



Sustainability Challenges

Networking Day

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Session: Planet in blue?

Groundwater: a hidden multiple resource and climate buffer for a sustainable future

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József & Erzsébet Tóth



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HOPE Sustainability Challenges Networking Day

University of Pannonia

Veszprém

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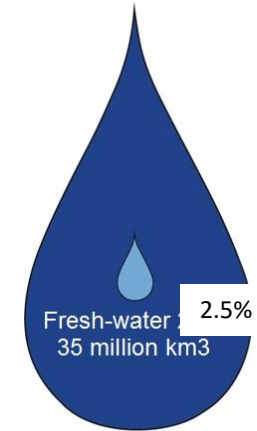
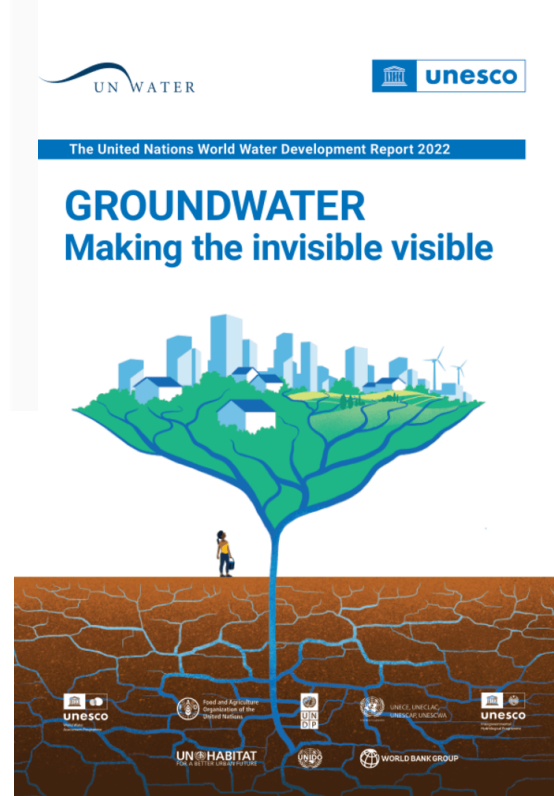


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The hidden water resource for the world and Europe

A comprehensive framework for sustainable adaptation to the changing blue planet



© Fetter, 1994 és Shiklomanov, 1999

- Groundwater accounts for 99% of the liquid freshwater.
- Social, economic and environmental benefits
- 50% domestic use, 25% irrigation (UN 2022)
- 65% drinking water, 25% agricultural irrigation in the 27 EU Member states (EEA 2022)
- 95% of drinking water (35% bank filtration) from groundwater in Hungary (OVF)
- Widespread pressure from pollution, abstraction and climate change

Europe's groundwater – a key resource under pressure

Europe's groundwater — a key resource under pressure



Outline - Questions



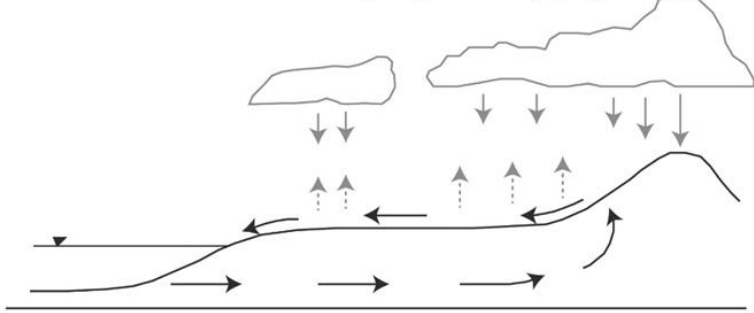
ELTE research topics in sustainability and EU strategies for groundwater

1. **Contribution to the „big picture” of the topic**
2. Research related to blue planet issues (on the EU level)
 - What problems and possible solutions do we see?
 - What are needed to implement the solutions?

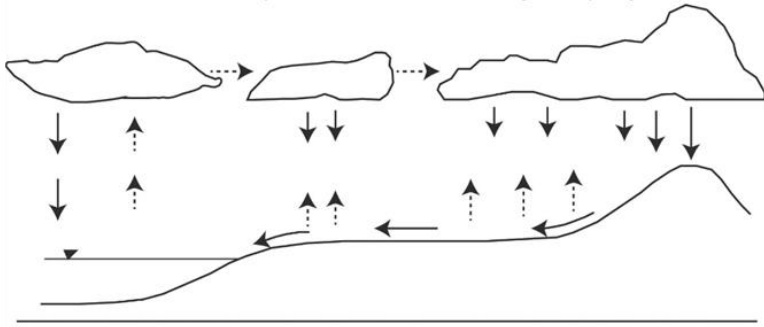


The modern water cycle vs aquifer-based thinking

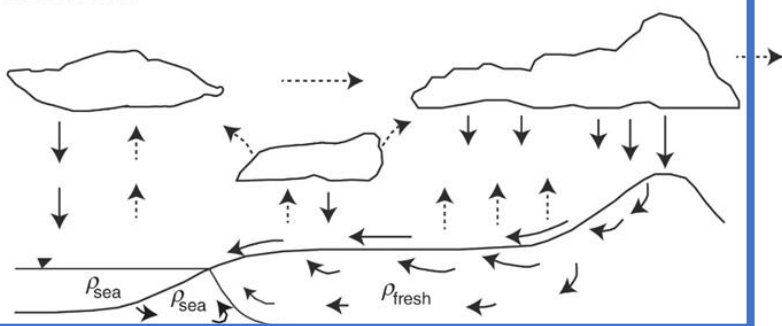
Reverse model: A subsurface origin of groundwater, springs and rivers



