

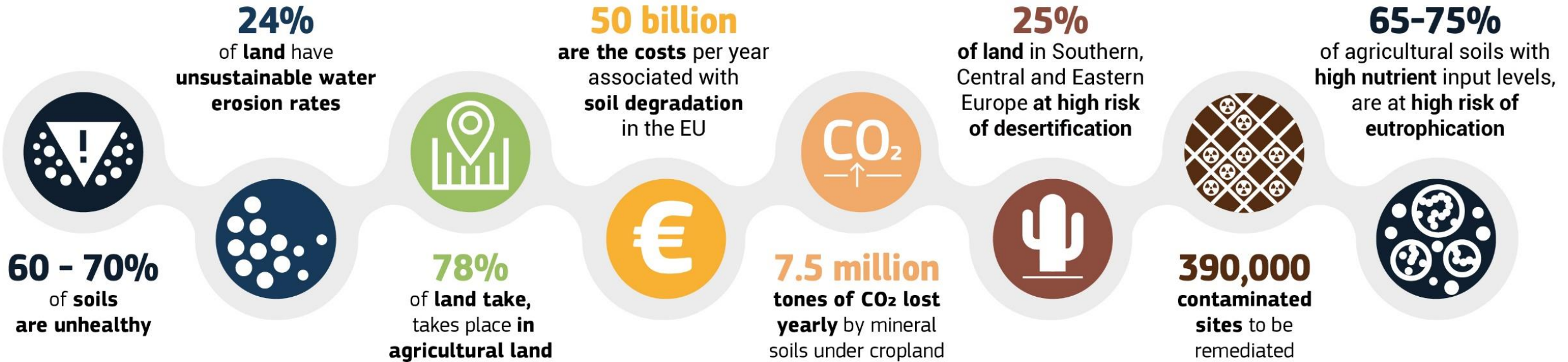
# The role of EU Soil Observatory (EUSO) in supporting EU policies with solid science

*Dr. Panos Panagos*

European Commission  
Joint Research Centre (JRC)  
Directorate D Sustainable Resources

# Soil Degradation in the EU

*The time to act is now!*



erosion } SOIL THREATS  
desertification }  
sealing land take compaction }  
loss of biodiversity pollution }  
organic matter decline salinisation }

# Soils in the EU Green Deal



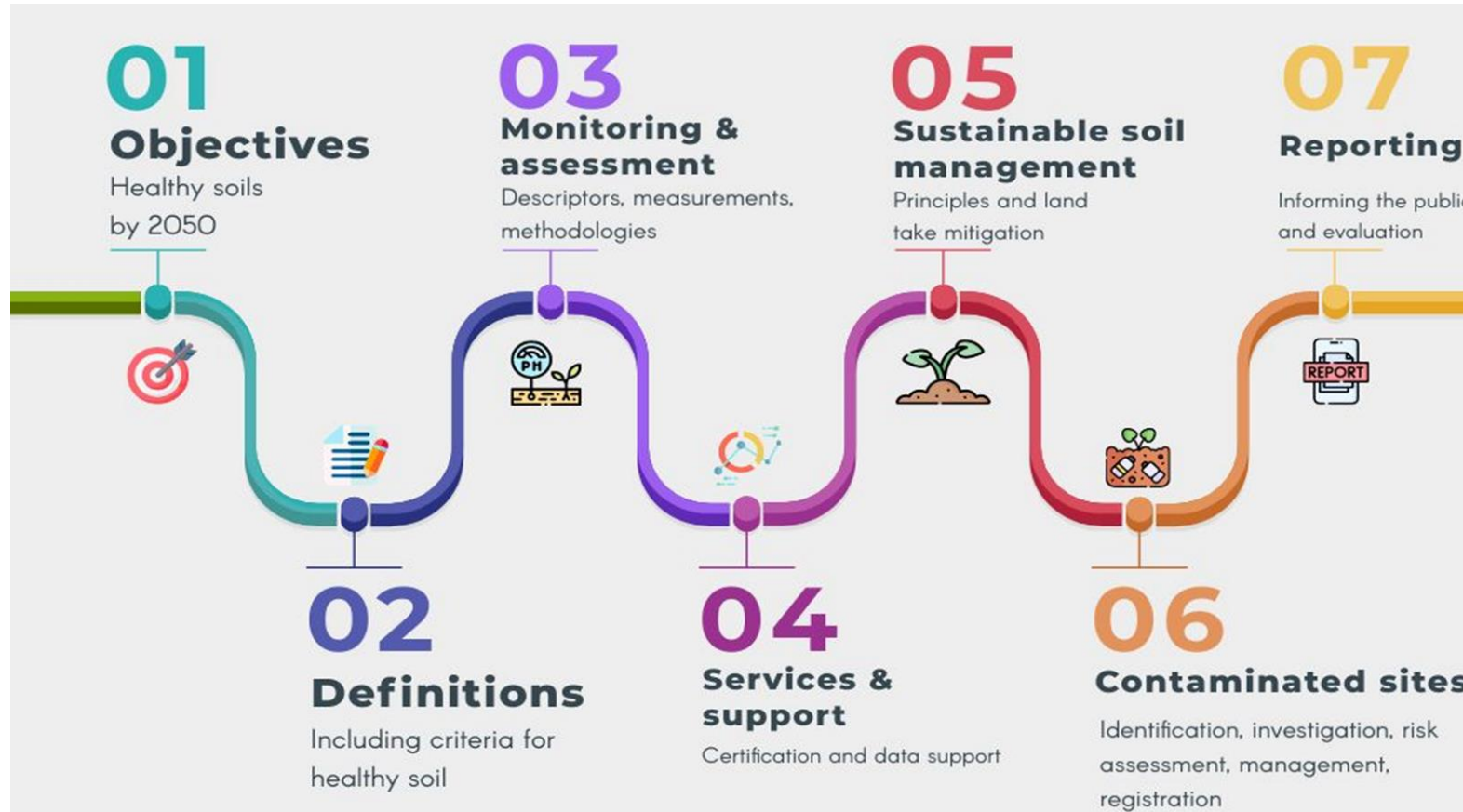
**Soils are a cross-cutting theme within the European Green Deal**

