



Regional Training on Flood and Stormwater Adaptation Solutions

C1_REG/ST-6: Adaptation Measures for flood and storm water management

Wednesday 22 April 2026

Nice, France / Online

Nature-Based, Natural Water Retention and Sponge Approaches for Flood and Stormwater Management

Presented by:

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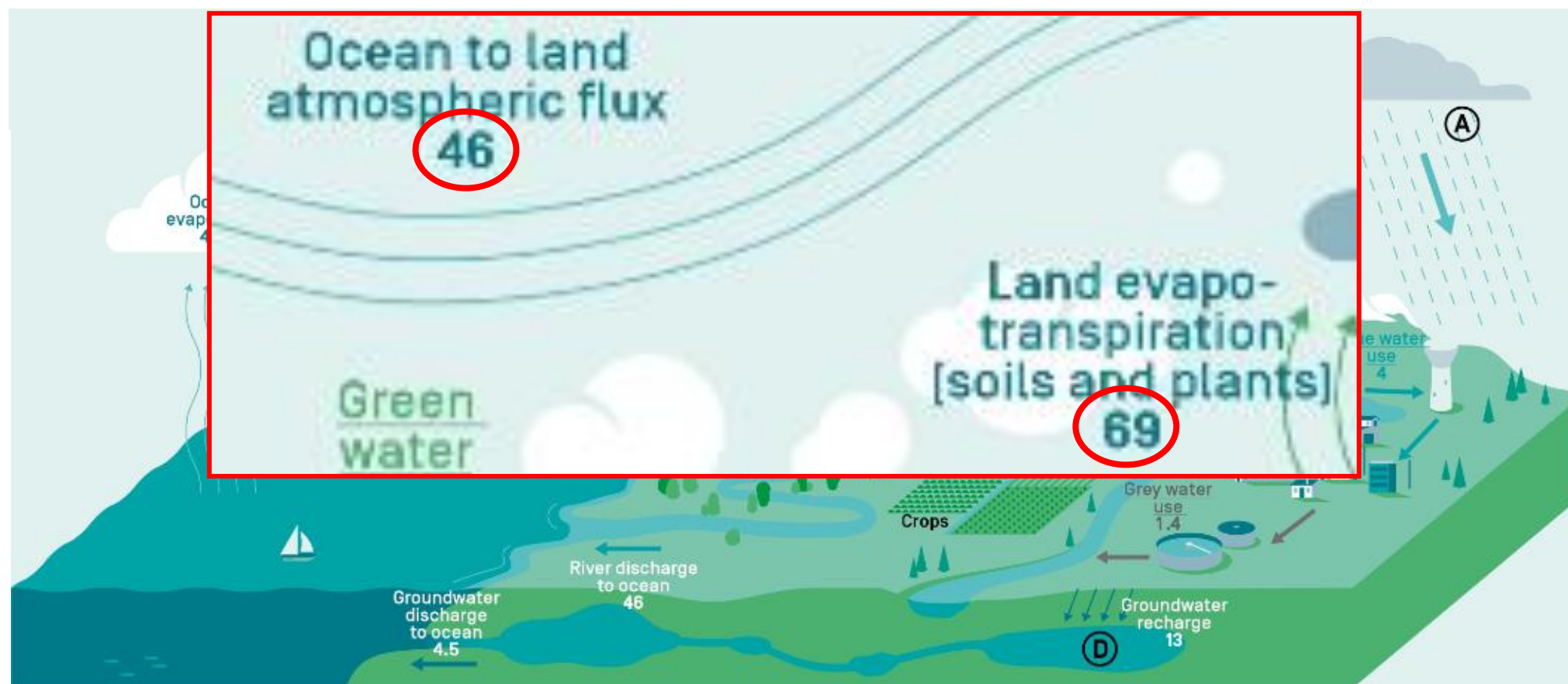
Presentation coverage



- Overview of NBS/NWRM/Sponge approaches for water retention and detention, including key concepts and illustrative measures, alongside reference to relevant engineering approaches
- Main functions, multifunctionality including environmental and social co-benefits
- General design concept and their application across different contexts (urban / peri-urban, rural and river-basin, coastal)
- suitability under Mediterranean conditions and typical application constraints
- Indicative cost category
- Illustrative examples of measures

The water cycle: a complex topic

→ Significant contribution of green water to land precipitation



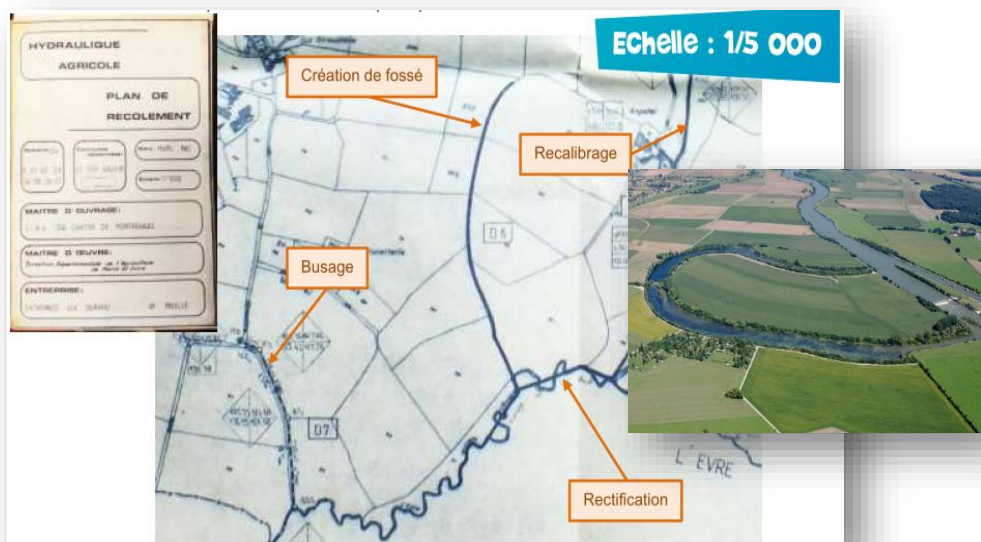
Source: [Inrae](#)

Water flow in landscape: some past trends



Land consolidation

Drainage



Agriculture hydraulics

Urbanisation

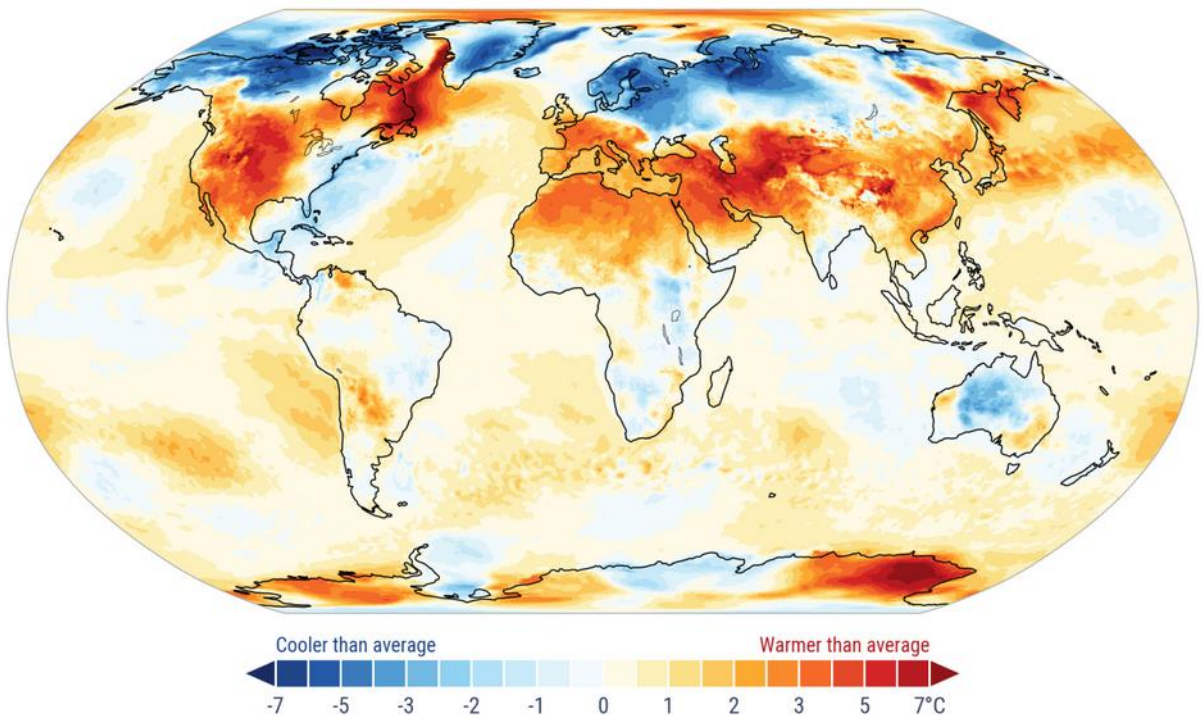


Climate change in Europe

Existing evidence

Surface air temperature anomaly • February 2026

Data: ERA5 • Reference period: 1991–2020 • Credit: C3S/ECMWF



PROGRAMME OF
THE EUROPEAN UNION



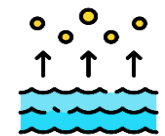
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Anticipated trends



