Sponge Scapes

Evidence and Solutions for improving **SPONGE** Functioning at Land**SCAPE** Scale in European Catchments for increased Resilience of Communities against Hydrometeorological Extreme Events

How do Sponge Measures Work? Monitoring & insights from the field

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Funded by the European Union

UK Research and Innovation

UK Centre for Ecology & Hydrology

SpongeScapes in short

5
Years
2023 - 2027

3
Million Euro
(Horizon Europe and
UKRI funding)

Funded by
the European Union

UK Research
and Innovation

10
European partners
Deltares project
coordinator

14
Case Studies
across 7 EU countries

Sponge measures?

Sponge measures **absorb**, **store**, and **slowly release** water, mitigating floods and droughts and providing lasting benefits.

SpongeScapes objective?

Accelerate towards solutions that improve the sponge functioning of soil, groundwater, and surface water landscapes.

Upscale individual “sponge measures” into overarching “**sponge strategies**” at the landscape scale.

SpongeScapes Case Studies

- **14 case studies**

1. Chaamse beken catchment (NL)
2. Aa and Maas catchment (NL)
3. Riseholme stream (UK)
4. Evenlode catchment (UK)
5. New Forest & Cole catchments (UK)
6. Upper Thames agricultural sites (UK)
7. Upper Biebrza catchment (PL)
8. Lèze catchement (FR)
9. Timonchio site (IT)
10. Municipality of Santorso sites (IT)
11. Agripolis site (IT)
12. Bosco Limite (IT)
13. Gradaščica catchment (SI)
14. Kavouropotamos stream (GR)

- **4 different climatic zones**

- *Atlantic Central*
- *Nemoral*
- *Mediterranean North*
- *Mediterranean South*
- *Mediterranean Mountains*
- *Alpine South*

- **140 recorded cases** of sponge measures
- **3 different sponge measure categories** (surface water, surface-groundwater, and soils-vegetation)
- **diverse soils** (sandy, silty, clayey, peaty, calcareous)

➔ monitor their performance under different types of hydrometeorological events

Monitoring (well) - why?

"If you do not measure it, you cannot manage it" – Peter Drucker

Or...if you do not monitor appropriately, then you cannot:

1. **Have a baseline before implementation to compare it with**
2. **Assess performance, benefits (and unintended consequences)**
3. **Plan maintenance!**

Design the monitoring according to:

1. **Aims of measures (longer-term)**
2. **Indicators that are representative (monitoring locations & frequency)**
   i. Measurable and scientifically credible
   ii. Comparable within a range of field settings across different sectors
   iii. Replicable and scalable
   iv. Meaningful to all key stakeholders
   v. Combine simple, minimum required (for sustainably monitor longer-term & lower frequency; citizen science?) with more technical/golden standard (statutory/research organisations)

Monitoring - General Framework (SpongeScapes/Works)

SpongeScapes: co-developed Indicators:

- **Guided by Water Retention 'Sponge Function' first**
- **Combined literature review, expert process understanding, and local contexts of 14 Case studies from 6 European ecoregions**
- **Hierarchy based on (i) key processes; (ii) ease to measure/estimate; and (iii) transversal to Case Studies types**
- **Determined 3 sponge measure typologies:**
  a) **Surface Water** measures; e.g., river floodplain reconnection, ponds and wetlands
  b) **Surface-Groundwater** interconnection; e.g., dams and swales to infiltrate & recharge groundwater
  c) **Soil-Vegetation** systems; e.g., regenerative agriculture practices

TYPOLOGIES OF SPONGE MEASURES

SURFACE WATER

Runoff Attenuation Features (RAFs): field corner bunds, ponds, constructed wetlands

Floodplain reconnection: leaky dams, infilling, remeandering

SURFACE-GROUNDWATER

RAFs for groundwater recharge

Managed aquifer recharge: forest infiltration areas, small weirs & dams, urban bioretention systems (rain gardens, swales)

VEGETATION-SOIL

Regenerative Agriculture Practices (RAPs): low/no till, green cover, controlled traffic, soil amendments (mulching)

Reforestation

Case Study typology groups in SpongeScapes

Surface Water

IT2 Timonchio pond

FR1 Leze flood barriers

UK1a Littlestock bunds, ponds, leaky barriers

UK1b Riseholme ponds

UK1c Lymington floodplain restoration

UK1d Cole floodplain restoration

Surface-Ground Water

GR1 Kavouropotamos check dams

NL1 Chaamse barriers

NL2 Aa & Maas flow barriers

PL1 Biebrza wetland catchment

IT1abc Santoro rain gardens

IT3 Agripolis rain garden

Soil-Vegetation

UK2ab Thames infield buffer strips

UK3 Thames crop rotation

UK4ab Thames low till, greeen cover, controlled traffic

SI1 Gradascica forested catchment

IT4 Bosco Limite forest infiltration area

Water Retention Indicators: key is Storage AND Release!

