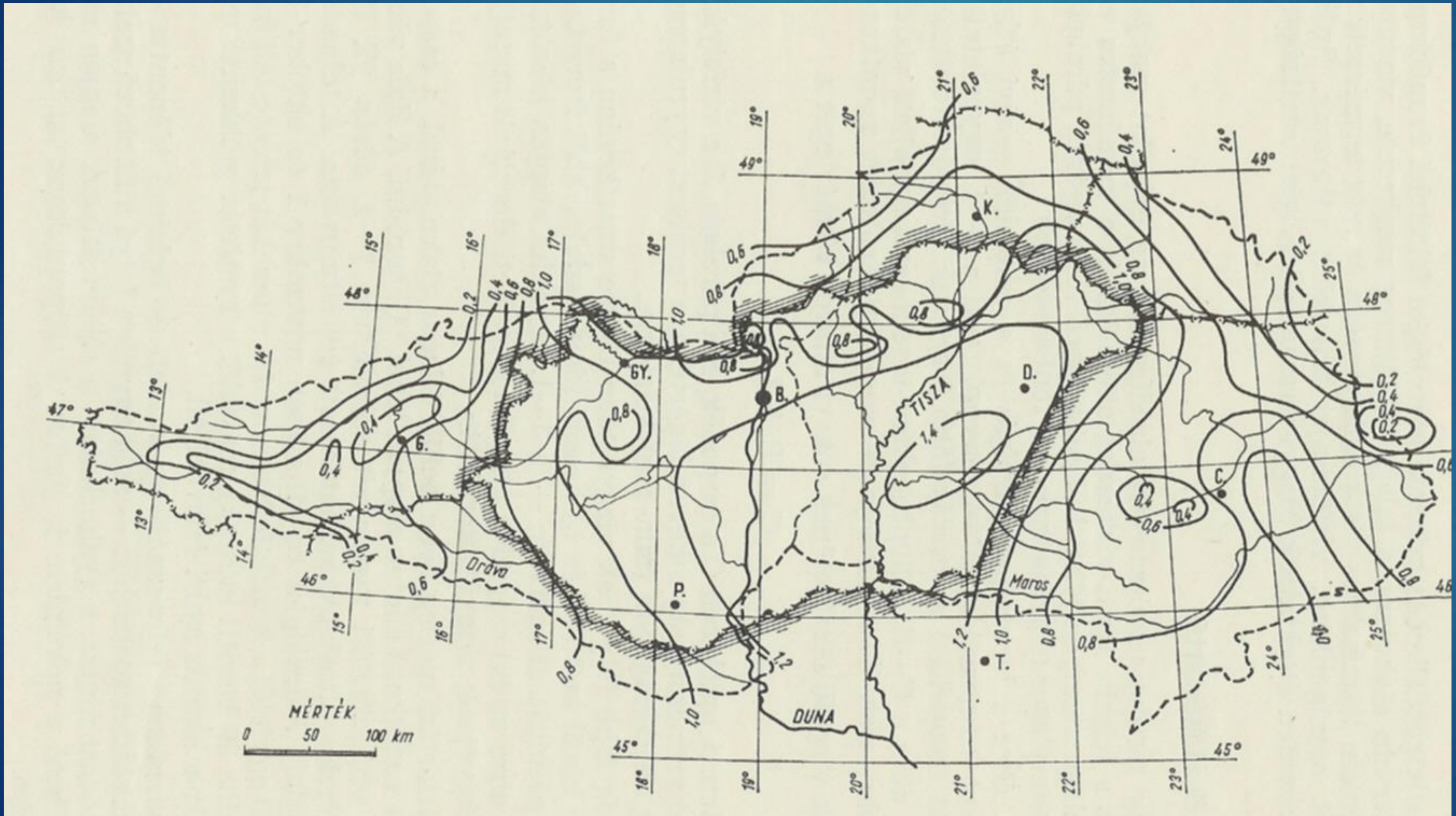
# Irrigation strategy of Hungary, 2018




The strategy prescribes surface water usage against groundwater usage.

Mostly sprinkler irrigation systems (not necessarily optimal for plants and greater loss in water budget).

# Long term average of aridity index over Hungary




3—1. *ábra.* Az ariditási tényező sokévi átlaga Magyarország folyóinak vízgyűjtő területén

Aridity index: the ratio of the potential evaporation and the precipitation.