10-30% decrease in precipitation



30% decrease in snow

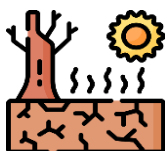


Increase in evapotranspiration



Increase in frequency of droughts

Trend towards decreasing soil
moisture content



Change in seasonal river flow
patterns

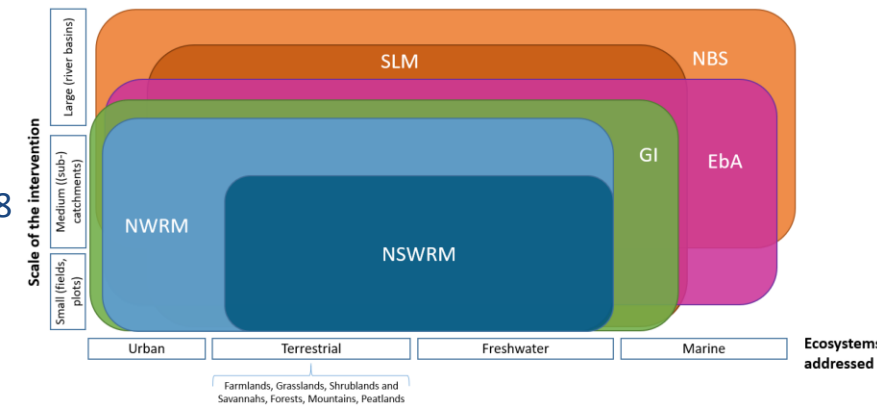
Intense rain events

Recent development in water management

At EU level, progressive maturation of water-related legislation to more integrated approaches to cover better the range of problems and interactions, and integrate recent knowledge development on ecosystem functioning.

- growing interest for a range of solutions inspired by nature (EU & international)
- EU developed the concepts of Green Infrastructure and Natural Water Retention Measure (NWRM) (2011) in support of WFD implementation
- IUCN and EU developed the concept of Nature Based Solution
- Various other institutions developed other similar concepts (NSWRM, SLM, EbA, SUDS, ...)

See for ex <https://www.mdpi.com/2071-1050/16/3/1308>



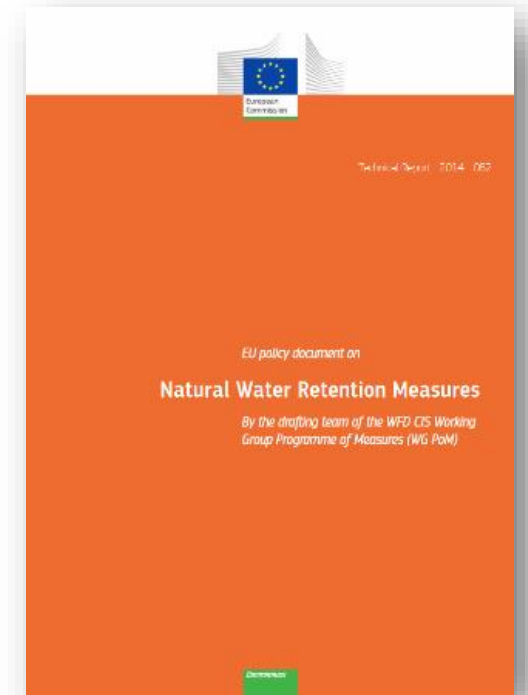
NWRM & Sponge: Origin of the concepts

NWRM

- In 2012, the mid-term review of the Water Framework Directive (*A Blueprint to Safeguard Europe's Water Resources*) highlights that "Natural water retention measures" could contribute significantly
 - to limit the negative effects of floods and droughts
 - and be included in the 1st pillar of the CAP 2014-2020
- Projects to support its development:
 - 2012 and 2013 (EC): NWRM for the implementation of the water and green infrastructure directives
 - 2013-2015 ...2019 (OIEau et al.): NWRM pilot project
 - 2014 (EC): Community policy document on NWRM
 - 2014 (EC): inclusion of the list of NWRM in CAP annex

Sponge

- **"Sponge theory"** existed already •for wetlands since 18th century and amongst foresters in the 19th century
- In the **early 2000s** **"sponge cities"** were tested by Kongjian Yu, a Chinese landscape architect
- In 2022 HORIZON programme - *Boost **the sponge function of landscape** as a way to improve climate-resilience to water management challenges*



[EU NWRM policy document](#)

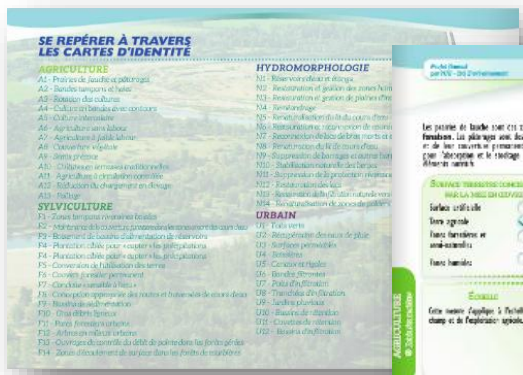
The knowledge hub nwrn.eu

- A technical guide and annexes (15 languages)



<http://nwrn.eu/implementing-nwrn/practical-guide>

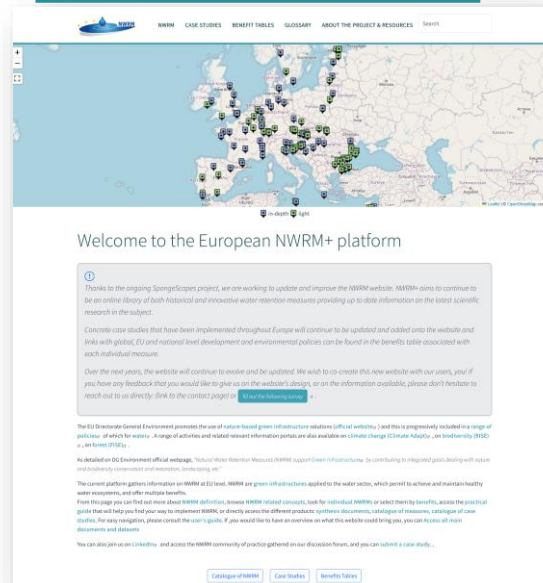
...with an organised list of measures



...a fiche for each of the 53 mesures



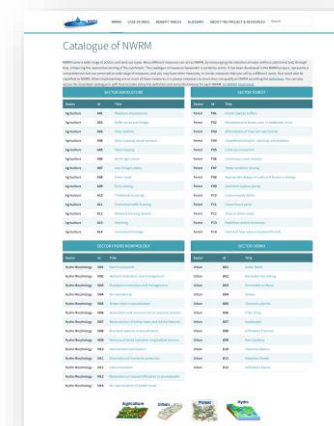
<http://nwrn.eu>



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➤ 53 NWRM measures:
<http://nwrn.eu/measures-catalogue>



A central hub at the EU level to:

- Understand NWRM definitions
- Browse concepts and individual measures
- Search by benefits, concepts or sectors
- Access synthesis documents, case studies, and guides
- Possibility to send your own case study
- Possibility to join the NWRM Community of Practice
- Participate via LinkedIn group and forum

- Transferred to **Wise Nature based solutions for water retention**
- Updated in a **Sponge Knowledge Platform**

NWRM: a catalogue of 53 measures in 4 sectors

Agriculture



A1 – Meadows and pastures

Hydromorphology



N3 – Floodplain restoration and management

Urban



U1 – green roof

Forest



F5 – Land use conversion

→ **Updated in 2025** in a sponge measures catalogue with new measures (beaver mimicry, check dams...) and updated measures (low till agriculture...)