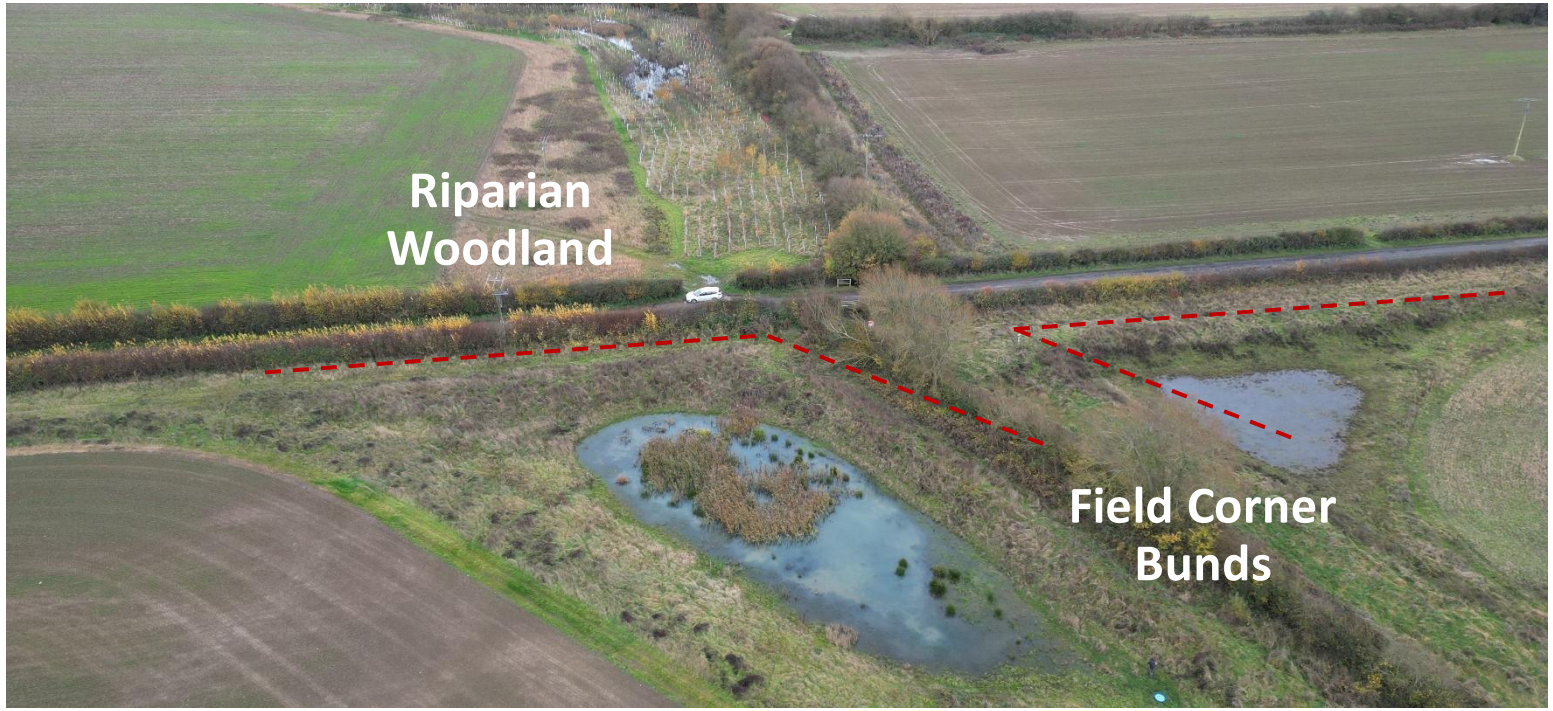
(fluxes, storages, timings)			Kavouropo	Chaamse	Aa & Maas	Biebrza	Santorso	Agripolis	Timonchio	Leze	Littlestock	Riseholme	Lymington	Cole	ASSIST	COSMOS	LANDWISE	Bosco limite	Gradascica
		CS contact									NS	LM	IE	IE	JB	JB	JB		
		MAIN IMPACT:									flooded homes								
		MAIN MEASURE:	small dams	drain blockages	drain blockages	wetland restoration	rain garden	exp rg	pond	buffer strips & belts	corner bunds	online ponds	floodplain restoration	floodplain restoration	buffer strips	crop rotation	controlled traffic	forest infiltration	forest
Indicator (if **bold** easier to estimate)	*abbreviation*	*usual units*																	
Interception storage	*Si*	*mm*																x	x
Wet canopy evap	*Ewc*	*mm/d*					x	x										x	x
Surface water storage volume	***Ssw***	***m3***	x	x	x	x	x	x	x	x	x	x	x	x					
Surface water level	***swl***	***m***	P	P	P	P	P	P	P	P	P	P	P	P					
Flooded area	***Aflooded***	***m2***				x	x	x	x		S	x	x	x					
Floodplain area reconnected	***Arfp***	***m2***									x	x	x	x					
Stream length restored	***Lsr***	***m***									x	x	x	x					
Stream flow velocity	***v***	***m/s***			x								x	x					