# Soil is cross cutting within many policy initiatives

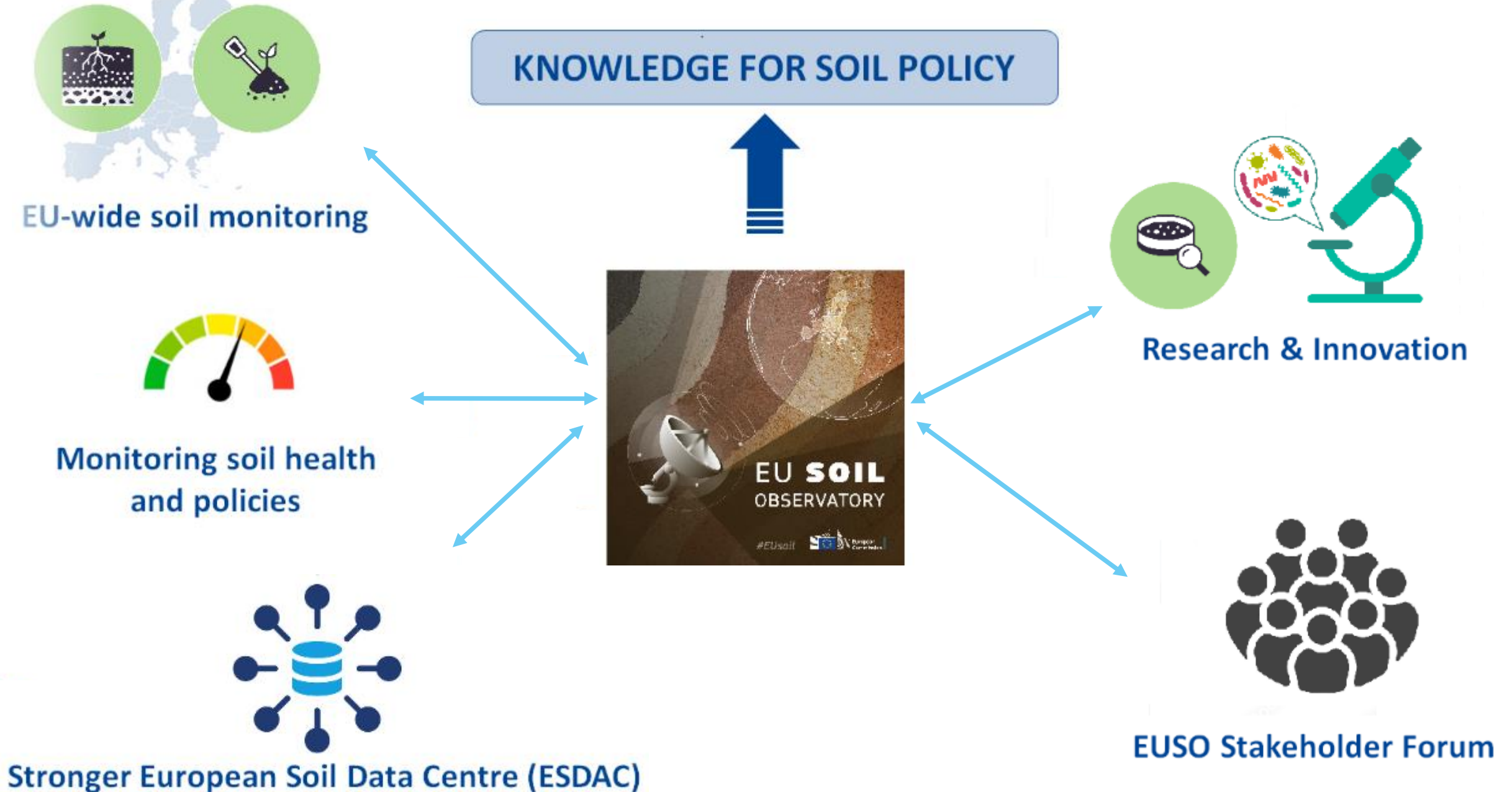


# Proposal for a Directive on Soil Monitoring and Resilience (Soil Monitoring Law, 5 July 2023)

Proposal for the first-ever EU legislation on soils provides a harmonised definition of soil health, puts in place a comprehensive and coherent monitoring framework and fosters sustainable soil management and remediation of contaminated sites.