Benefits of NWRMs

NWRM could have many positive effects on the environment:

➔ They must have multi-benefits to qualify NWRM



		ES: Ecosystem Services Benefits													
		ES1	ES2	ES3	ES4	ES5	ES6	ES7	ES8	ES9	ES10	ES11	ES12	ES13	ES14
		Provisioning			Regulatory & Maintenance						Cultural		Abiotic		
		Water Storage	Fish Stocks and Recruiting	Natural Biomass Production	Biodiversity Preservation	Climate Change Adaptation and Mitigation	Groundwater/Aquifer Recharge	Flood Risk Reduction	Erosion/Sediment Control	Filtration of Pollutants	Recreational Opportunities	Aesthetic/Cultural Value	Navigation	Geological Resources	Energy Production
Legend: Qualitative Scale			High												
			Medium												
			Low												
			None												
			Negative												
A1	Meadows and Pastures														
A2	Buffer Strips and Shelter Belts														
A3	Crop Rotation														
A4	Strip Cropping														
A5	Intercropping														
A6	No Tillage														
A7	Reduced or Conservation Tillage														
A8	Green Cover														
A9	Early Sowing														
A10	Traditional Terracing														
A11	Controlled Traffic Farming														
A12	Reduced Stocking Density														
A13	Mulching														

Matrix example:
“Ecosystems services
for the Agriculture
sector’s measures”

2013-Looking Ahead: EU research projects SpongeScapes and SpongeWorks

... in the field you hear things you don't see in literature... Evidences?

Some nice numbers:

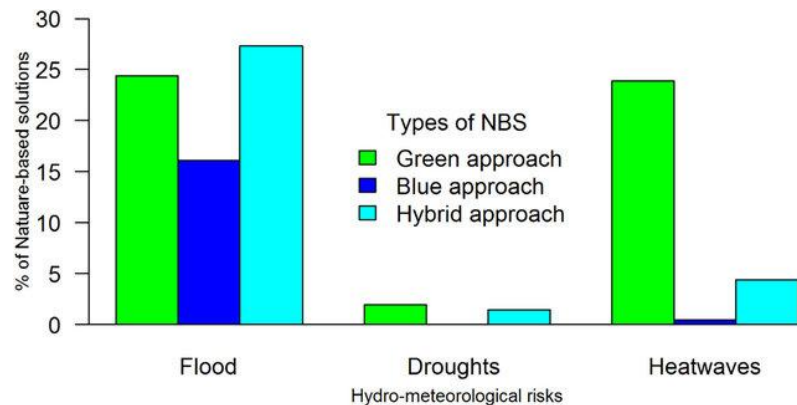
- Infiltration rate from 4,5 min to 23 seconds
- Bird diversity from 44 to 89
- 17 K€ woody dam or 4 M€ dredging project
- From 16,5 days in 1850 to 9 hours now (lowland stream of sandy soil and 50km)
- 'the only grazing place left'
- 'peace of mind'
- 'I've not been flooded this year'



Photo: David Gasca – Blenheim Estate

How about the evidence?

While there is **substantial scientific evidence supporting the sponge functioning concept**, the effectiveness of landscape-based flood and drought mitigation may vary depending on the specific local conditions, climate, and land use practices. It's essential to consider the local context and consult with experts when implementing landscape management strategies for water regulation and risk reduction.

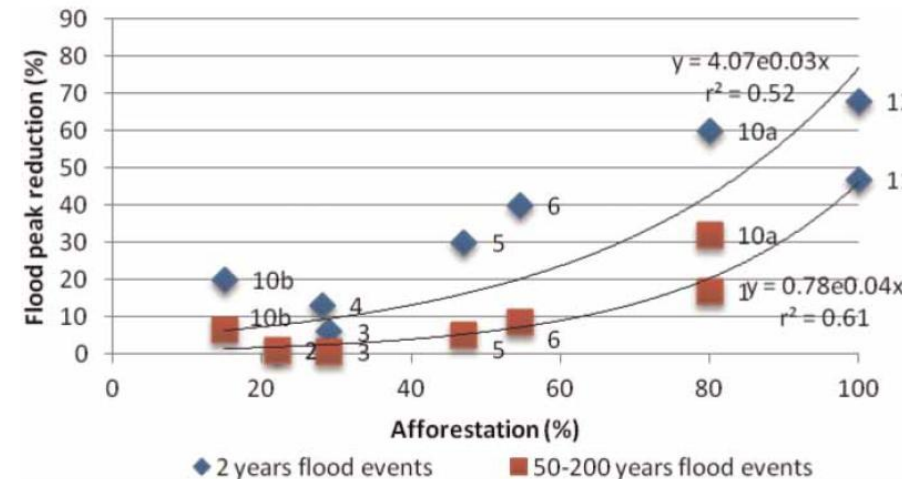


(Sahani et al 2019 <https://doi.org/10.1016/j.scitotenv.2019.133936>)

database	#cases	F&D	F&D&B	F&B	D&B
Nwrm.eu	140	8	5	18	7
World Bank	72	12	7	23	9

<http://www.nwrm.eu/>
<https://naturebasedsolutions.org/projects>

(Penning et al, 2023 –doi:10.1017/wat.2023.12)



Iacop et al 2014 doi: 10.2166/nh.2014.184



Deliverable 1.1 Critical review of existing knowledge on sponge functions for different climatic zones, soils and land uses in Europe