Vertical model: Precipitation and dew as the origin of springs and rivers



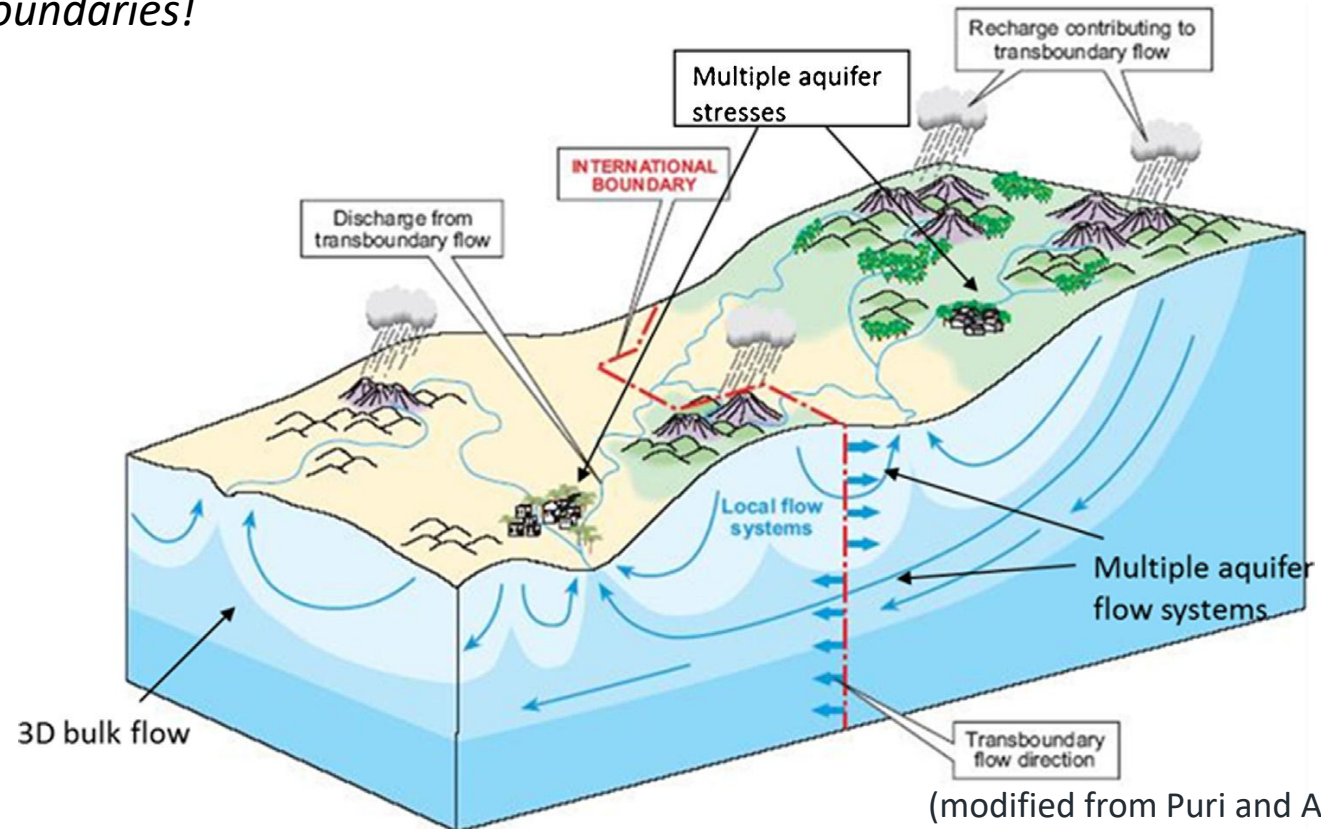
Modern View



(Christopher J Duffy 2017)