# The EU Soil Observatory (EUSO)

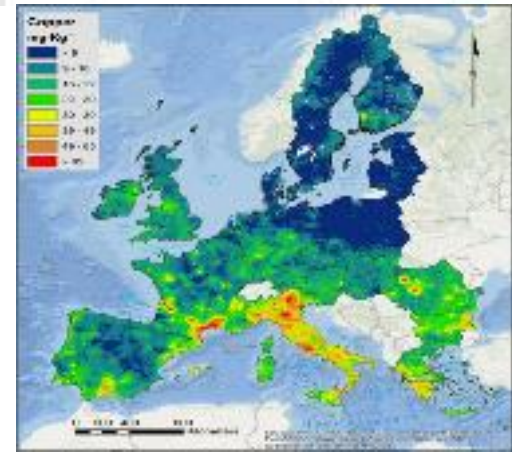
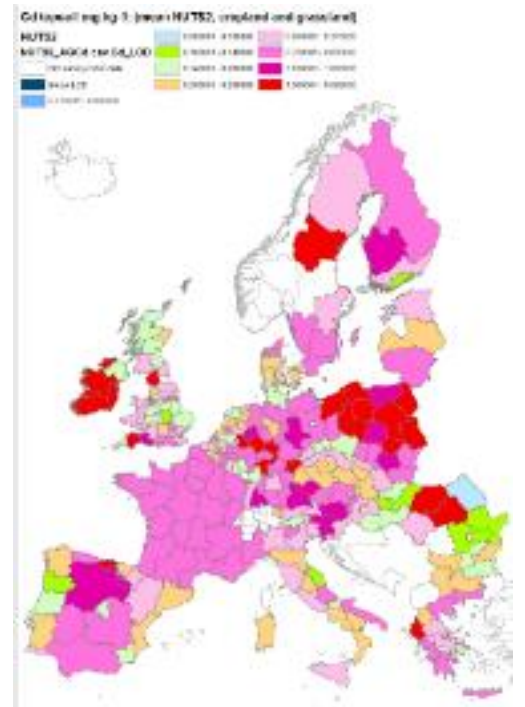
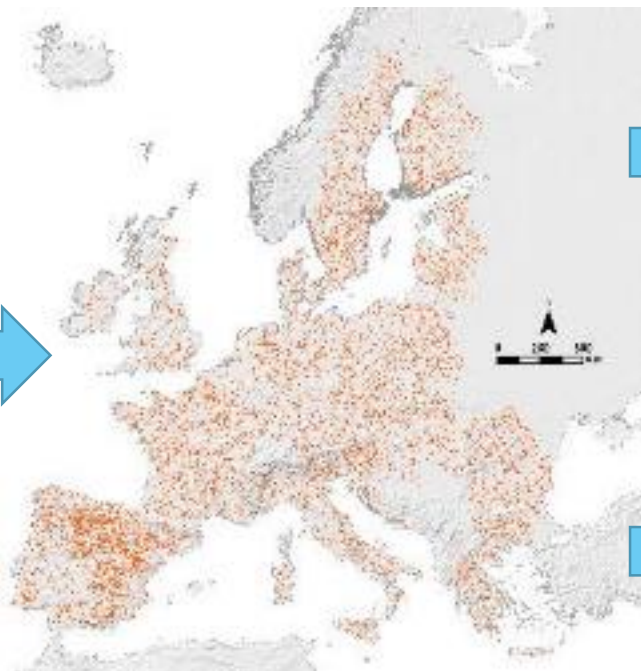




# LUCAS SOIL survey

The JRC manages the LUCAS SOIL survey: sample design, measurement protocols through integrated analysis and monitoring, training of surveyors

## EU-wide soil monitoring



- Surveys (and the resulting data) span multiple years 2009, 2015, 2018, 2022
- 42,000 observations
- Soil archive at the JRC premises in Ispra (IT)
- Close cooperation with MSs

# LUCAS Contributes to EU-Wide Soil Monitoring

From monitoring physical, chemical and biological soil properties to support EU policies

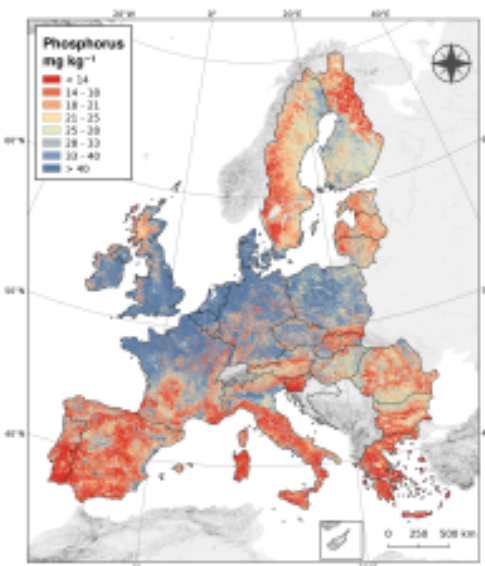
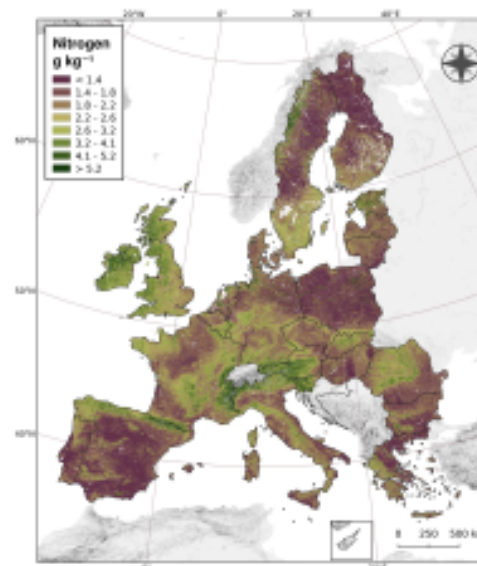


## SOIL PROPERTIES

Organic carbon  
Total nitrogen content  
Phosphorus content  
Heavy Metals  
Pesticides  
Fungicides  
Antibiotics  
Soil Biodiversity