29/11/2024

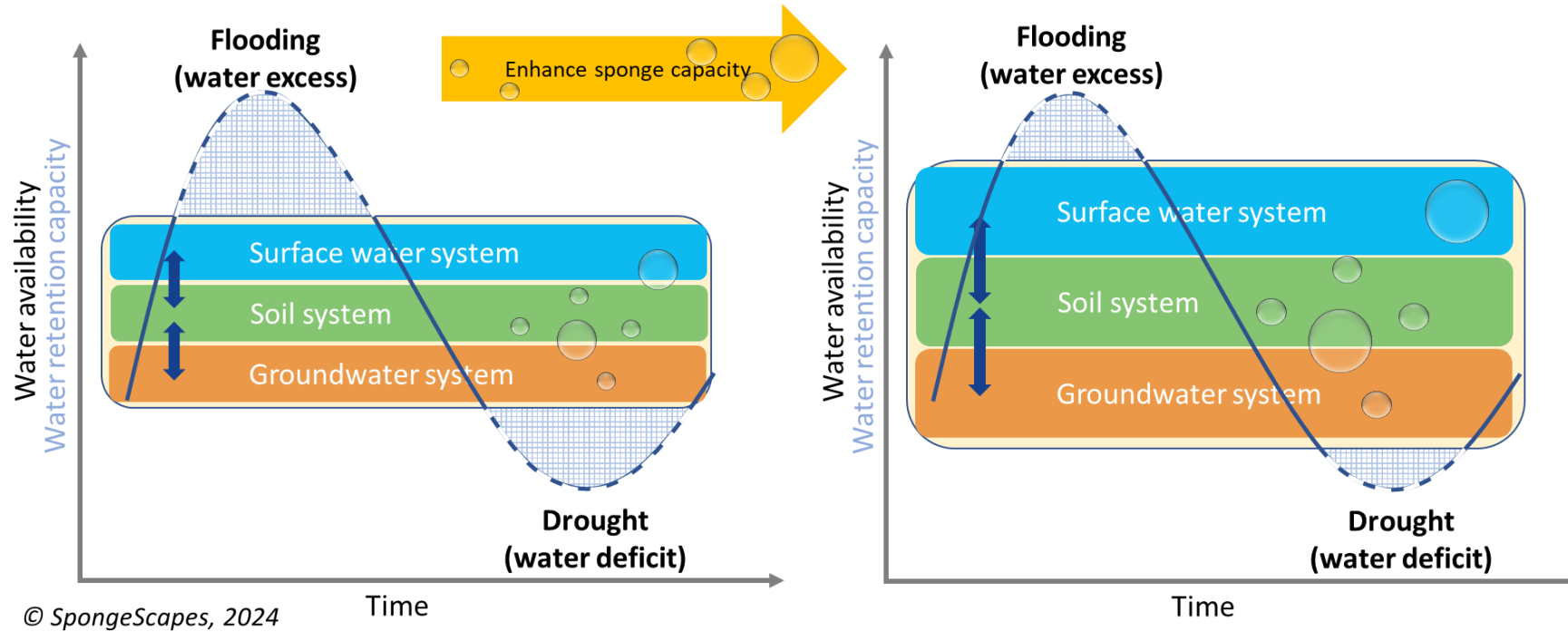


Study	Sponge Measure	Location/Region	Observed (O) or Modelled (M) Effect	Flood & Drought Management Benefit
Majidi et al. (2019); Ruangpan et al. (2020)	Water retention ponds, vegetated buffer strips	General (Urban, Agricultural)	Reduced flood volume, peak, and delay; increased infiltration and soil water retention.	Flood reduction, increased water retention and infiltration.
Lockwood et al. (2022)	Offline ponds	Tone & Parrett catchments, SW England	Attenuation of peak flows from 3% when ponds are filled by rain/runoff to 7% when filled from channel [O]	Flood reduction
Nauta et al. (2024), Waterloo et al. (2019)	Wetland restoration	Kylldal catchment, Germany	12-24% reduction in annual maximum peak flows; increased low flows by up to 21% in summer/fall, suggesting drought risk reduction. [JM]	Flood reduction, drought risk reduction.
Kurki-Fox et al. (2022)	Wetlands, river basin afforestation	Neuse River Basin, North Carolina, USA	6-9% reduction in runoff, 5% reduction in peak flow at sub-watershed level.	Flood and drought risk reduction.
Frédéric Paran (2024)	Wetland restoration	General	Limited effect on summer low flows but effective in retaining high flows after dry periods.	Drought and flow regulation, seasonal flow retention.
Ottermann et al. (2017)	restored floodplains, wetlands, peatlands	Rhine basin	Reduced peak flows 5-8%	Flood reduction
Shuttleworth et al. (2019)	Peat restoration	N England	27% reduction in peak flows, longer lag times >100% increase [O, M]	Flood reduction
URBAN				
Baggio et al. (2023)	Rain gardens, bio-retention areas	Veneto Region, Italy	>98% runoff retention in two years of data, even for extreme rainfall events (up to 15-year return periods).	Pluvial flood mitigation, stormwater retention.
Cerema (2020)	Schoolyard greening, de-impermeabilization	France	Reduces stormwater runoff and provides co-benefits like heat reduction and improved health for children.	Flood reduction, heat island mitigation, health benefits.
Kõiv-Vainik et al. (2022)	Bioretention systems (ponds, rain gardens, swales)	General	40% reduction in peak discharge (though data on real-world runoff retention often missing, especially in cold climates).	Flood reduction, stormwater management.
Kõiv-Vainik et al. (2022)	Permeable pavements	Warm and wet climate conditions	75-80% reduction in stormwater runoff.	Flood reduction, stormwater management.
Quagliolo et al. (2021)	Green parking, rain gardens	Rapallo, Italy	69-71% average water retention capacity in urban scenarios.	Urban flood vulnerability reduction.



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Sponge functioning - hypothesis

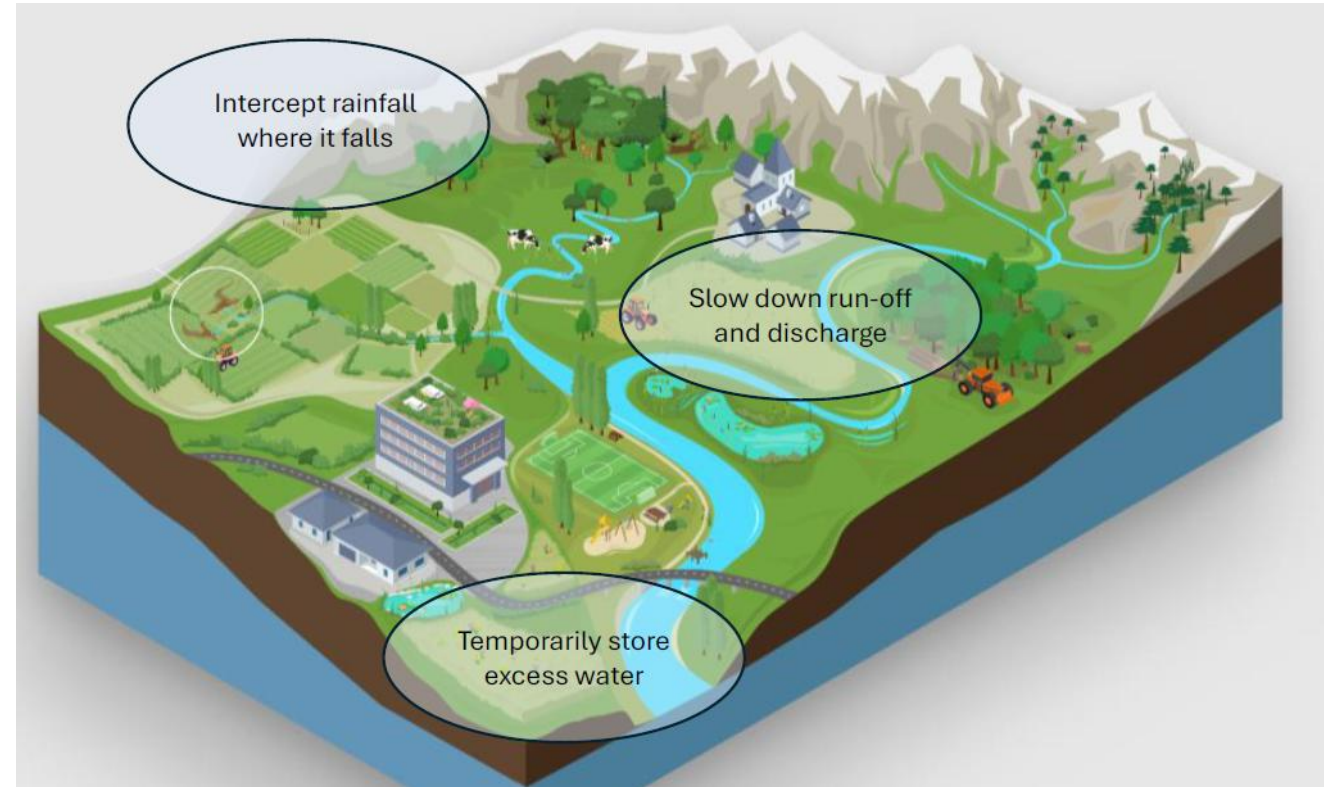


www.nwrm.eu

Sponge principles

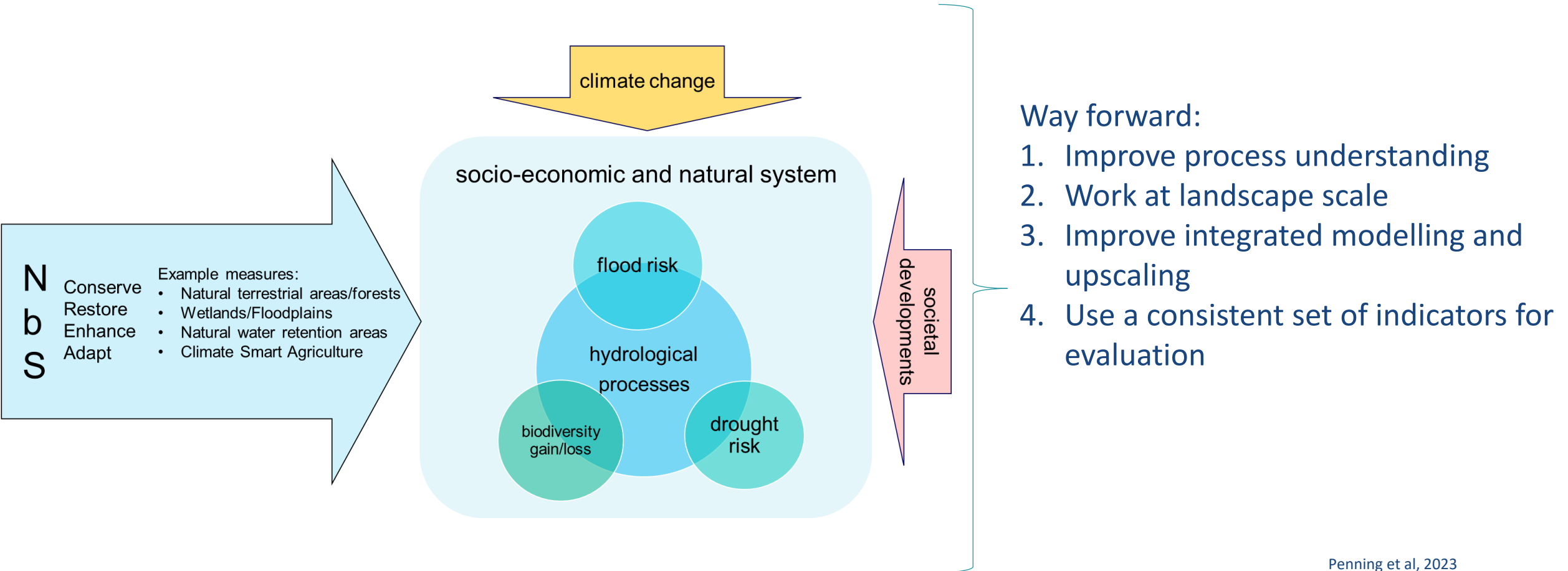
There are three main sponge principles:

1. Reduce the formation of runoff by intercepting rainfall where it falls and stimulating infiltration into the soil,
2. Slow down the runoff that has formed on the surface, is drained from groundwater, or is channelised in streams, and
3. Temporarily store excess water in the soil, groundwater or surface water bodies.