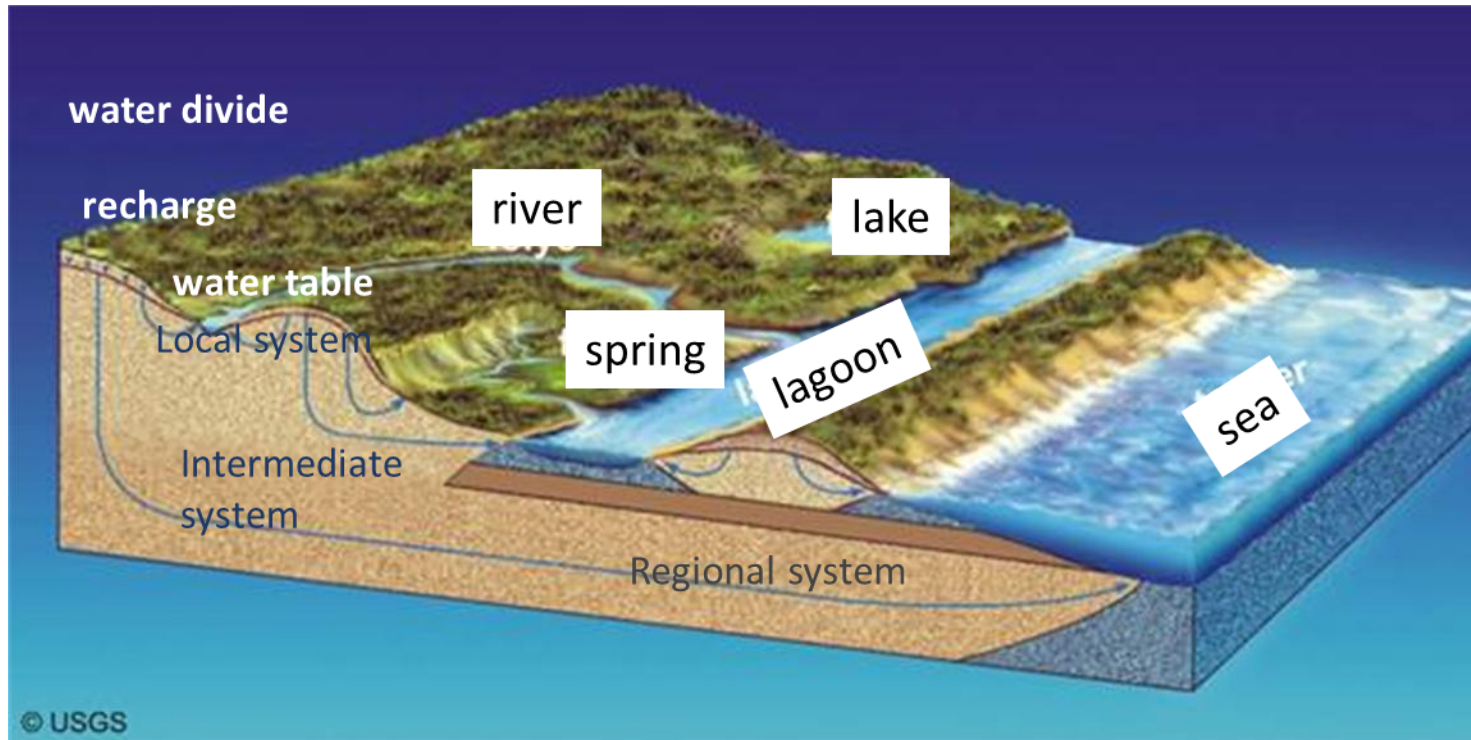
The problem: Practice and regulation cannot handle **physically-based complex groundwater flow systems**. The unit of interpretation is the aquifer/aquifer system/water body (WFD). **Less attention** is paid to flow and transport processes in groundwater and **their complex connection** with surface water bodies and groundwater-dependent ecosystems (GDEs).

Example: *Transboundary Aquifer System - flow does not follow the aquifer boundaries!*



(modified from Puri and Arnold, 2002)

Consider the „still missing” system approach



ELTE Hydrogeology
Research Group



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Review papers

From basin-scale groundwater flow to integrated geofluid research in the hydrogeology research group of Eötvös Loránd University, Hungary

Brigitta Czauner^{a,*}, Anita Erőss^a, Szilvia Szkolnikovics-Simon^a, Ábel Markó^a, Petra Baják^a,
Tímea Trásy-Havril^a, Márk Szijártó^b, Zsóka Szabó^a, Katalin Hegedűs-Csondor^a,
Judit Mádl-Szőnyi^a



Recommendations:

- More attention should be paid to reveal flow and transport processes.
- This can provide sound background information on sustainability issues, climate change, and anthropogenic intervention.



Regional
Groundwater Flow
Commission of
International
Association of
Hydrogeologists

Outline - Questions

ELTE research topics in sustainability and EU strategies for groundwater

1. Contribution to the „big picture” of the topic

2. **Research related to blue planet issues** (on the EU level)

2.1. Groundwater as multiple resources (ENeRAG H2020 project)

2.1. Groundwater as a climate buffer for extreme events (Hungarian National Laboratory Project, ClimEx-PE Water4All 2022 Project)



2.1. Groundwater as multiple resources, the ENeRAG H2020 project

Groundwater is the **most abundant geofluid** in the Earth's crust, down to 10-15 km.

Revealed problem:

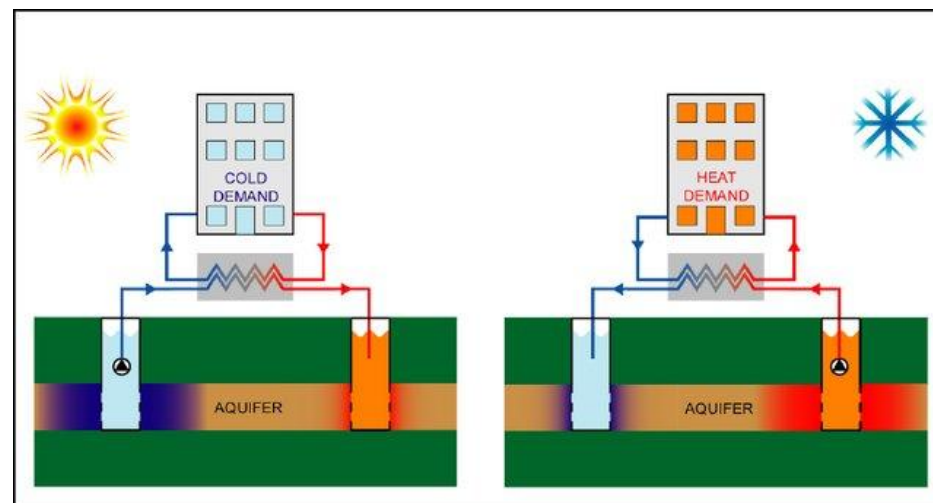
Besides domestic, agricultural, and industrial use, groundwater serves as:

- **Heat source** (geothermal energy) to reduce greenhouse emissions and adopt renewable energy systems
- **Hydrothermal mineral resources** (Li and critical raw minerals) for the rapidly developing green technologies, etc.