## MODELLING + AI



**COM(2023)416 - Directive  
Soil Monitoring and Resilience  
(Soil Monitoring Law)**

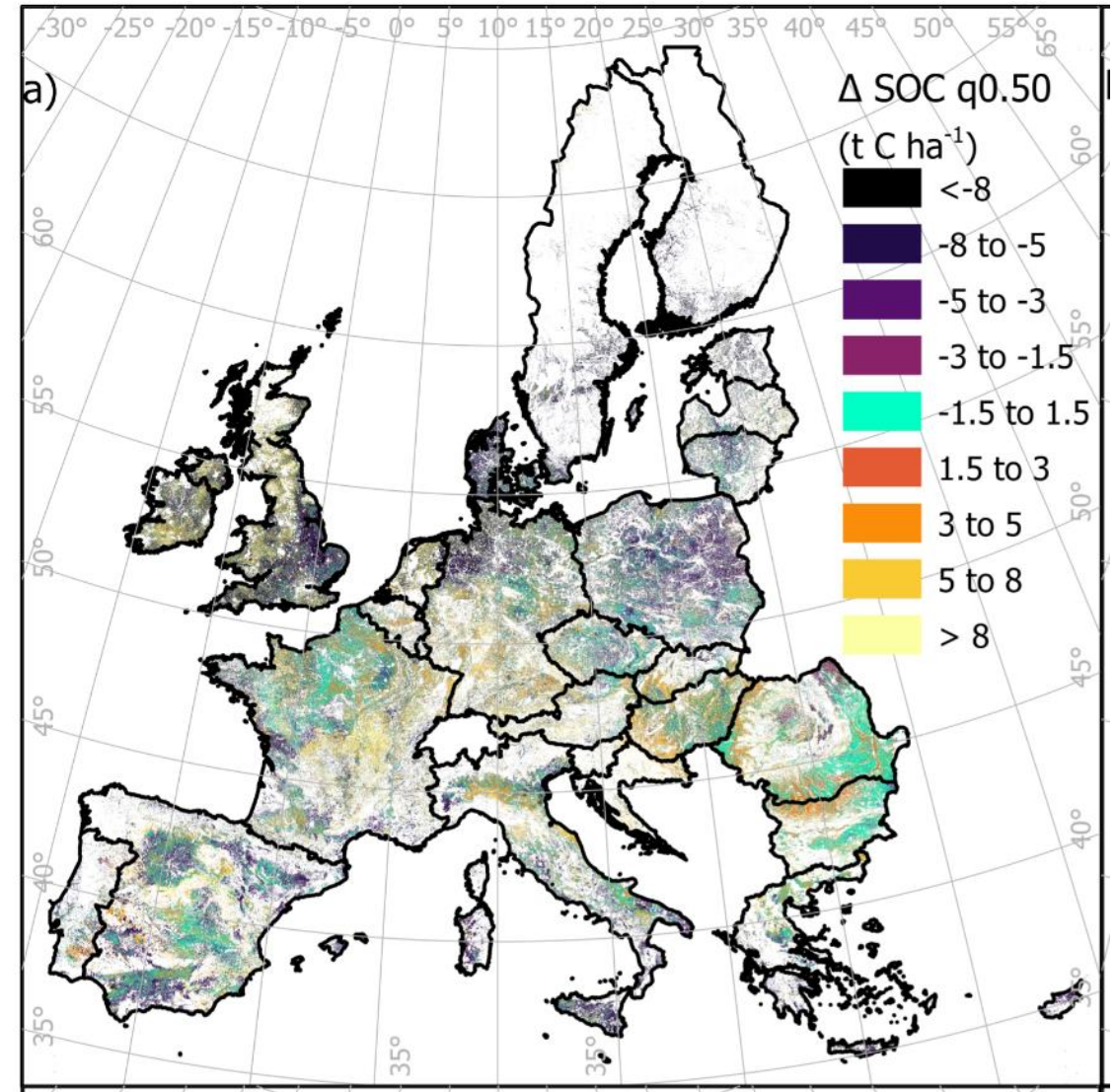
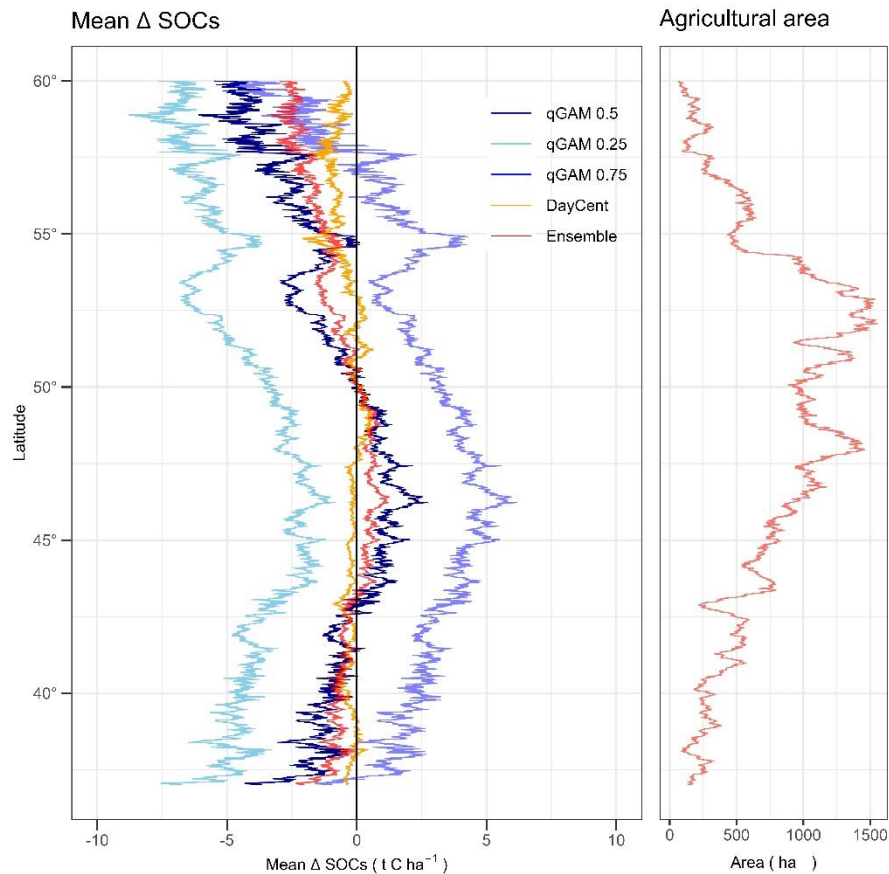
## POLICY MAKING

- EU Soil Strategy 2030
- Soil Mission
- Carbon Farming Certification
- Nature Restoration Law
- Zero Pollution Action Plan
- Common Agricultural Policy (CAP)
- Biodiversity Strategy 2030
- Chemical Strategy



# SOC, how much have we lost in the past decade?

-0.75% between 2009 and 2018  
~ 70 Mt C (0-0.2m depth) =  
**28 MtCO<sub>2</sub>e per year**





# European Soil Data Centre



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JOINT RESEARCH CENTRE  
EUROPEAN SOIL DATA CENTRE (ESDAC)