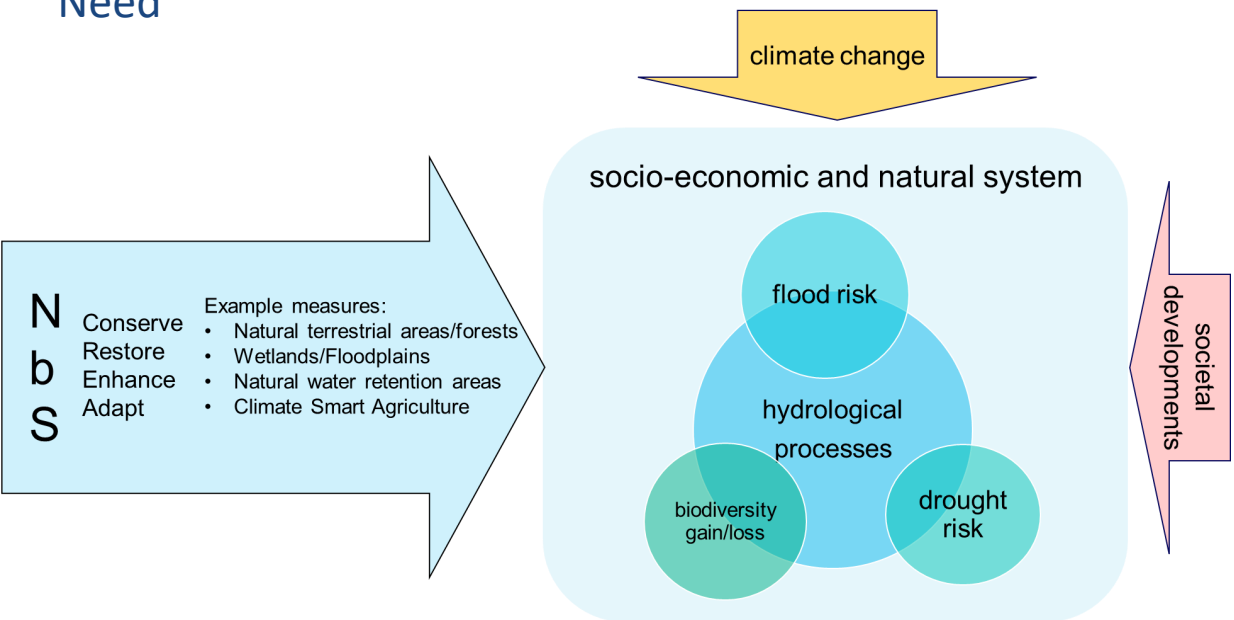
<https://www.spongescapes.eu/deliverables>