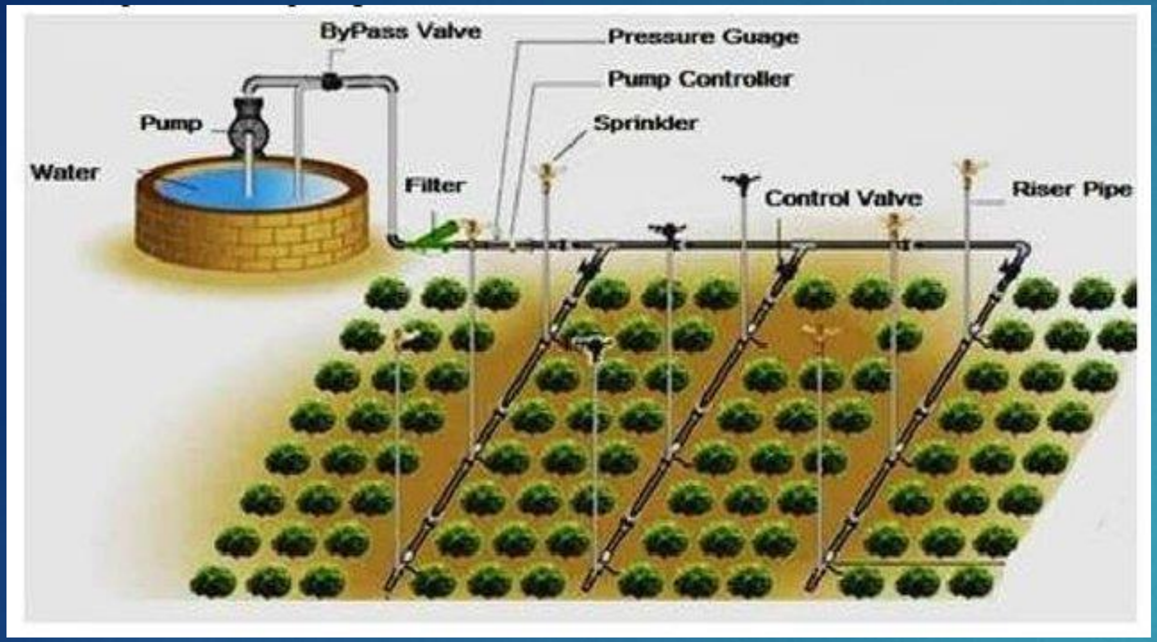
Aridity index >1

Need of irrigation?