Stream peak flow	*Qp*	*m3/s*	x	x	x		P	P		x	P	P	P	P					P
Time to peak	***tp***	***h***		x	x		S	S	x	x	x	x	x	x					x
Flow volume	*Vf*	*m3*	x	x		x	x	x	x	x	x	x	x	x					x
Desynchrony of tributary flows	***ts (= tp1 - tp2...)***	***h***								x	x	x	x						
Depression storage	*Sd*	*mm*		x	x		x	x		x	x				x	x	x	x	x**
Time to ponding	***Tponding***	***h***					S	S											
Hydraulic roughness	*n*		x	x	x		x	x		x	x	x	x	x	x	x			
Runoff	*r*	*mm*					x	x		x					S	S	S		
Runoff coeffcient	*rc = r/p*						x	x		x					x	x	x		x
Saturated soil water content	***theta_sat***	***%volume***					x	x							x	x	x	x	P
Soil water storage (retention capacit	*Ssoil*	*mm*					x	x							P	P	P	x	x
Saturated hydraulic conductivity	*Ksat*	*mm/h*													x	x	x	x	x
Infiltration	*f*	*mm/h*	x	x			x	x		x	x				x	x	x	P	x
Percolation/seepage	*s*	*mm/h*	x				x	x										P	x **
Recharge	*gwr*	*mm/h*	x			x	x	x										x	
Groundwater level	***gwl***	***m***	x	P	P	P	x	x				x						x	
Stream base flow	*Qb*	*m3/s*		x	x					x	x		x	x					x
	CATEGORY:		SW-GW	SW-GW	SW-GW	SW-GW	SW-GW	SW-GW	SW	SW	SW	SW	SW	SW	SoilW	SoilW	SoilW	Veg-SoilW	Veg-SoilW
		number:	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5