EUROPEAN COMMISSION > JRC > ESDAC

Search

## EU SOIL OBSERVATORY

EUSO

## SOIL DATA

DATASETS

MAPS & DOCUMENTS

APPLICATIONS & SERVICES

## SOIL KNOWLEDGE

THEMES

NETWORKS & COOPERATIONS

PROJECTS

## UPCOMING EVENTS

06/Sep/2023 Joint conference on trace elements and heavy metals to 10/Sep/2023

13/Sep/2023 European Healthy Soils to Conference Series to 15/Sep/2023

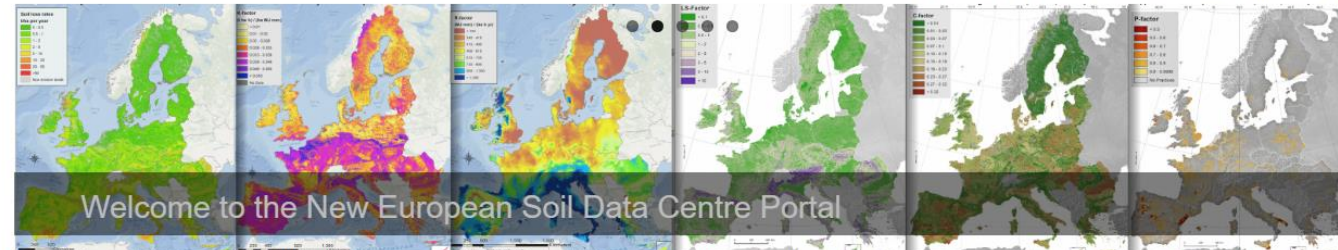
## HIGHLIGHTS

**24 Aug 2023** 40 publications in peer-review journals (Scopus Indexed) produced by EUSO team in JRC during 2022.

**18 Aug 2023** Report on Pesticides residues in European agricultural soils.

**16 Aug 2023** New dataset on Soil biodiversity - DNA eukaryotes and relevant publication in Global Change

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The **European Soil Data Centre (ESDAC)** is the thematic centre for soil related data in Europe. Its ambition is to be the single reference point for and to host all relevant soil data and information at European level. It contains a number of resources that are organized and presented in various ways: datasets, services/applications, maps, documents, events, projects and external links. We hope you can find your way in this site. When in doubt or for any question, you may contact [ec-esdac@ec.europa.eu](mailto:ec-esdac@ec.europa.eu)



## Dataset Highlights

### GloREDA

The data collection started in 2013 with the objective to develop a pan-European assessment of soil erosion. After the successful release of the pan European Rainfall Erosivity database and the derived R-factor map, we extended the data collection to a global scale. The first version of...

[Read more](#)

[More Datasets](#)



One year after the First EU Soil Observatory Stakeholders Forum, the Second EUSO Stakeholders Forum was held from 24 to 26 October 2022.

This **three-day event** covered the following topics:

- The first day dealt with "Recent EU policy developments in soil".
- The second day discussed the concept of Soil Health Districts, and the EUSO engagement with the Mission "A Soil Deal for Europe".
- The third day was dedicated to look at the work done in the EUSO Technical Working Groups.

The agenda is available from [here](#), which also publishes all presentations and recordings of the various sessions.



## Scientific-Technical Reports

### EUSO Annual Bulletin - 2022 activities

### EU Soil Observatory 2022

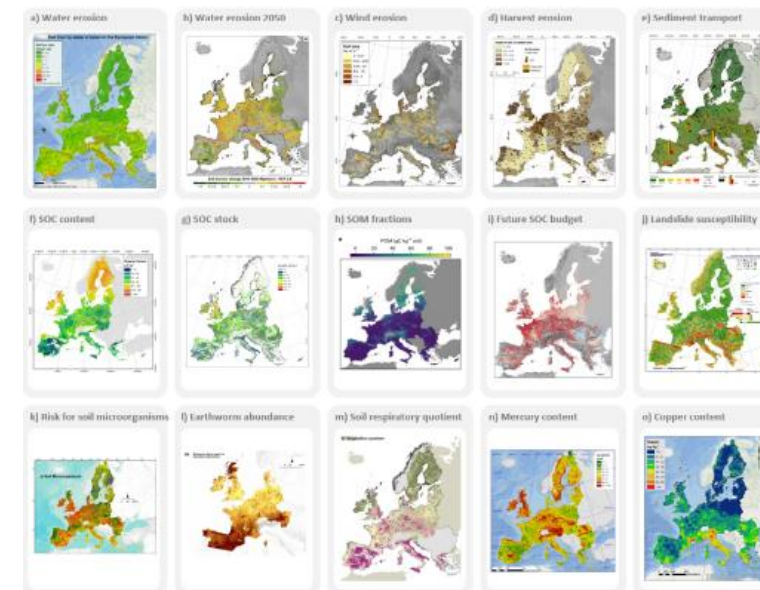
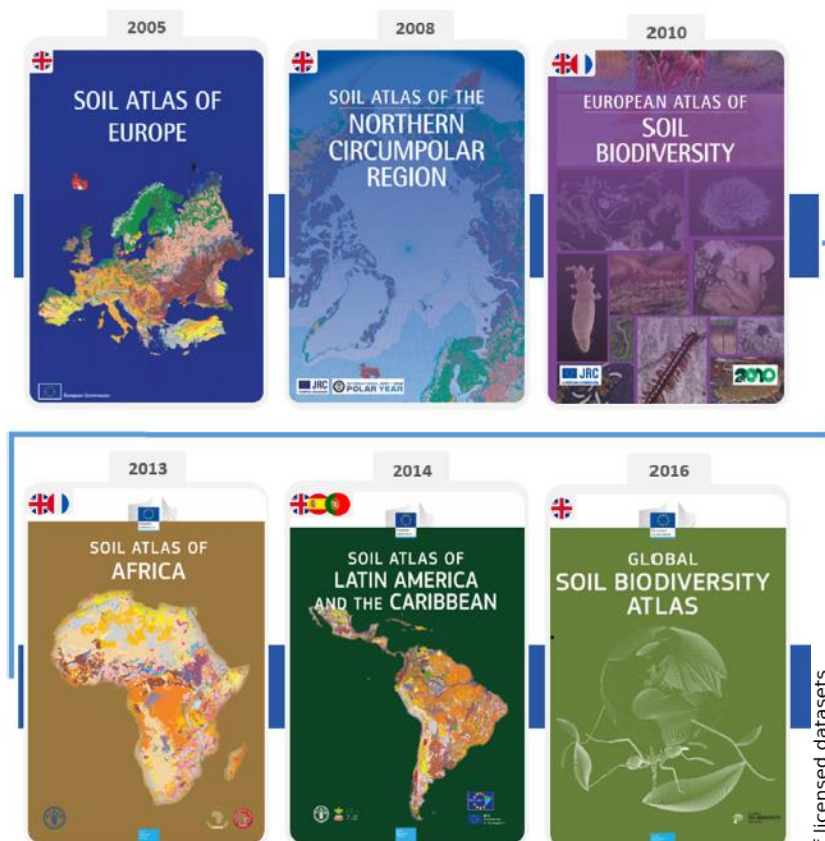
This report presents the activities of the EU Soil Observatory (EUSO) that took place during 2022. Through its five main objectives, the EUSO... [Read more](#)