Hydrological processes & NbS at the core

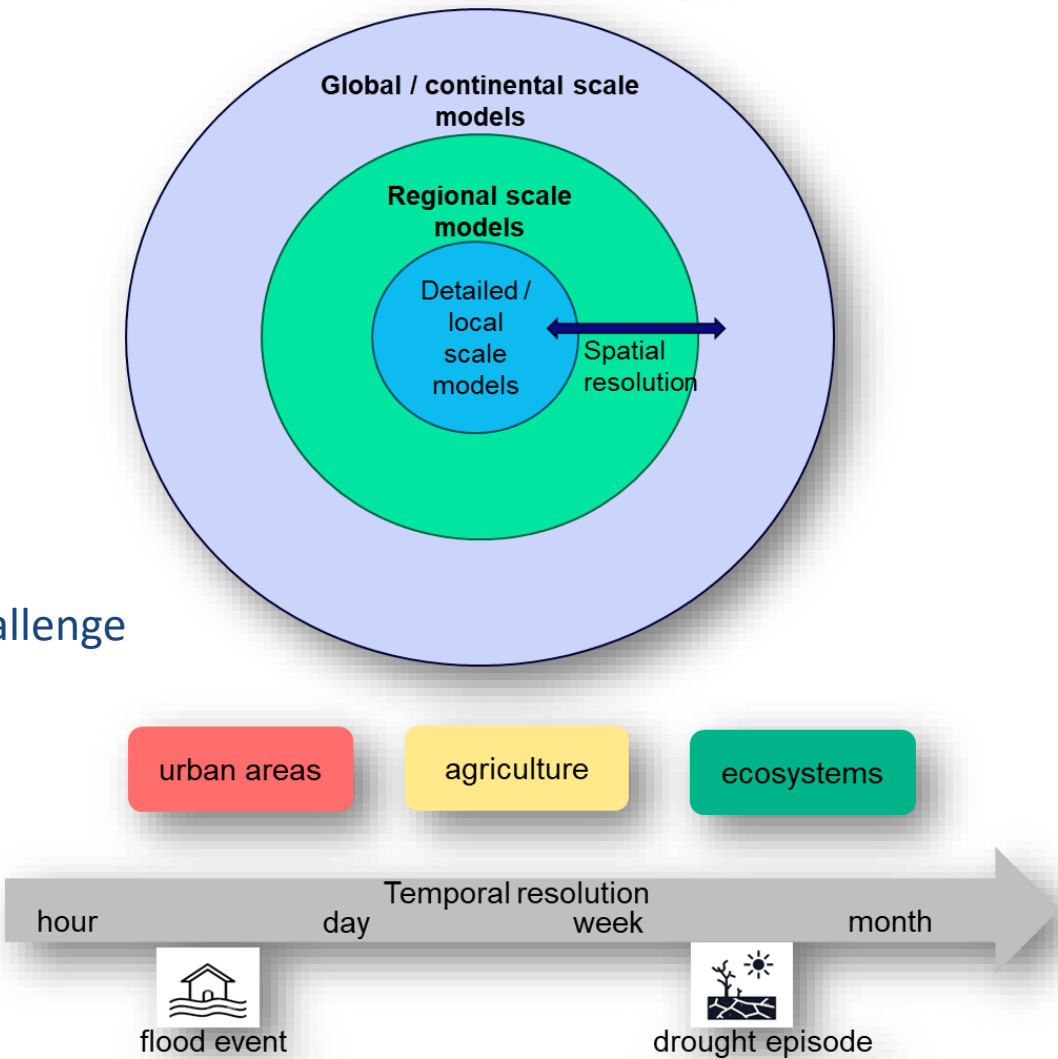


Quantifying Sponge Measures for Floods AND Droughts AND Biodiversity

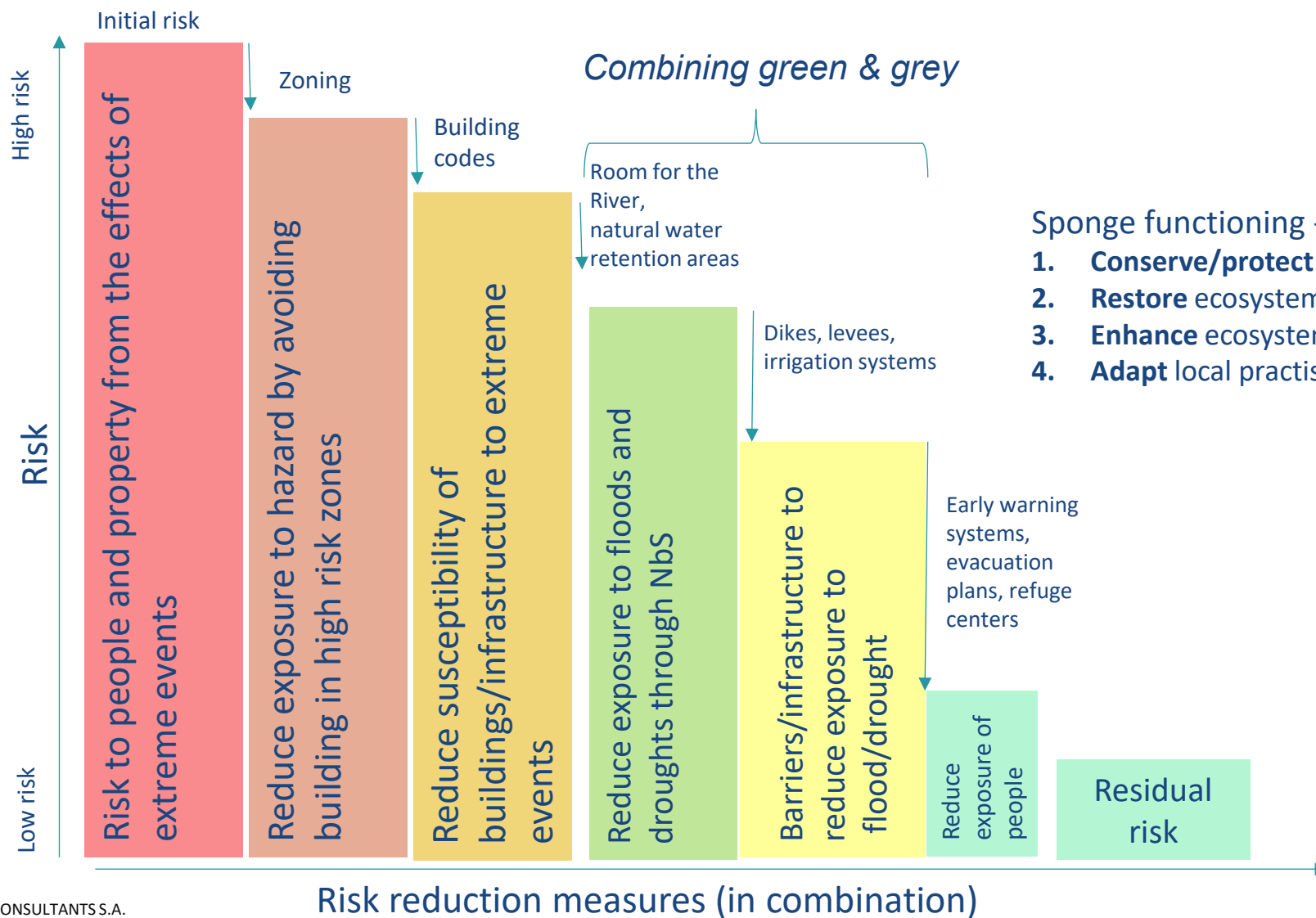
Need



Challenge



Where do sponge measures fit in?

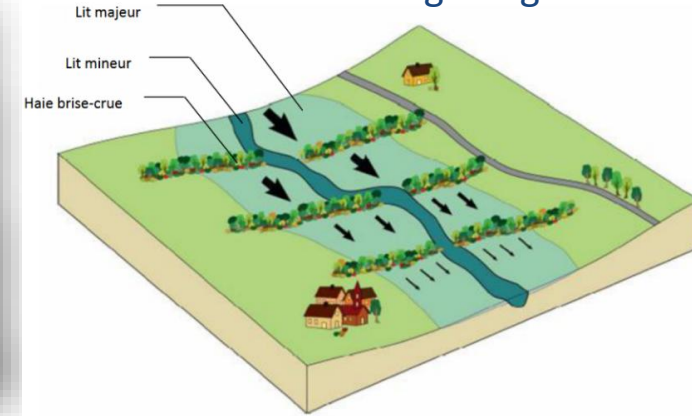


Sponge functioning - priorities

1. **Conserve/protect** ecosystem functioning and services
2. **Restore** ecosystem functioning and services
3. **Enhance** ecosystem functioning and services
4. **Adapt** local practises/use of ecosystem services

SpongeScapes/Spongeworks Example – Agriculture & Hydromorphology – La Lèze (FR, Smival)

Floodbreaking hedgerows



Buffer strip along a crop field and forest riparian buffer



Agriculture hilly landscape



With erosion issues...



- A long and narrow river, 350km²
- Recent shift in agriculture
- Large crop fields
- Irregular rainfalls (600-1000mm/y)
- An approach at river basin scale
 - Floodbreaking hedgerows
 - Leaky dams
 - Hedges
 - Agriculture practices (low till, green cover...)
 - Urban measures
 - ...

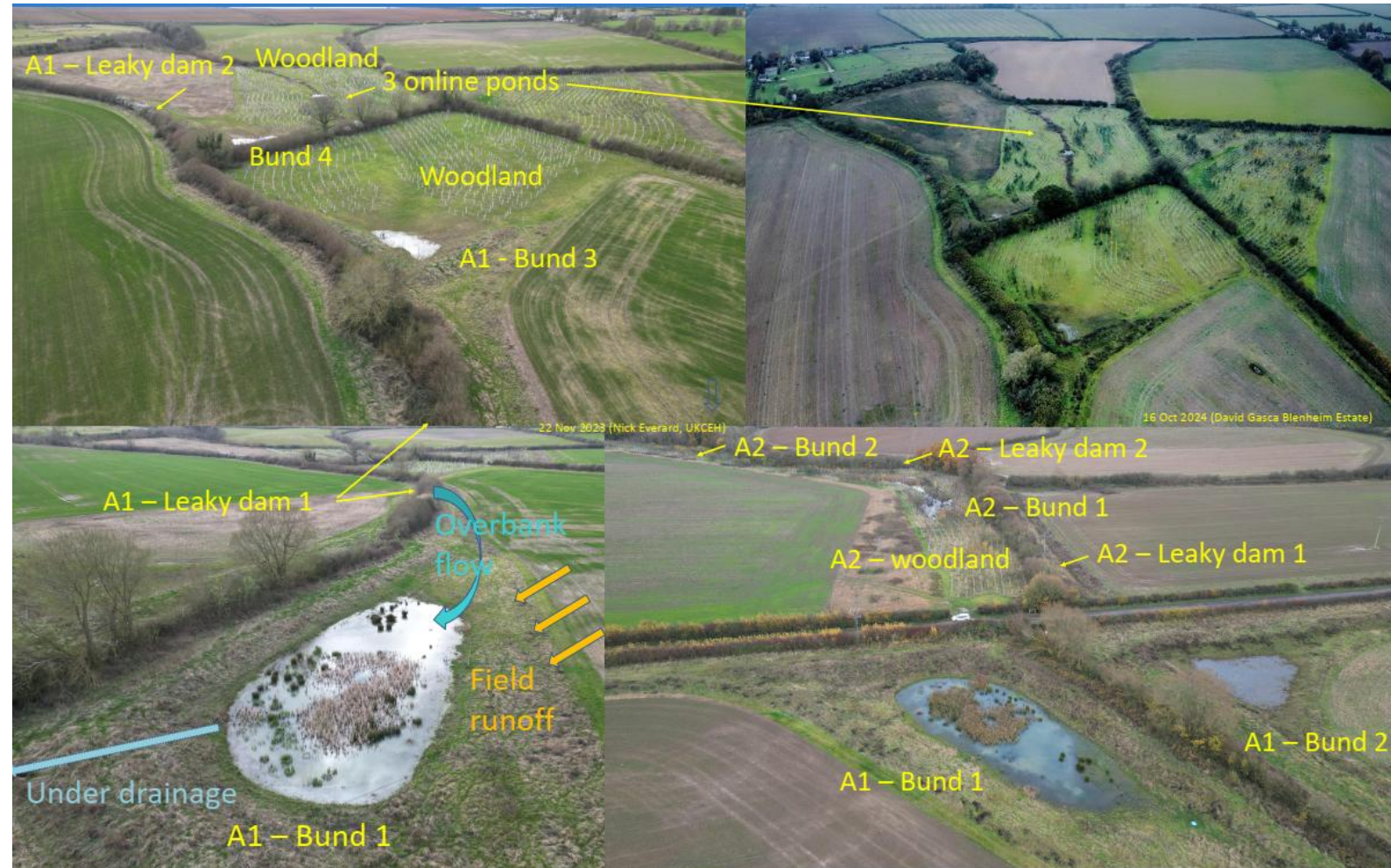
SpongeScapes Example – Agriculture & Hydromorphology – Littlestock (UK, CEH)



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- A narrow river constrained by buildings
- Recurrent flooding
- An approach at river basin scale
 - Woodland
 - Retention pond
 - Leaky dam + overbank flow
 - Bunds and permanent grass



Source: SpongeScapes project posters, CEH

SpongeScapes Example – Forest: Bosco limit (IT, Etifor)

- Started in 2013
- 2,5 ha converted for 20y
- 2,300 trees selected (venetian forest)
- Forest Infiltration Area (FIA)
- 1,200m waterway, **infiltrate 1Mm³/y**
- Multifunction:
 - protect water and recharge groundwater,
 - Reduce impact of use of chemicals,
 - produce biomass,
 - reconstitute fertile soil,
 - promote biodiversity...



Source: <https://www.etifor.com/en/portfolio/boscolimite/>

SpongeScapes Example – Hydromorphology – Check dams on Paros island (EL, WWF)

- Intermittent rivers
- Drought and unsustainable water use
- Use of 34 traditional stone check dams
- Multifunction:
 - recharge groundwater,
 - Enhance biodiversity
 - Increase vegetation
 - ...



Source: SpongeScapes project posters, WWF greece

Examples of Urban measures

- Effectively **Sustainable (urban) Drainage Systems**
- Although can be applied outside of urban areas!



Green roof



Infiltration trenches



Swale



Infiltration pave way



Retention basin



Stockholm trenches



SpongeScapes Example – Urban – (Agripolis & Santorso, IT, Padova uni.)