European and Hungarian legislations do not provide an **aligned framework** for managing and using different geofluids in the Earth's crust. The increasing production of geofluids can influence their utilisation for different purposes, cause interactions and **unforeseeable conflicts**, and have **complex environmental** effects in underground space.

Example: In Hungary, the Mining Law (modified in 2023) regulates geothermal energy production, although groundwater transfers heat to the surface. The Water Management Law regulates thermal water use in SPAs and agriculture.

Reinjection is a crucial practice to ensure the sustainable utilisation of thermal water, so the WFD requires reinjection from 2027 Dec. Problems: 500 thermal water wells use geothermal energy, but only 50 reinjection wells are operating. There is strong social and economic resistance from agricultural users against reinjection. There are scientific and technical problems with reinjection etc.



Groundwater as multiple resources, possible solutions



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Concept Paper

Groundwater Flow System-Based Dynamic System Approach for Geofluids and Their Resources

Brigitta Czauner ^{1,*}, Ferenc Molnár ^{2,3}, Marco Masetti ⁴, Teppo Arola ⁵ and Judit Mádl-Szőnyi ¹

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Recommendation and implementation :

- We proposed a new scientific-based '**Dynamic System Approach for Geofluids and their Resources**' for handling fluids and their resources in the Earth's crust.
- Workflow: displays key concepts and summarizes the related methodology
- Guideline: demonstrates practical application and provides knowledge transfer to public

Geothermal
systems

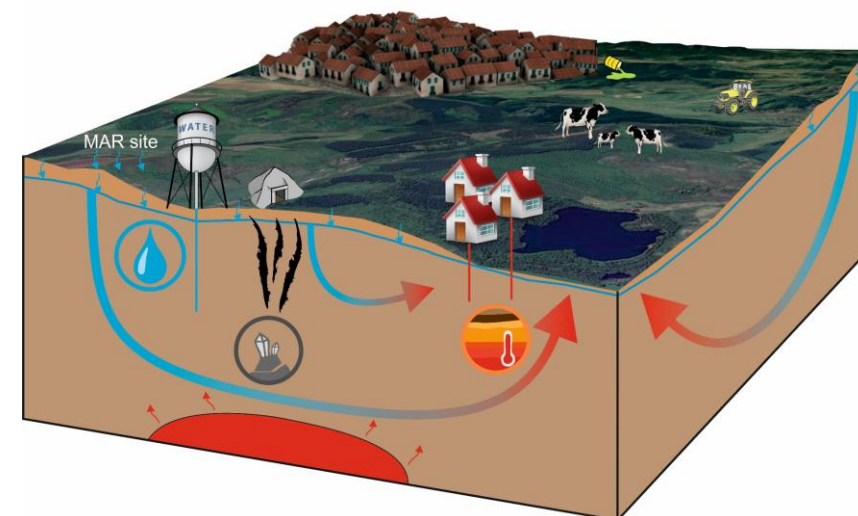
Groundwater
flow
systems

?

Mineral
systems

Petroleum
systems

© ENeRAG



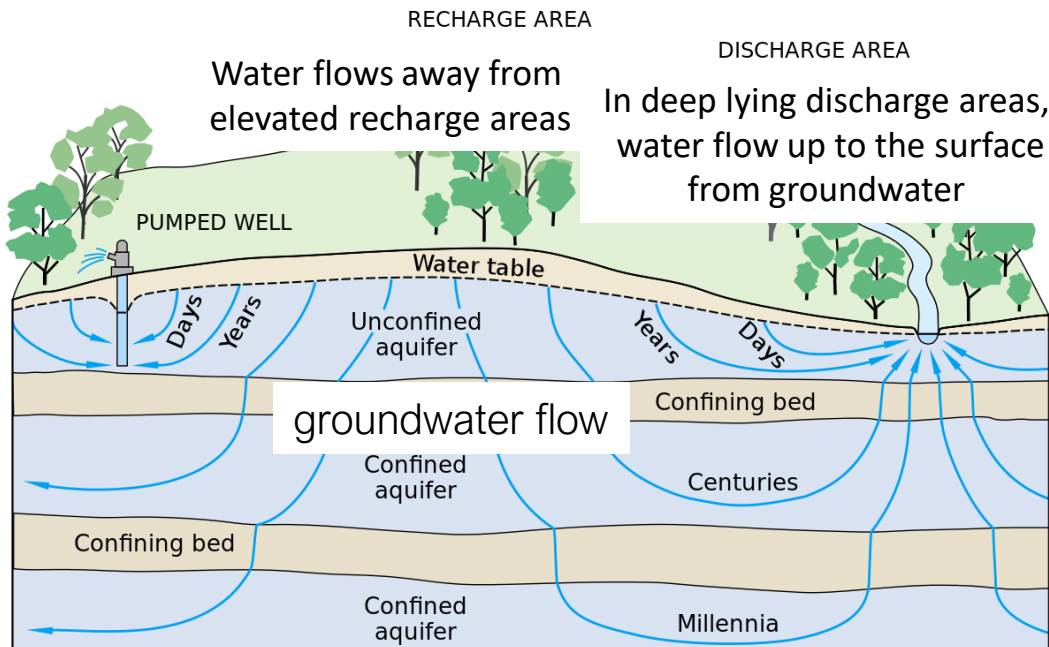
Available at <https://zenodo.org/communities/enerag/>