DG AGRI is currently supporting under Horizon 2020 an European Joint Programming Initiative (JPI) on agricultural soil management to overcome current fragmentation in national research programmes and unleash the potential of agricultural soils to contribute to climate change mitigation/adaptation, while... [Read more](#)



# ESDAC: Towards v2.0

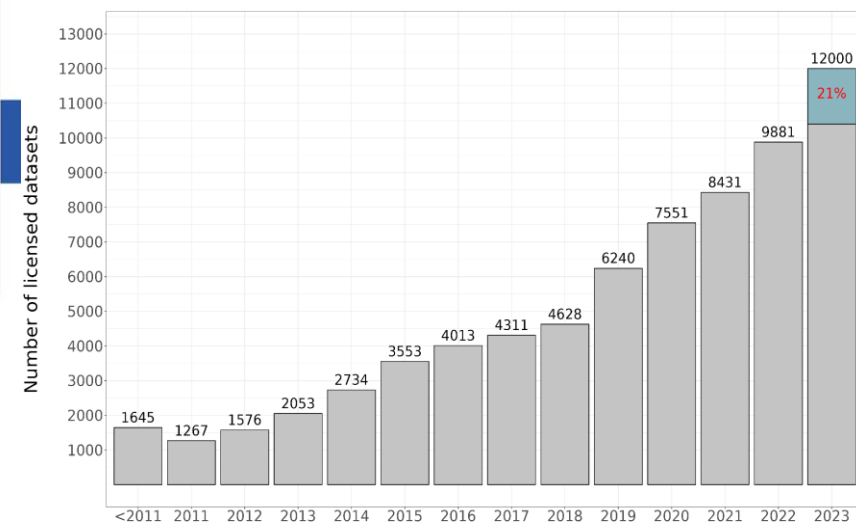
- 110 blocks of data
- 300,000 visitors per year
- > 80,000 total data downloads since the start
- One of the most visited JRC websites



2024+



Accommodate data flows from MS  
Outcomes of Soil Mission  
Enhanced functionality