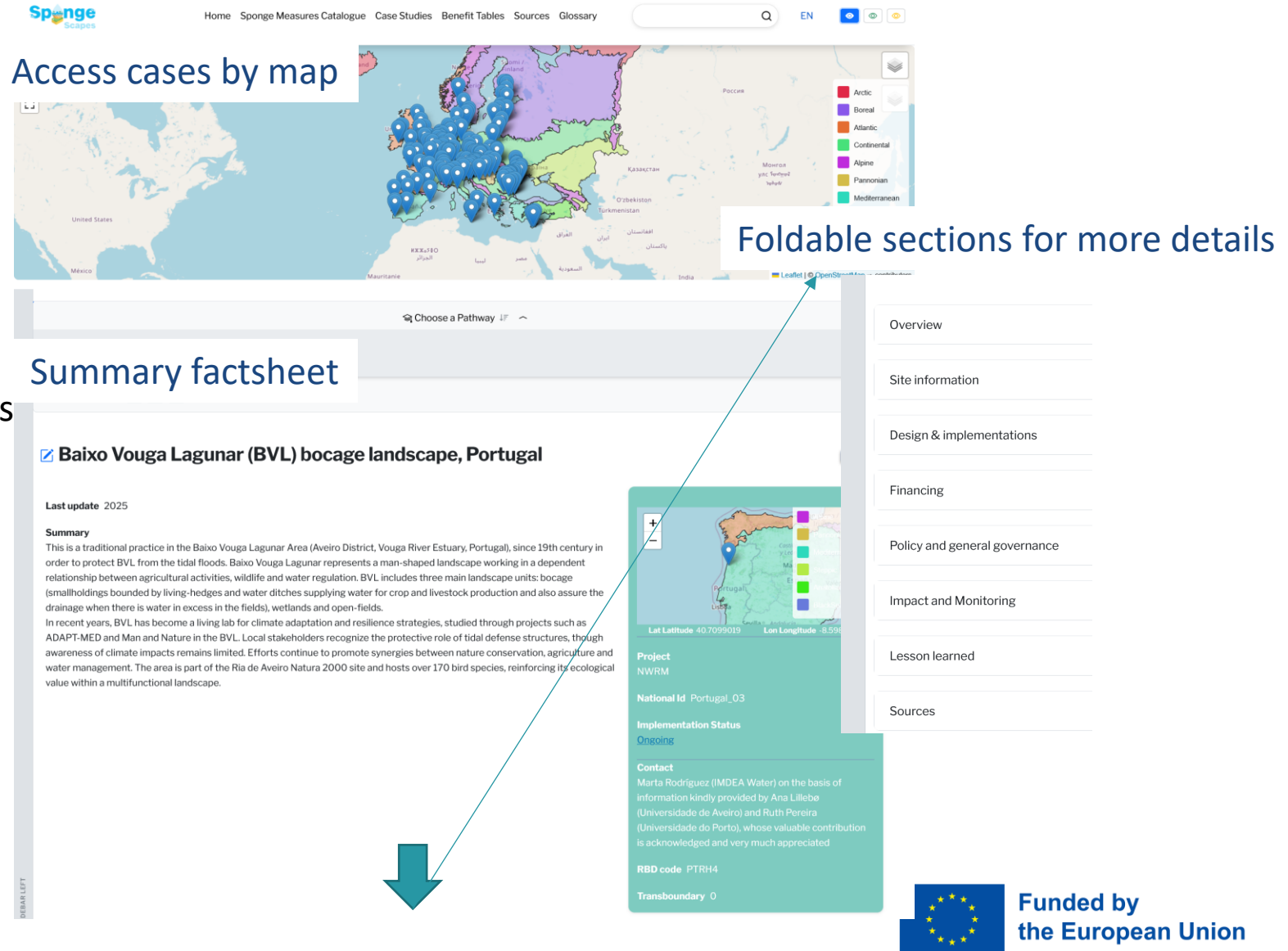
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- Veneto region from mountains to plain, North of Italy
- Pluvial flooding, droughts, landslides, erosion
- Test, monitor and improve
- An approach at the city and its surrounding catchment scale
 - Rain garden
 - Bioretention
 - Swales
 - Retention pond in rural suburb
 - Rain garden at university



NWRM/SpongeScapes Case studies catalogue

- A catalogue gathering 180 cases
- Linked to sponge measures factsheets
- Access by location, name, or summary
- A set of search criteria
- To be expanded further with new cases



The screenshot displays the NWRM/SpongeScapes Case studies catalogue interface. At the top, the navigation bar includes links for Home, Sponge Measures Catalogue, Case Studies, Benefit Tables, Sources, and Glossary, along with a search bar and language options (EN, ES, PT). The main content area is titled "Access cases by map" and features a world map with a legend for various regions: Arctic, Boreal, Atlantic, Continental, Alpine, Pannonian, and Mediterranean. A callout box labeled "Foldable sections for more details" points to a sidebar on the right containing a list of sections: Overview, Site information, Design & implementations, Financing, Policy and general governance, Impact and Monitoring, Lesson learned, and Sources. Below the map, a "Summary factsheet" for the "Baixo Vouga Lagunar (BVL) bocage landscape, Portugal" is shown. The factsheet includes a "Last update" of 2025 and a "Summary" section describing the traditional practice of BVL in the Aveiro District, Portugal, since the 19th century. It highlights the man-shaped landscape's role in protecting BVL from tidal floods and its importance for agriculture, wildlife, and water regulation. The factsheet also mentions that BVL has become a living lab for climate adaptation and resilience strategies, studied through projects like ADAPT-MED and Man and Nature in the BVL. Local stakeholders recognize the protective role of tidal defense structures, though awareness of climate impacts remains limited. Efforts continue to promote synergies between nature conservation, agriculture, and water management. The area is part of the Ria de Aveiro Natura 2000 site and hosts over 170 bird species, reinforcing its ecological value within a multifunctional landscape. A callout box labeled "Summary factsheet" points to the factsheet content. A large blue arrow points from the factsheet to the bottom right corner of the page.

Access cases by map

Foldable sections for more details

Summary factsheet

Baixo Vouga Lagunar (BVL) bocage landscape, Portugal

Last update: 2025

Summary

This is a traditional practice in the Baixo Vouga Lagunar Area (Aveiro District, Vouga River Estuary, Portugal), since 19th century in order to protect BVL from the tidal floods. Baixo Vouga Lagunar represents a man-shaped landscape working in a dependent relationship between agricultural activities, wildlife and water regulation. BVL includes three main landscape units: bocage (smallholdings bounded by living-hedges and water ditches supplying water for crop and livestock production and also assure the drainage when there is water in excess in the fields), wetlands and open-fields.

In recent years, BVL has become a living lab for climate adaptation and resilience strategies, studied through projects such as ADAPT-MED and Man and Nature in the BVL. Local stakeholders recognize the protective role of tidal defense structures, though awareness of climate impacts remains limited. Efforts continue to promote synergies between nature conservation, agriculture and water management. The area is part of the Ria de Aveiro Natura 2000 site and hosts over 170 bird species, reinforcing its ecological value within a multifunctional landscape.

Project
NWRM

National Id
Portugal_03

Implementation Status
Ongoing

Contact
Marta Rodríguez (IMDEA Water) on the basis of information kindly provided by Ana Lillebe (Universidade de Aveiro) and Ruth Pereira (Universidade do Porto), whose valuable contribution is acknowledged and very much appreciated