2.2. Groundwater as a climate buffer, Hungarian National Laboratory Project, ClimEx-PE Water4All 2022 Project

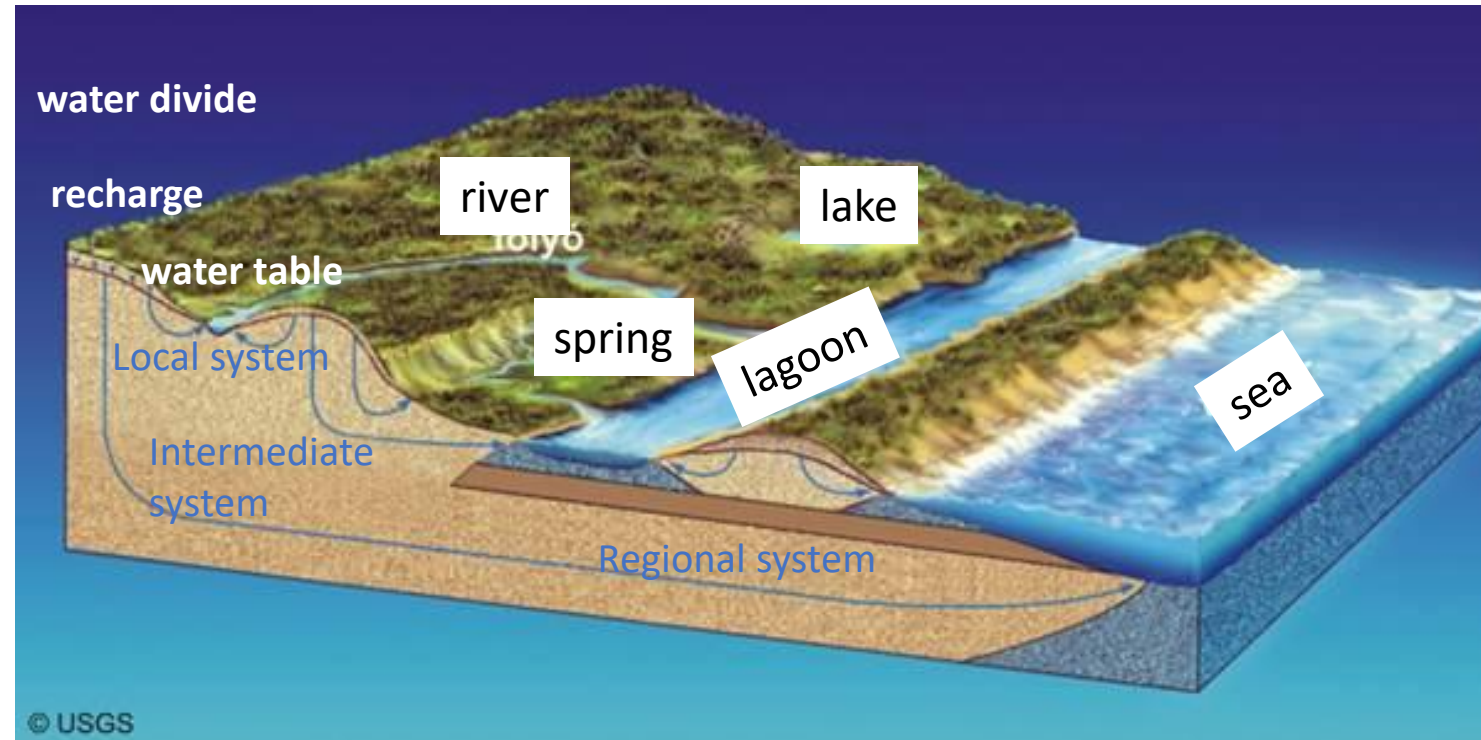
Groundwater can serve as a natural climate buffer:

- Transit time from days to million years
- Huge storage capacity from the surface to some km (not only in the soil!)
- The amount of naturally stored water can decrease or increase due to natural or anthropogenic effects

Effect of climate change and water abstraction: **Recharge areas are sensitive to drought**, and **discharge areas for flood**. **Short-local systems** are more sensitive than longer regional ones.



(USGS 1998)