if bold: easier to measure/estimate

P = *Primary Indicator*
S = *Secondary Indicator*

IDENTIFY if:
Measured vs Estimated (eg modelled)

Monitoring Example 1: UK Littlestock Brook NFM



Bank-full leaky woody dam linked to FSA (flood storage area such as field corner bund)

2007 floods: 2016-21 project for 16 km^2 agricultural catchment in upper Thames basin, 20 ha of measures

Littlestock Brook Natural Flood Management project:

- 15 field corner bunds (can store up to 30,000 m^3 of water)
- 27 woody leaky dams (or log jams or leaky barriers)
- 14 nutrient retention ponds
- 14.4 ha riparian woodland and others

SpongeScapes:

1. Flood mitigation provided by individual & combined measures?; e.g., dam & bunds
2. How will measures evolve?
3. What are co-benefits of sediment capture and aquatic biodiversity?

Monitoring Example 1: Design & Preliminary Results

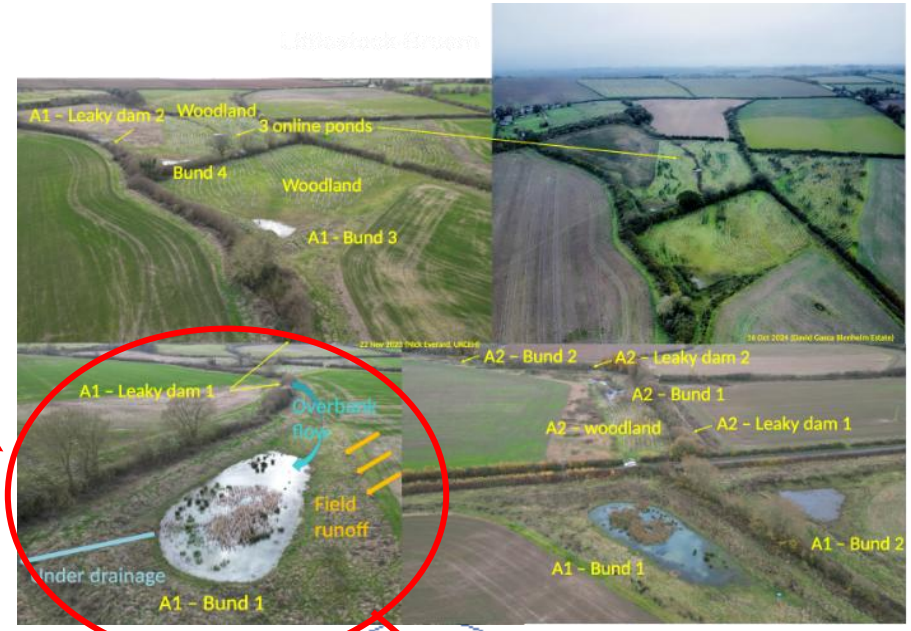
Littlestock Brook monitoring by SpongeScapes:

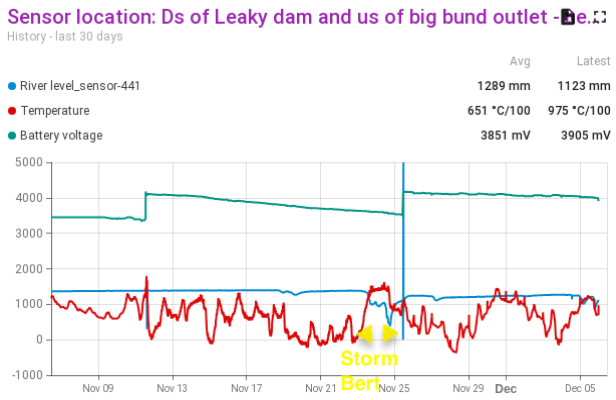
Floodplain reconnection with surface storage capacity & drainage outflow

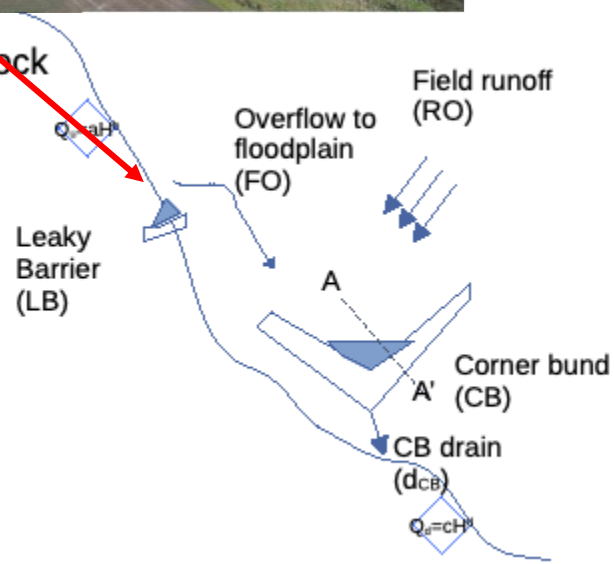
- Key to monitor: water level in ponds, bunds & stream (upstream and downstream of features)
- Low-cost (~e500) telemetered sensors for water level
- Gauging to determine water level-flow relation
- Bathymetry surveys (storage volume)
- Soil moisture: ground sensors + drone/satellite
- Surveys: aquatic macroinvertebrate & macrophytes

Field considerations – a selection

- Needed to relocate water level sensor due to shade
- Soil moisture sensors affected by farm operations
- Collaboration on leaky dam surveys; citizen science