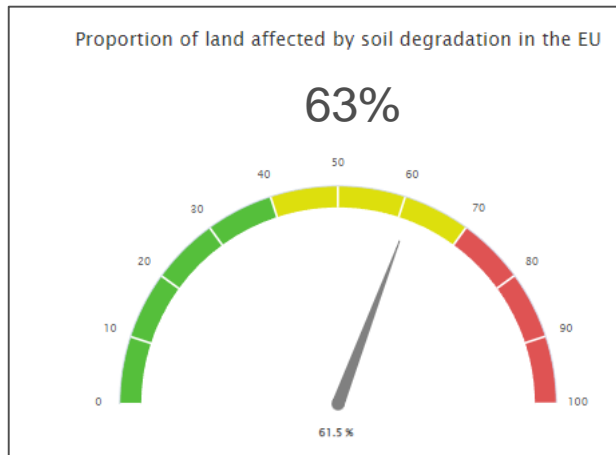
Monitoring soil health and policies

# Assessing Policy Impact

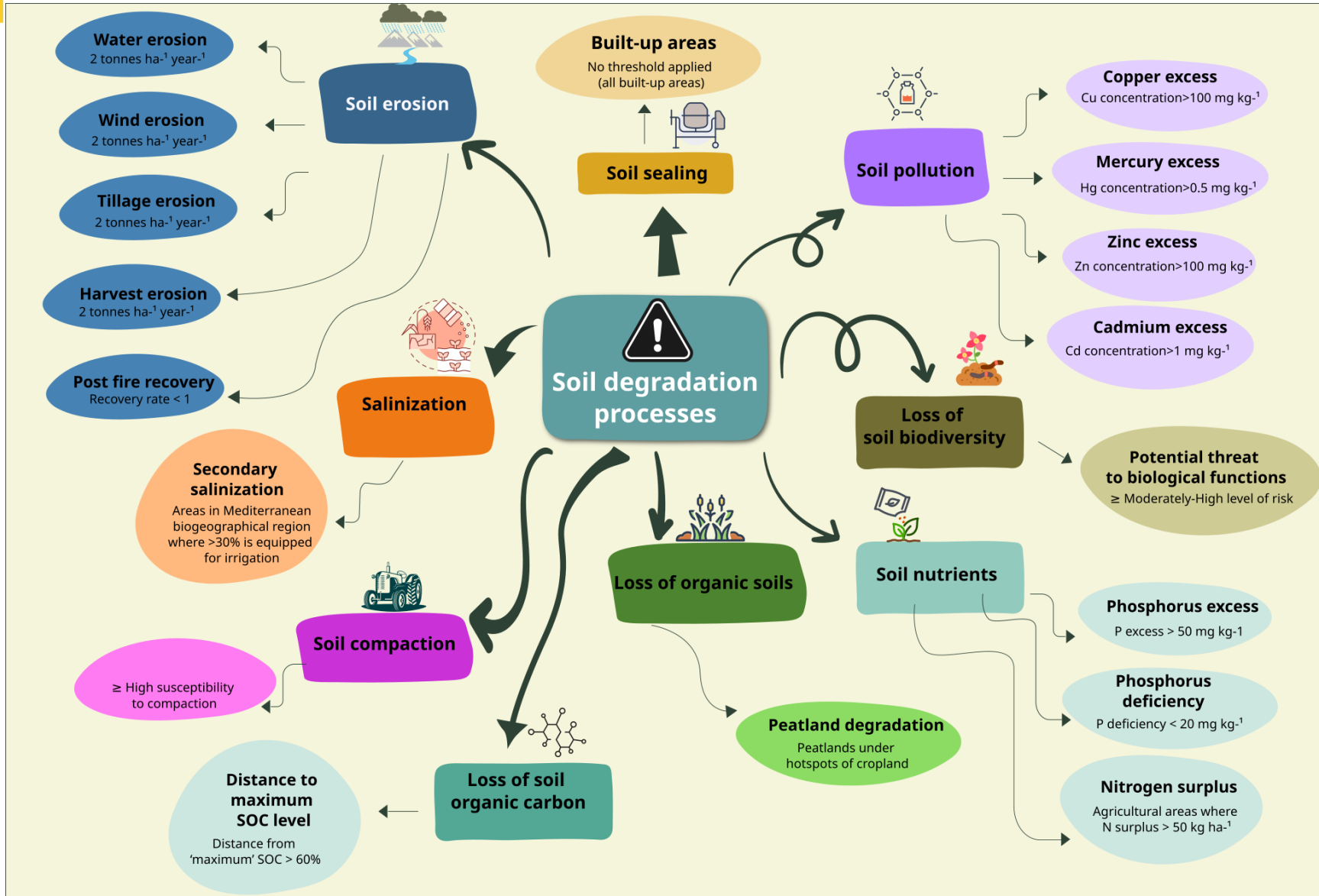
## EUSO Soil Dashboard

### Convergence of scientific evidence

- 18 Soil degradation indicators
- 63 % of unhealthy soils
- Dashboard shows location and different types of soil degradation in the EU

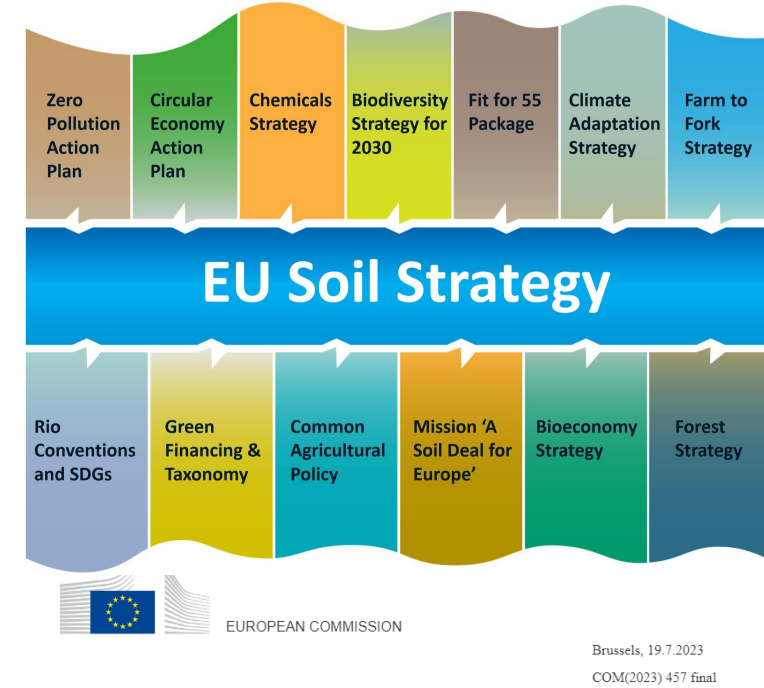


# Soil Degradation processes in the Dashboard



# Contribution to soil related policies

- **Soil Mission**
- Contribution to the **Nature Restoration Law**
- Development of **Clean Soil Outlook**
- Contribution to **Carbon Removal Certification**
- Contribution to the review of **CAP Performance indicators** (Soil Organic Carbon, Soil Erosion)
- **Farm2Fork**: pesticides & nutrient management indicators



COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

EU Missions two years on: assessment of progress and way forward

{SWD(2023) 260 final}

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

EU Missions two years on: assessment of progress and way forward





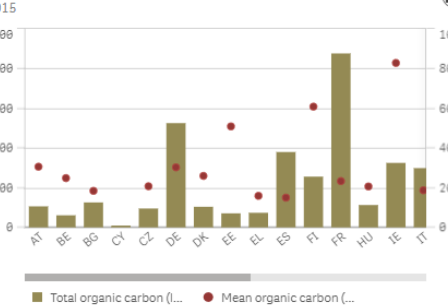
# CAP Performance indicators

## Monitoring soil health and policies

2020

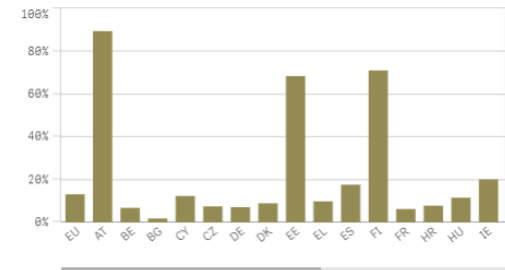
⬇️ B

organic matter in arable land (Mega t & g/kg)



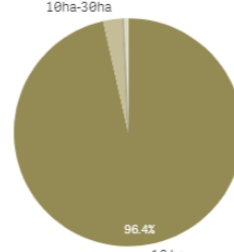
Share of agricultural land under contracts to improve soil (%)

In 2020 (soil management and/or prevent soil erosion, focus area 4C, rural development programmes)