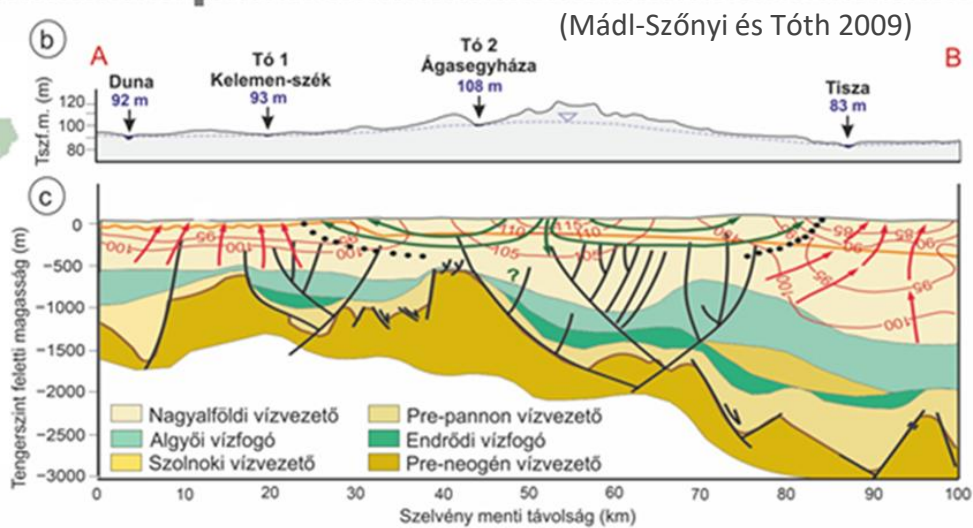
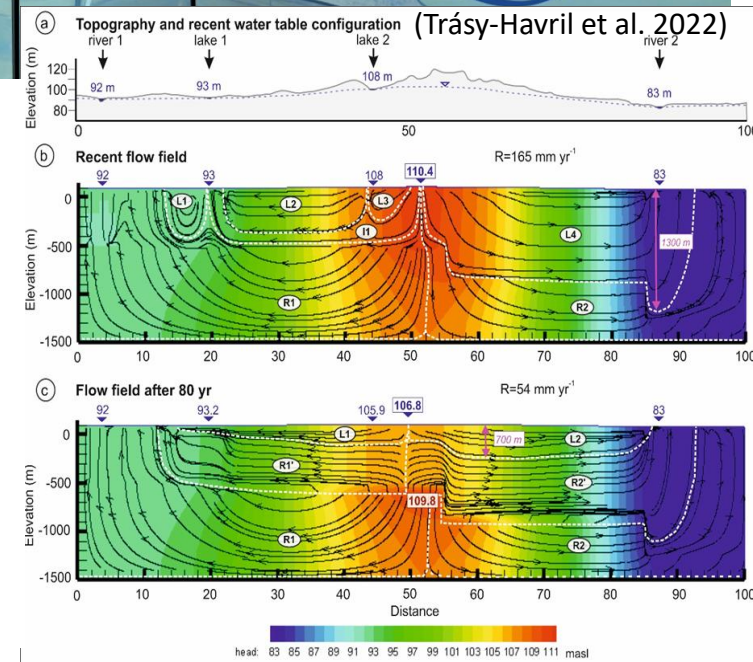
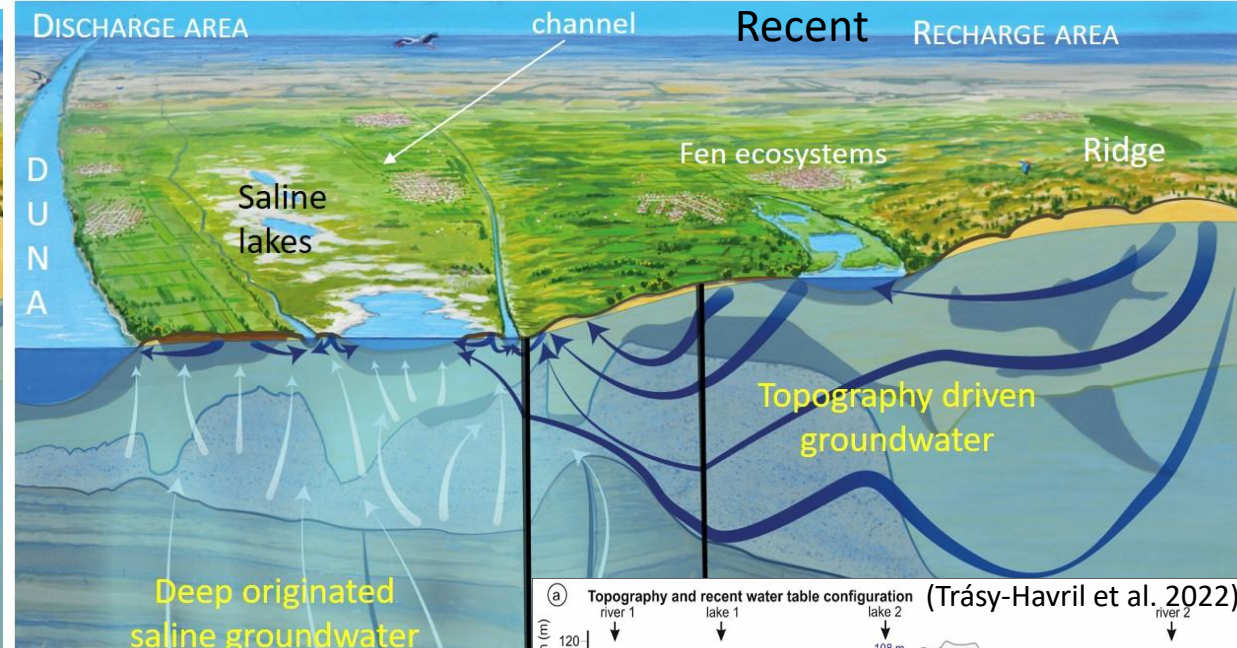
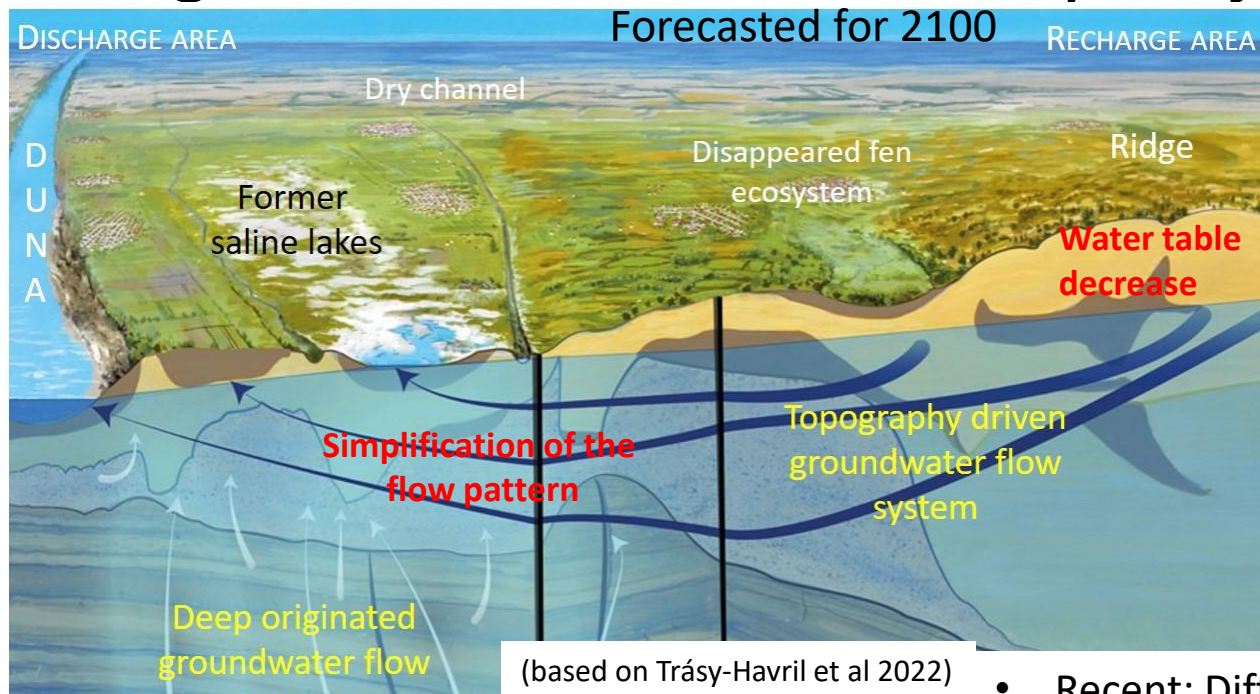