# Ways of irrigation

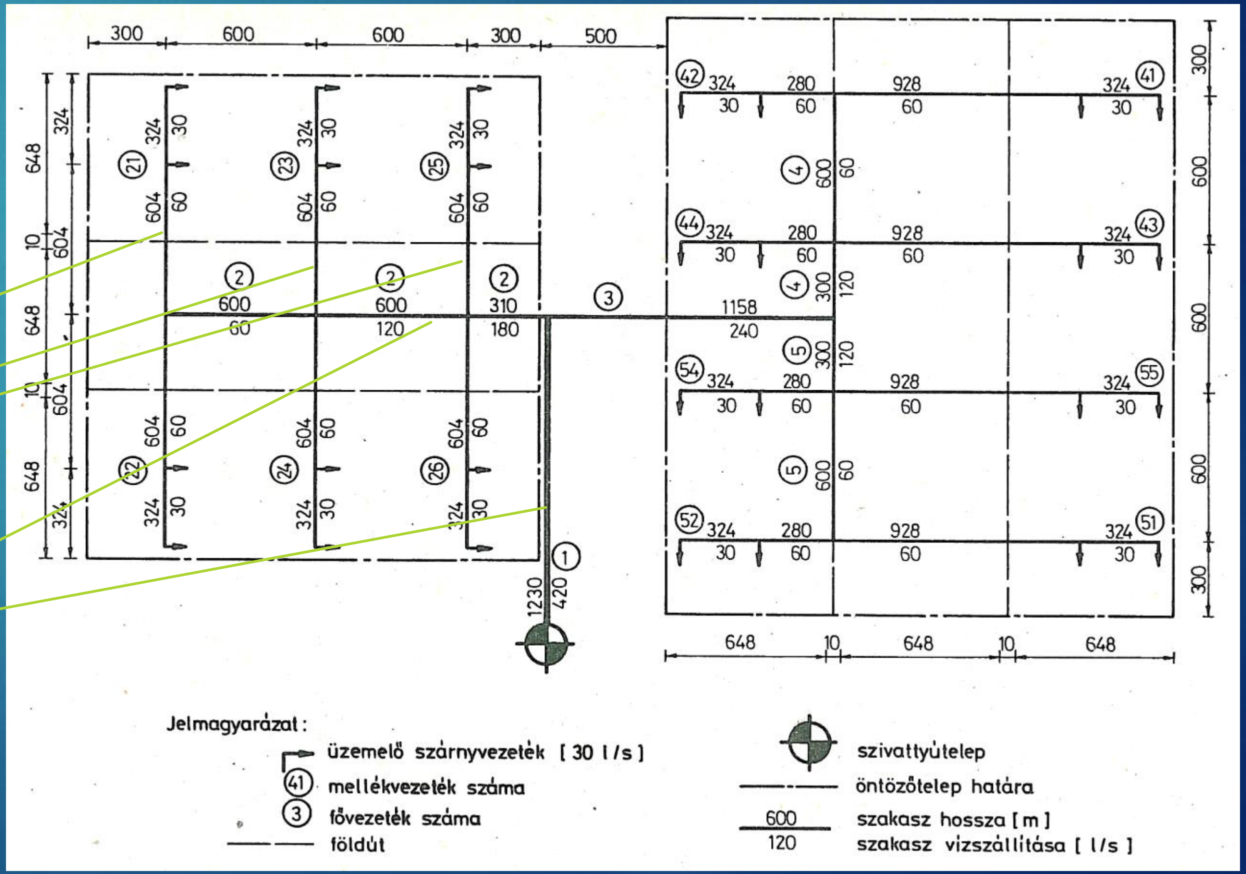
- Sprinkler irrigation.
- Surface irrigation.
- Drip irrigation.

# Sprinkler irrigation system




E. S. Mohamed and N. T. Abdo, Overview of Pumping Systems with Focus on Deferrable Irrigation Loads, 2017

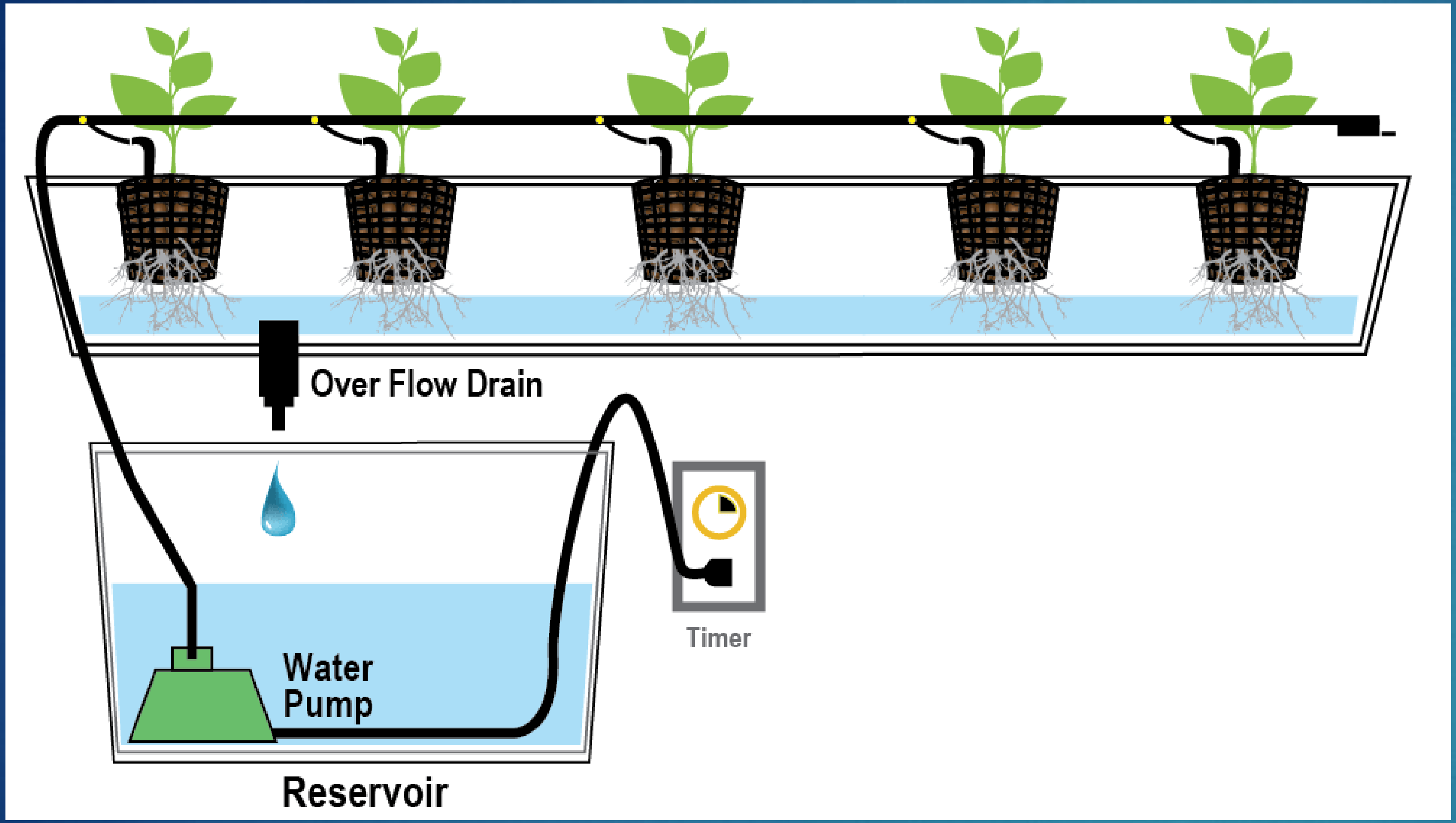
The pipe system can be fixed (built under the ground), partially fixed (some pipes are moveable and placed over the ground) and mobile.