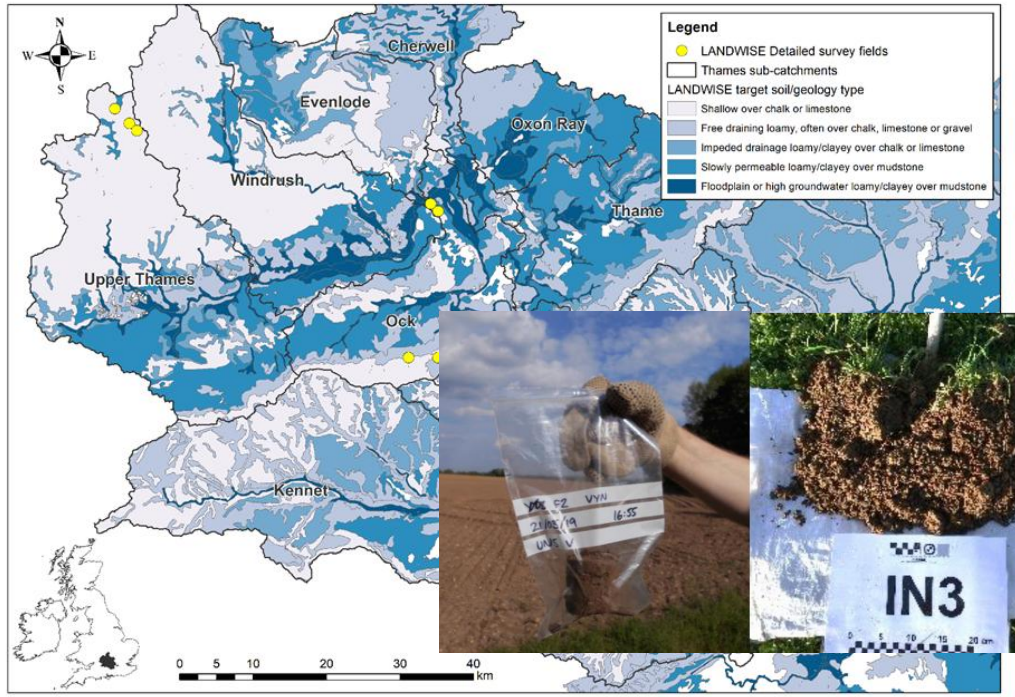






Monitoring Example 2: UK agricultural sites

- Selection of LANDWISE NFM (2019-22) sites
  - Traditional rotational crop
  - Regenerative Agricultural Practices (buffer strips, cover crop, controlled traffic) versus traditional
  - Wooded versus grassland
- Key environmental challenge: mostly flooding/waterlogged fields
- Major co-benefit(s) studied: Soil Organic Matter (SOM)



How land use and **soil management affects soil properties**, impacting flood risk

- **LW & SpongeScapes (2023-27):** How much water can the soil hold? (floods & droughts)
- **SS innovation:** seasonal soil monitoring by Cosmic-Ray Neutron Sensor rover and RS (UAV/EO); start by **analysing longer-term soil water datasets**

Monitoring Example 2: Design

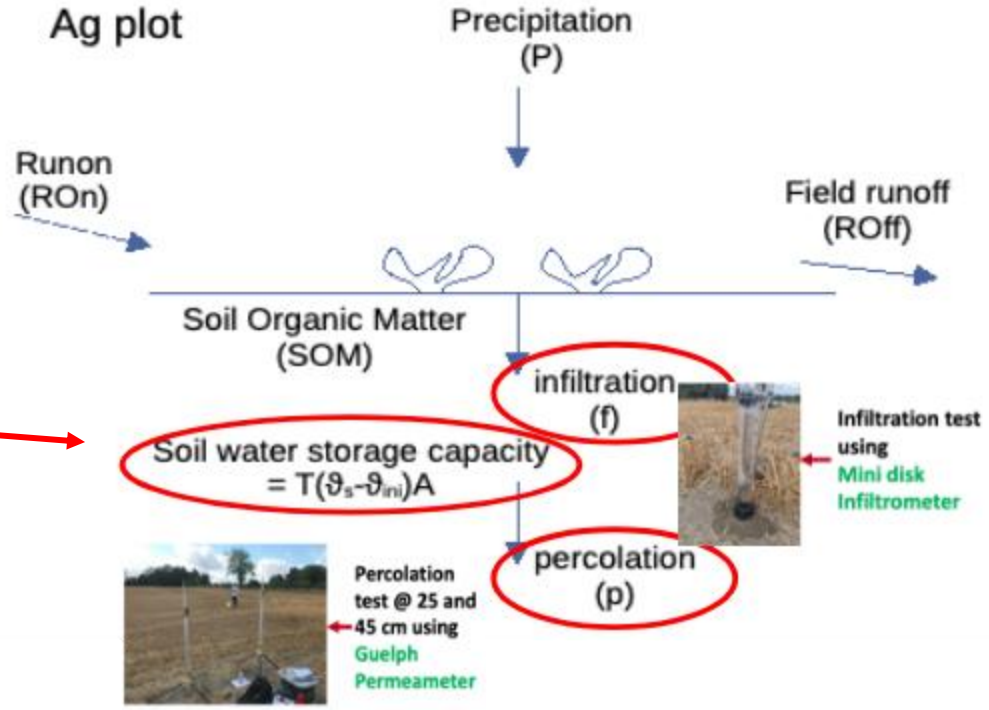
Agricultural Practices monitoring by SpongeScapes:

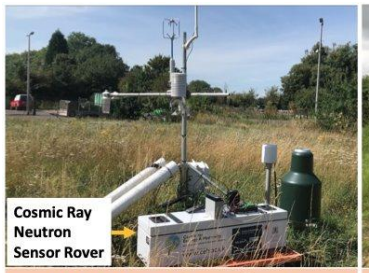
Soil water storage capacity + infiltration & percolation

- Key to monitor: (root zone) soil moisture storage
- Low-cost (~e500) soil moisture sensors (TDRs/TDTs)
- Cosmic Ray Neutron Sensors (CRNS) - COSMOS-UK
- Remote sensing for soil moisture: satellite workflows (+ testing UAV) + ground sensors (CRNS, TDRs)
- Soil surveys (before/after)

Field considerations – a selection

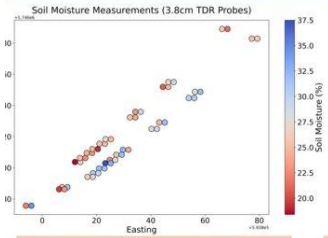
- Representative soil sampling design needs experience!
- Biases: sample location, sampling method; e.g., Ksat
- Assess impact of farming management: initial versus final condition



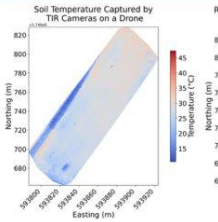


COSMOS station and rover

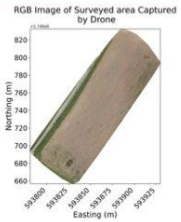
Multi-spectral Drone trial



TDR (3.8 cm probes) measurements

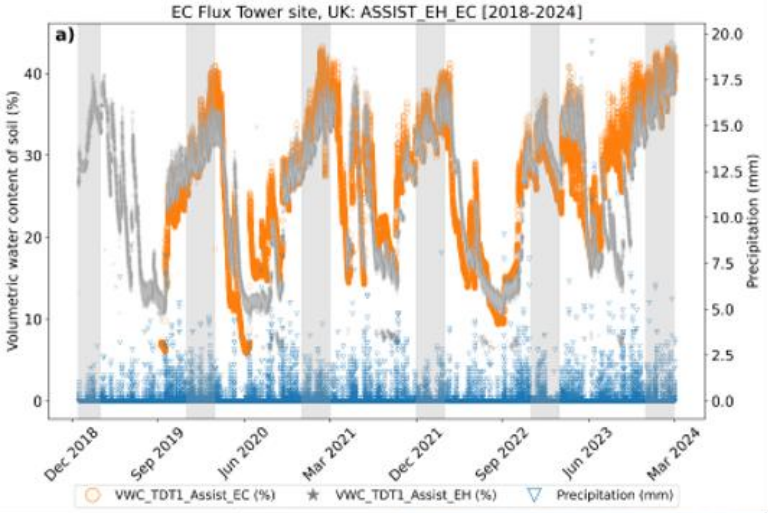


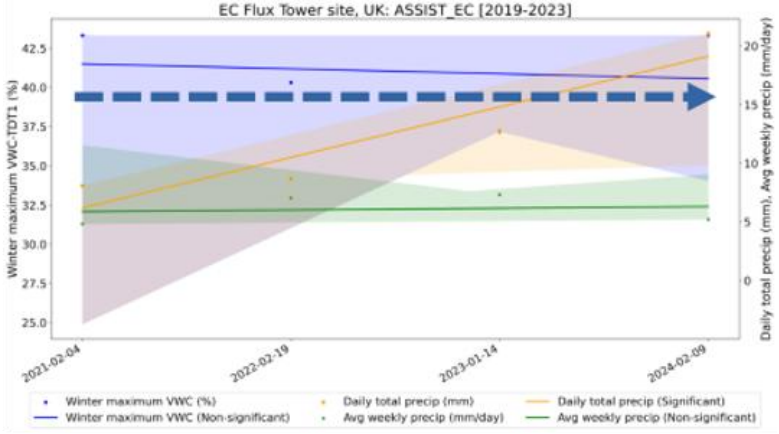
Soil temperature from TIR cameras on Drone