Reaction of groundwater for climate change, Hungarian National Laboratory Project



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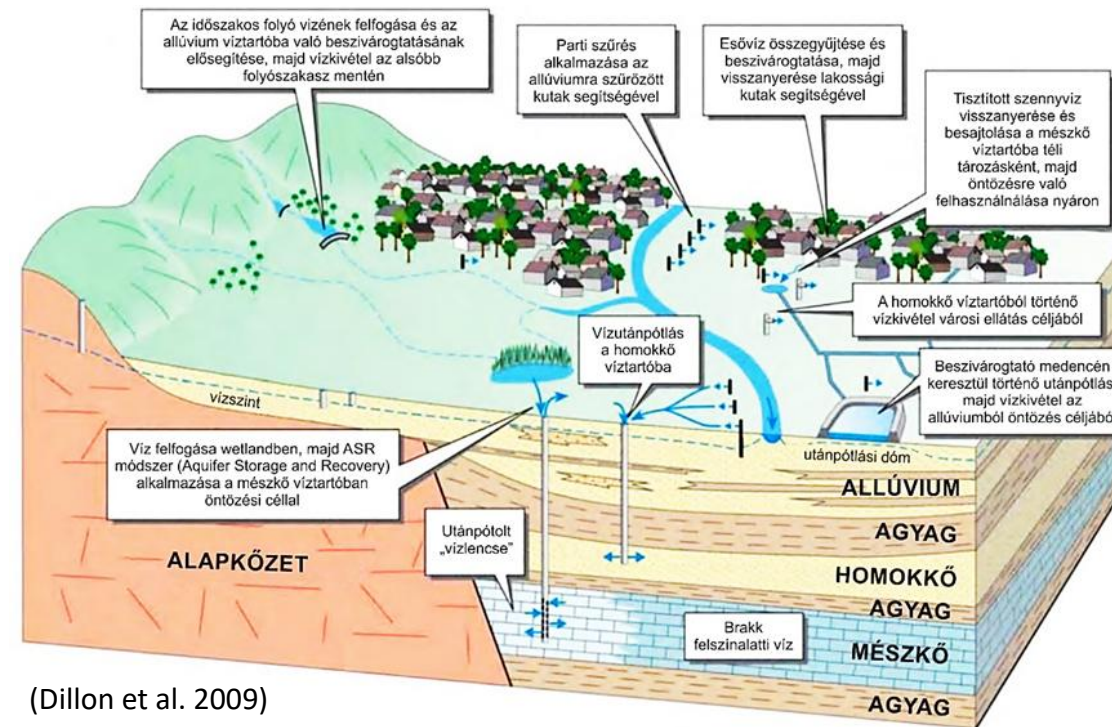


- Recent: Different flow systems are connected to the saline and fresh GDEs.
- Forecasted: decreased water table and the simplification of flow systems.
- The original GDEs lose the connection with the groundwater and feeding flow systems.
- It can lead to severe degradation of the original ecosystems.

Groundwater: a climate buffer for extreme events



- Droughts and floods are severe consequences of hydroclimatic extreme events.
- Aquifers can receive excess water to store it for periods of water shortage
- MAR is a local engineering approach to the intentional recharge of groundwater.