Fixed pipeline

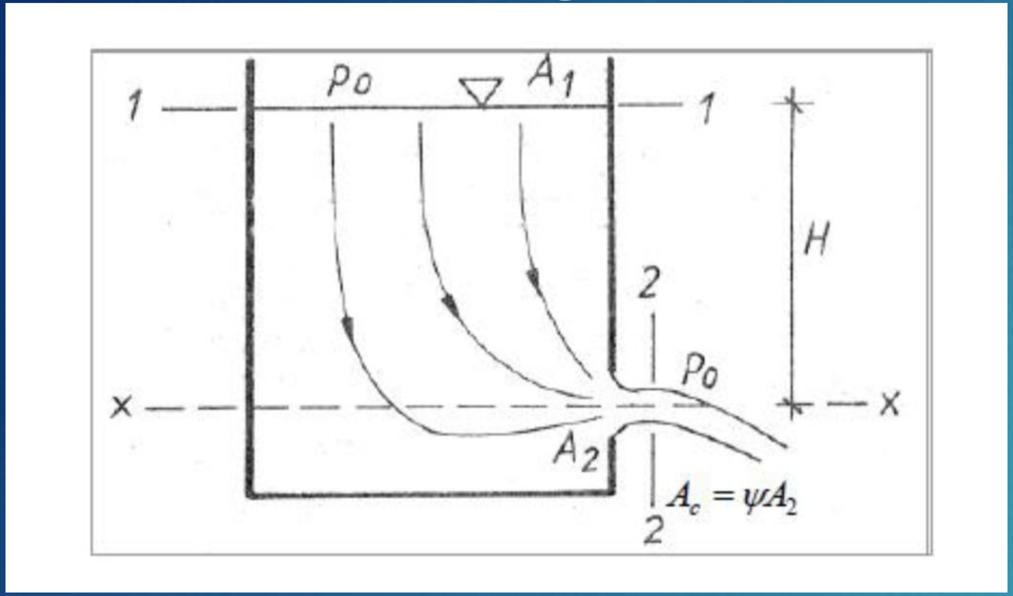
Moveable pipeline

# Drip irrigation system




- Targeted water release and precise dosing
- Low evaporation loss, water saving
- Simple and precise nutrient delivery
- Low phytosanitary risk
- High efficiency, minimal energy investment
- It can also be operated in areas with poor water management