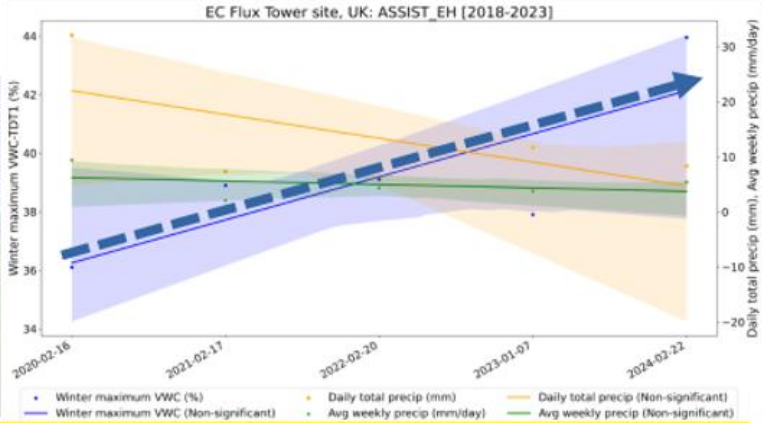


Drone Survey area

Monitoring Example 2: Preliminary Results

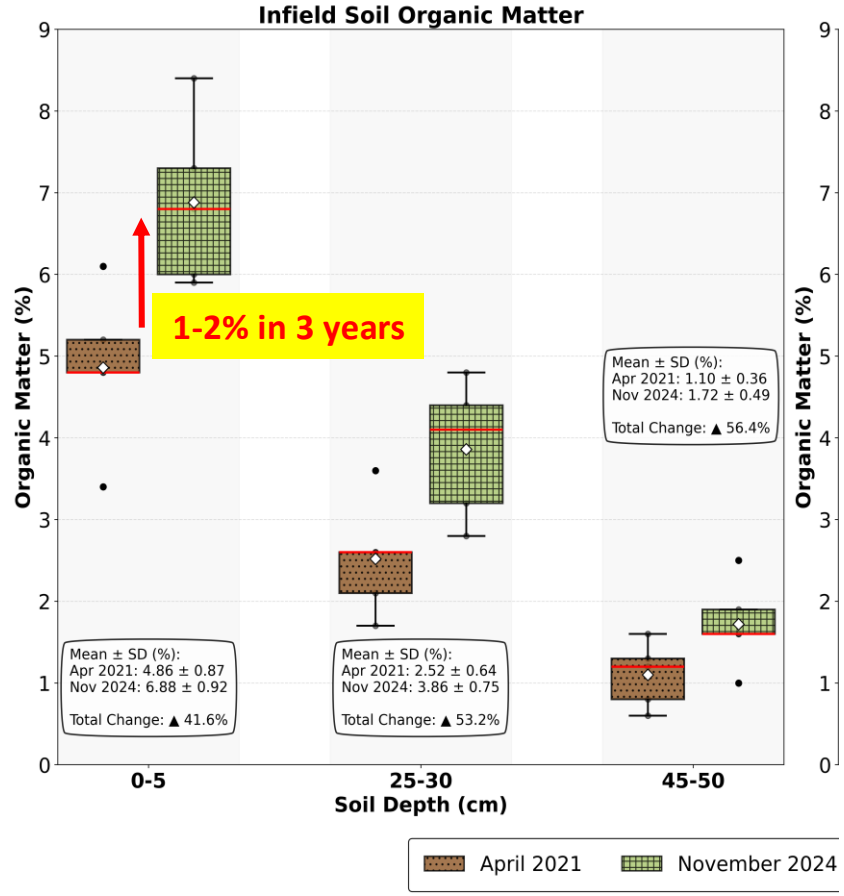






Regenerative ag practices (ASSIST-EH site) are:
- cover crop
- buffer strips
- controlled traffic

Note: an extra 5% of VWC capacity in 1m-deep soil in a 1ha field amounts to an extra 500 m³ of storage!



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