(Dillon et al. 2009)



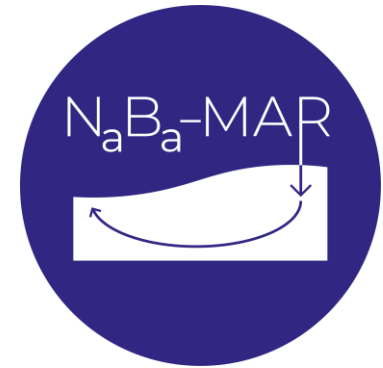
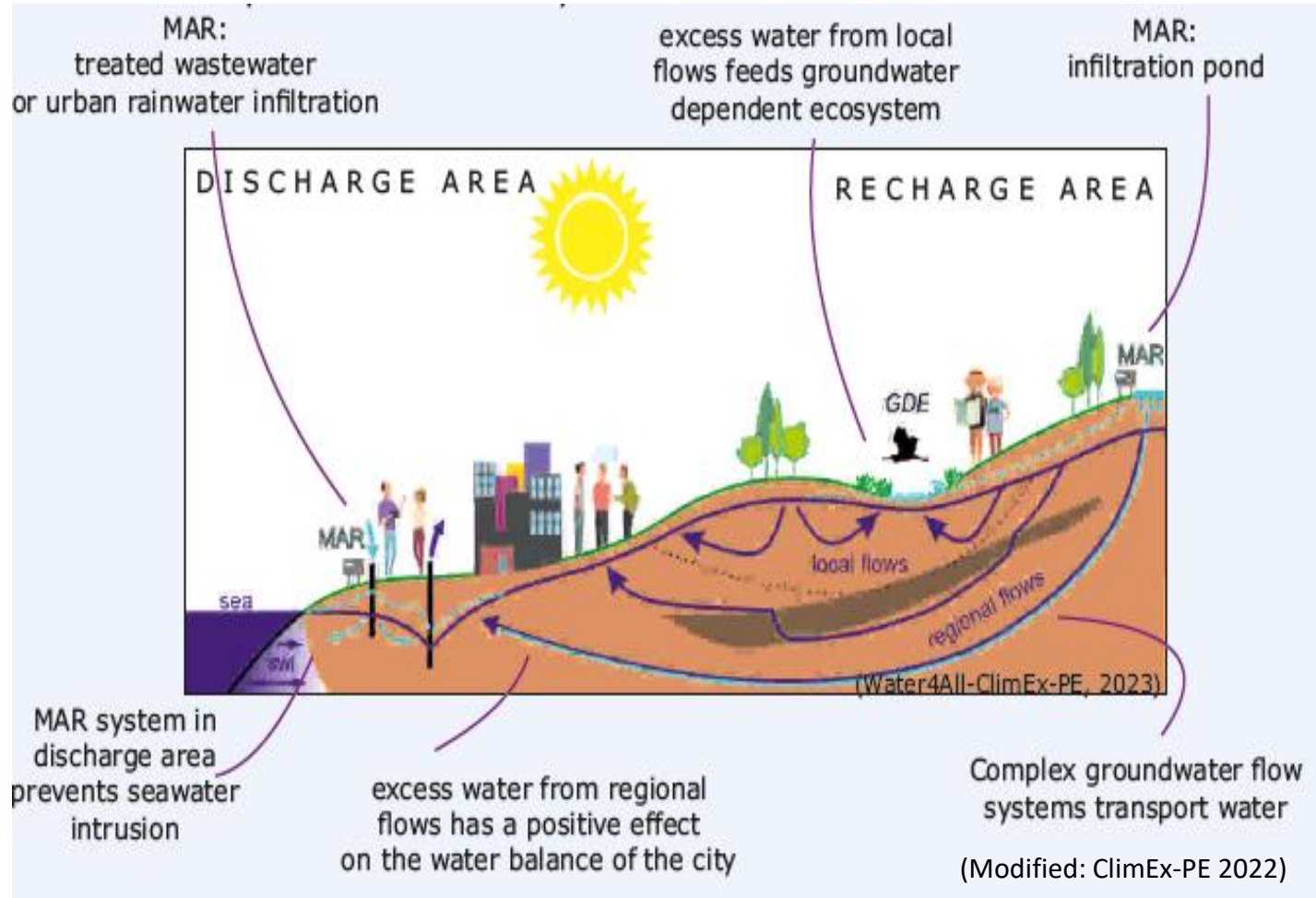
- In the ClimEx-PE project, a new approach is developed to mitigate the impact of extreme events.
- Ensure a safe water supply for humans and ecosystems.



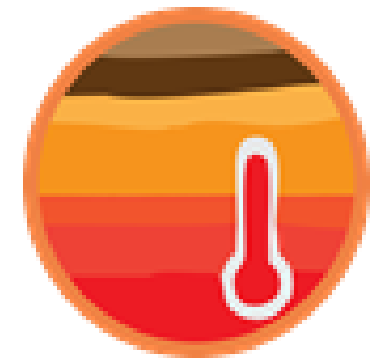
Groundwater: NaBa-MAR approach

The ELTE group developed a **so-called** nature-based **NaBa-MAR** approach/trademark.

- It combines the **natural groundwater flow** processes with **MAR solutions**.
- The invention extends current MAR solutions **to landscape and regional scale**



- Intends to improve **national and international science-based public policy** and **decision-making**
- Enhance **education**, **public awareness** and **stakeholder perception** of groundwater.



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Wrap-up

- Consider physically-based groundwater flow systems
- Do not neglect the groundwater interactions with surface water and all other geofluids
 - More attention to the invisible groundwater in the Missions
- Support inter- and transdisciplinary cooperation in the topics
 - More focus on the synergies of different projects
- Improve education and communication on groundwater

Thank you for your attention!

ELTE-Dunakéke Surface and Groundwater Field table



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