# Hydraulic background for irrigation systems: outflow through small orifices




$$z_1 + \frac{v_1^2}{2g} + \frac{p_1}{\rho g} = z_2 + \frac{v_2^2}{2g} + \frac{p_2}{\rho g} + \boldsymbol{h_L}$$

$$v_2 = \frac{1}{\sqrt{1+\xi}}\sqrt{2gH}$$

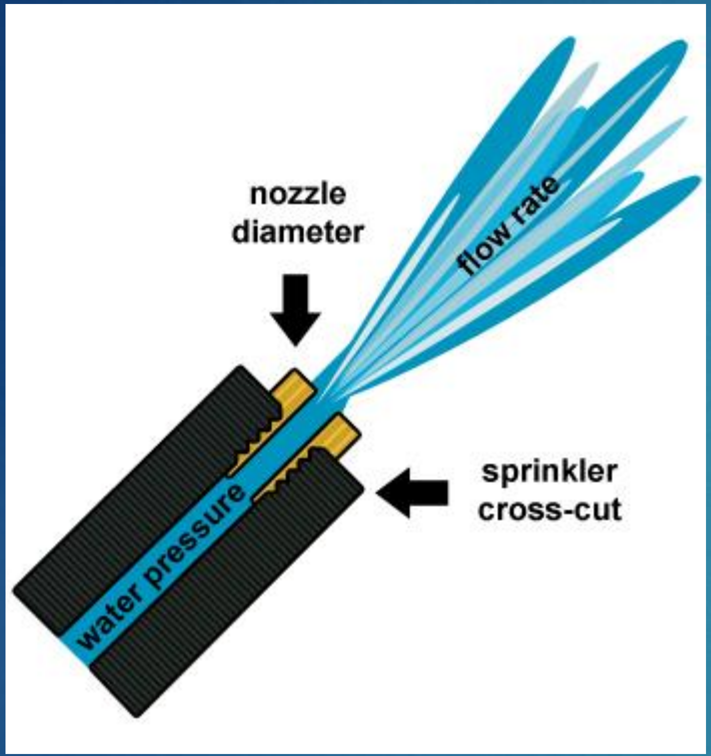
$$\frac{1}{\sqrt{1+\xi}} = \varphi$$

$$v_2 = \varphi\sqrt{2gH}$$

$$A_c = \psi A_2$$

$$Q = A_c v_2 = \psi A_2 \varphi \sqrt{2gH} = \mu A_2 \sqrt{2gH}$$

# Discharge formula of nozzles

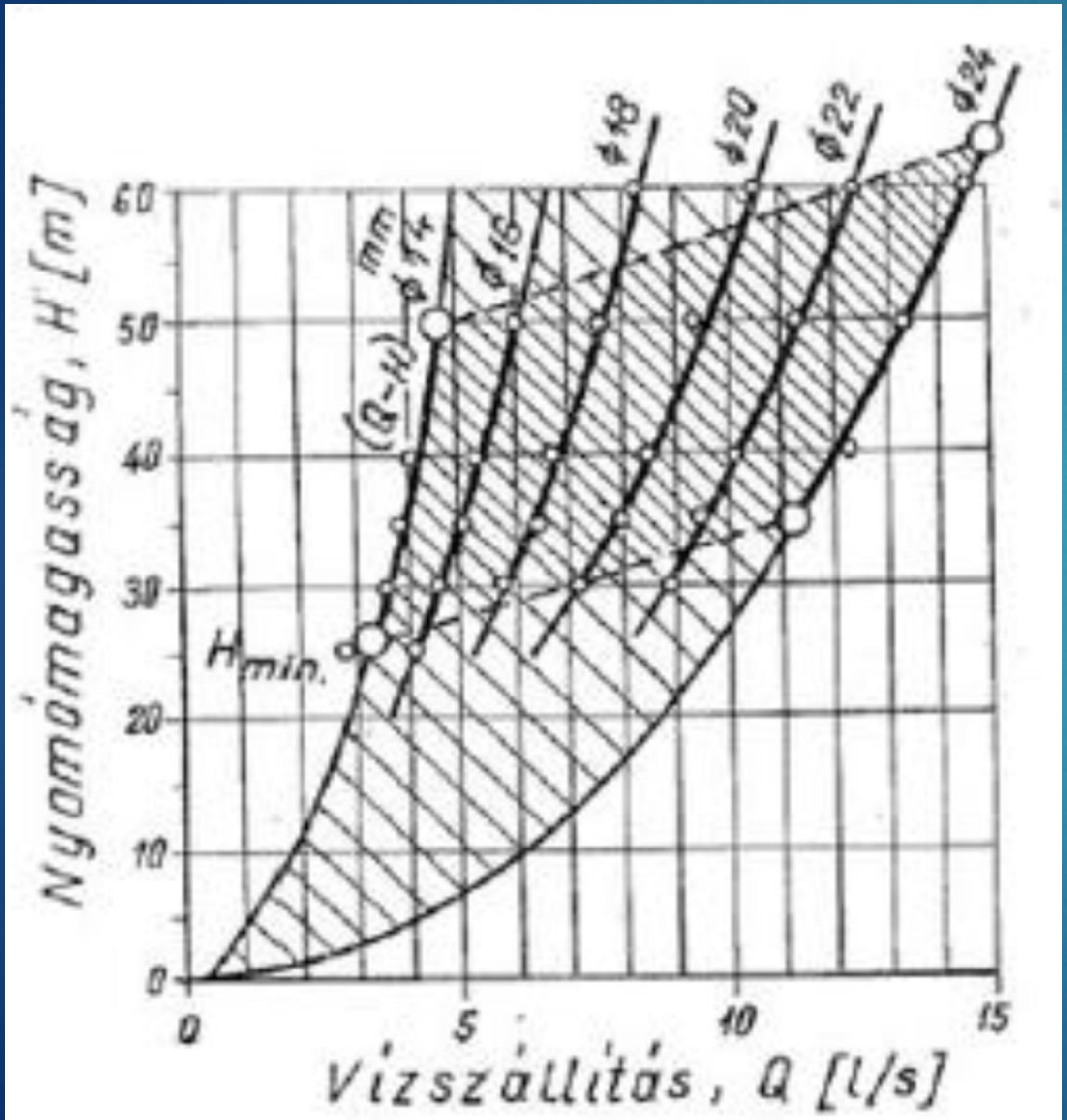