RBD code
PTRH4

Transboundary
0

Funded by the European Union

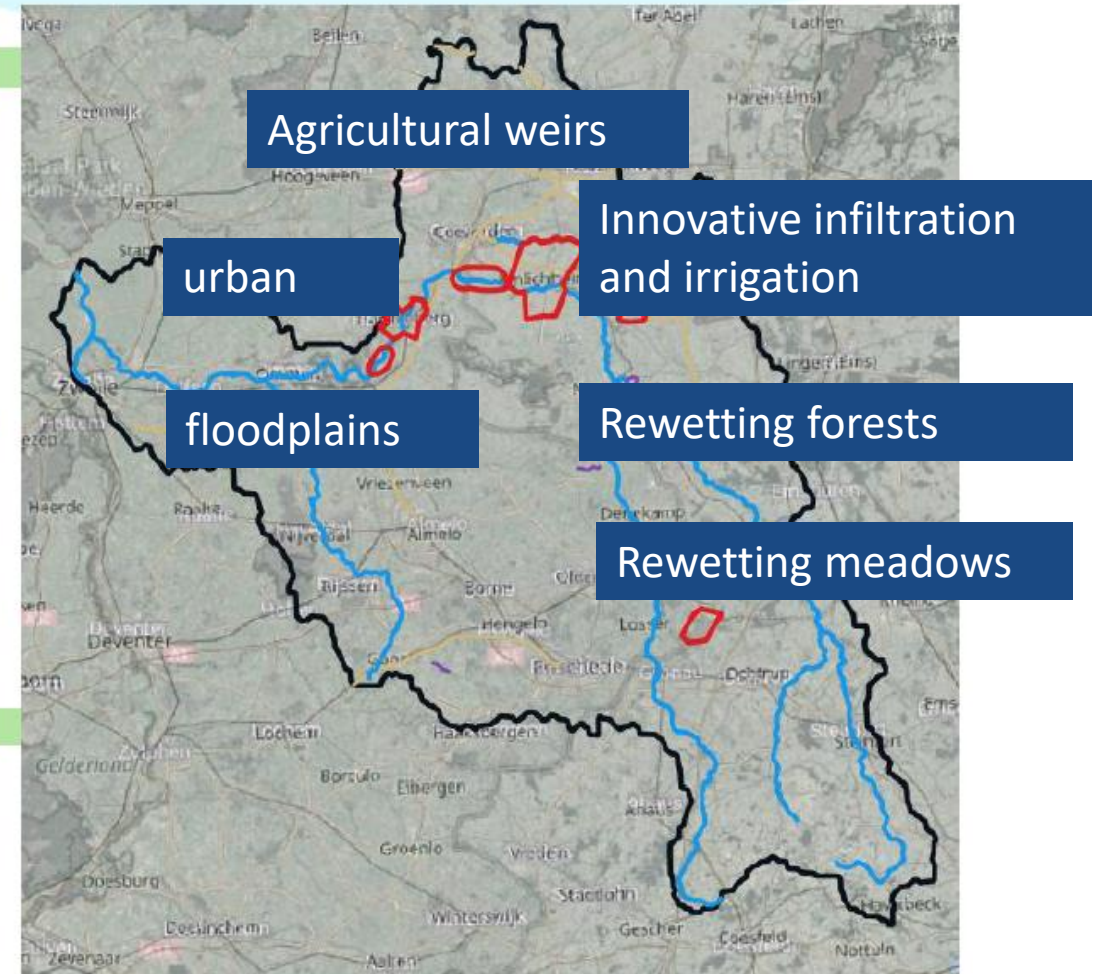
SpongeWorks Example – Vecht basin

Location and characteristics

- The cross-border Vecht basin (Germany – the Netherlands)
- Area: 4,190 km², approximately 55% of the basin in the Netherlands and 45% in Germany.
- River length: 167km (107km in DE and 60km in NL),
- Average annual rainfall: 800mm
- Land use: agriculture (55%), grassland (22%), forests (10%) and urban areas (10%), and wetlands (2%).
- Total population: 2.3 million people live in the basin (1.5 million in DE, 0.8 million in NL).

Key challenges

- Surface and groundwater quality and quantity improvement.
- Mitigation of impacts from climate extremes (floods and droughts).
- Quality of life and awareness



Take away message

3 key principles, 1 motto



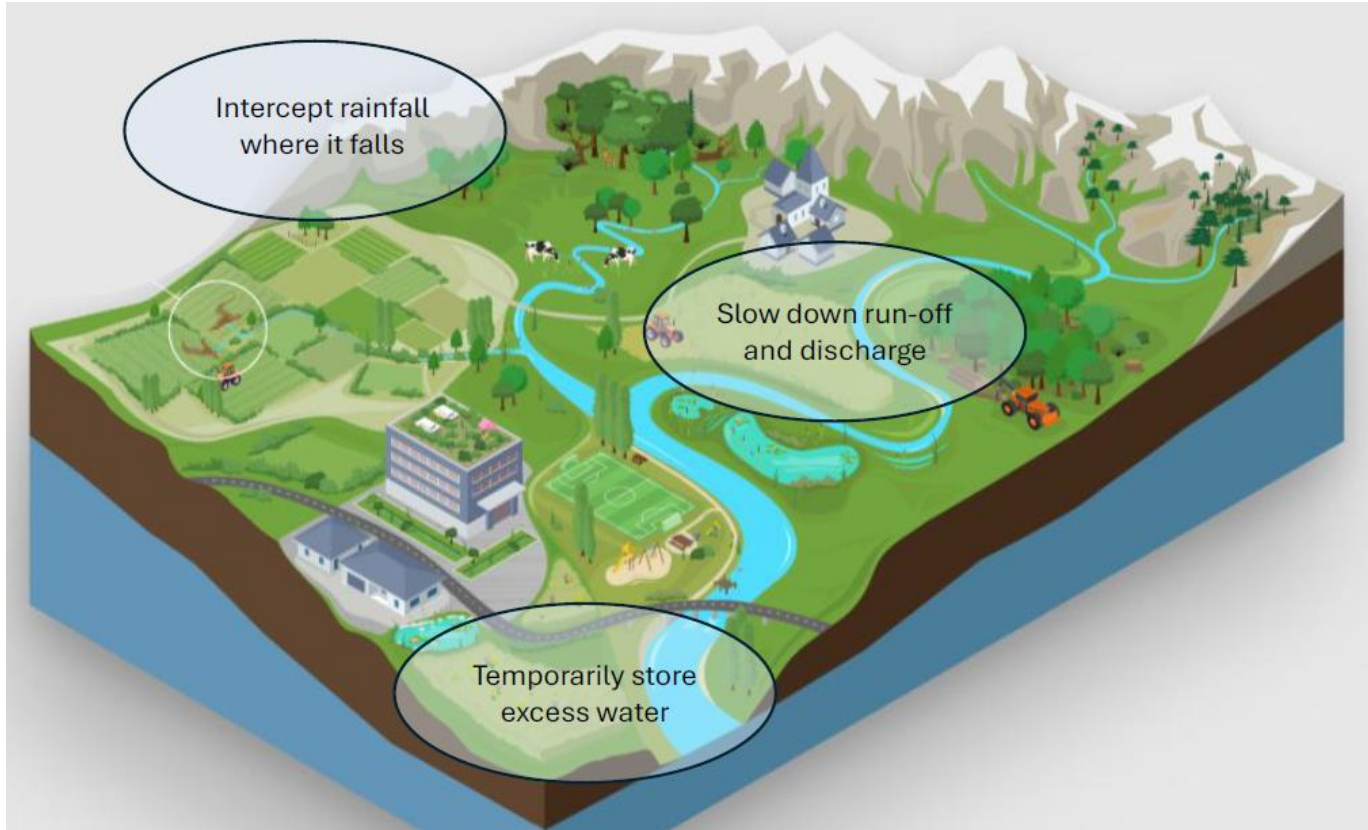
future

current

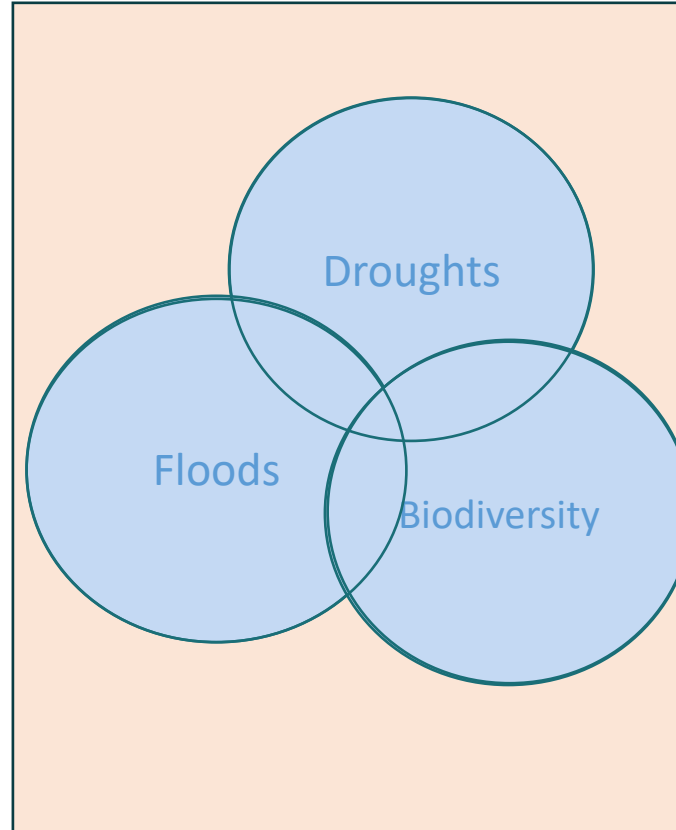
Droughts

Floods

Biodiversity



<https://www.spongescapes.eu/deliverables>



'Green where you can, Grey where you must'



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