$$Q = \mu A\sqrt{2gH}$$

Q: discharge (volume flow rate)
μ: discharge coefficient (representing the local energy loss due to the outflow through the nozzle and the water flume contraction)
A: area of the nozzle
g: gravitational acceleration
H: pressure potential at the nozzle expressed by water height

Source (nozzle discharge calculator): http://irrigation.wsu.edu/Content/Calculators/Sprinkler/Nozzle-Requirements.php

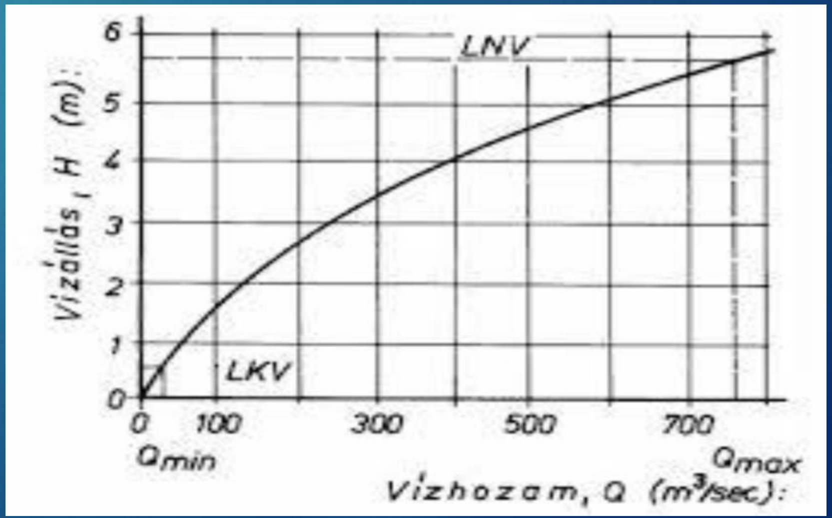
# *Q-h* curves (system curves) of nozzles for different diameters



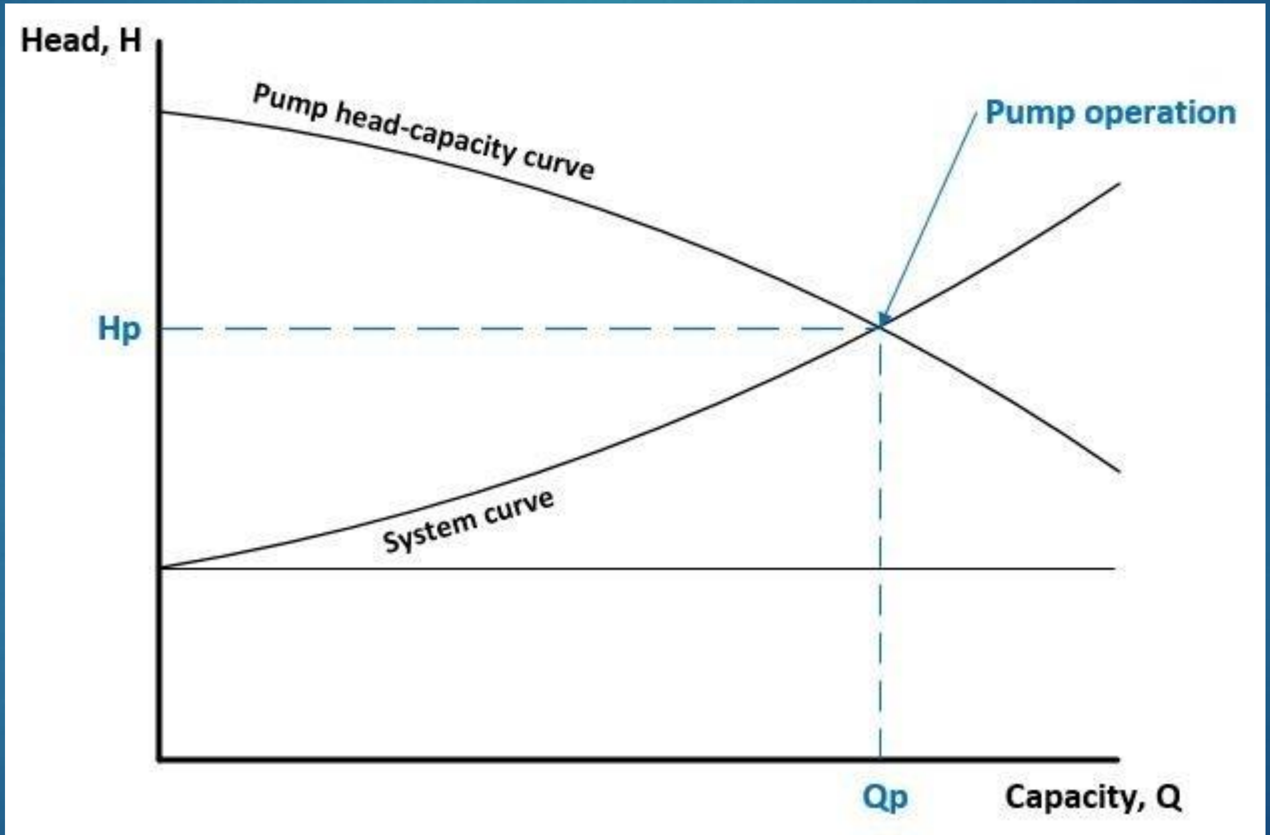

$$Q = \mu A\sqrt{2gH}$$

The discharge is proportional to the square root of the pressure head.

This formula is approximately the inverse of the *Q-h* curves (rating curves) of open channel flows.



# The intersection of the system curve and the pump head-capacity curve is the operation point of the system (a single nozzle system is shown in the figure)



# Questions

- Describe the capillary potential (pF) – water content curves. (What do they belong to? What do the notable water contents and force potentials mean?)
- How does the irrigation process affect a local (watershed-sized) hydrological circle?
- Define the aridity index. What do the different values of the aridity index mean?
- Describe the main irrigation types. What are the advantages of drip irrigation?
- Describe the discharge formula of nozzles. How does it connect to the Bernoulli equation?
- What is the difference between the system curve of nozzles and the rating curve of open channel flows? What is the explanation for the difference?