Farms with 1 arable crop by size class (%)

In 2016



Share of UAA in severe risk of soil erosion by water (%)

In 2016

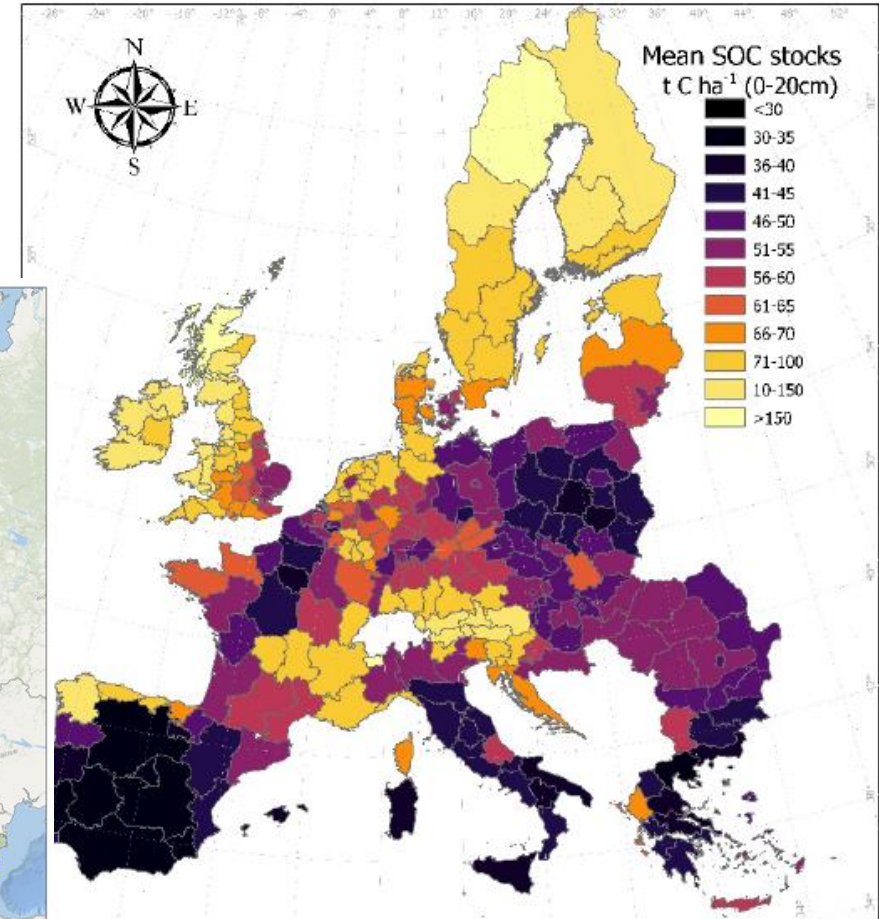
Crop diversity on EU farms (%)

In 2016 (Share of farms classified by number of arable crops)

Sh

In 2

Figure 2. Mean soil organic carbon (SOC) rates of 2018 aggregated data at NUTS2



Thematic Indicators Context Indicators

Data up to 2019



### Socio-economic indicators

- C01 Population
- C02 Age structure
- C03 Territory
- C04 Population density
- C05 Employment rate (\*)
- C06 Self-employment rate
- C07 Unemployment rate
- C08 GDP per capita (\*)
- C09 Poverty rate (\*)
- C10 Structure of the economy
- C11 Structure of the employment
- C12 Labour productivity by economic sector



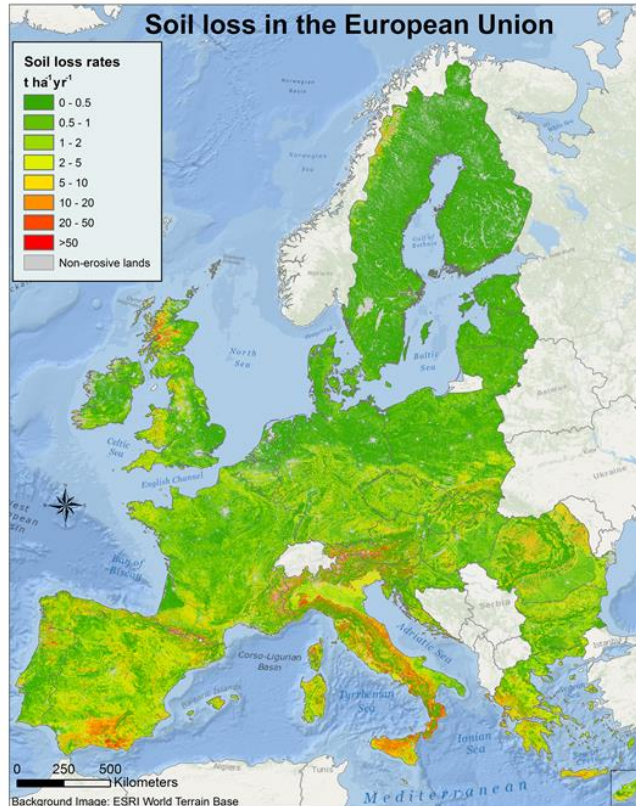
### Sectoral indicators

- C13 Employment by economic activity
- C14 Labour productivity in agriculture
- C15 Labour productivity in forestry
- C16 Labour productivity in the food industry
- C17 Agricultural holdings (farms)
- C18 Agricultural area
- C19 Agricultural area under organic farming
- C20 Irrigated / Irrigable land **NEW**
- C21 Livestock units
- C22 Farm labour force
- C23 Age structure of farm managers
- C24 Agricultural training of farm managers
- C25 Agricultural factor income (\*)
- C26 Agricultural entrepreneurial income (\*)
- C27 Total factor productivity in agriculture (\*)
- C28 Gross fixed capital formation in agriculture
- C29 Forest and other wooded land (FOWL)
- C30 Tourism infrastructure



### Environmental indicators

- C31 Land cover
- C32 Areas facing natural and other specific constraints (ANCs)
- C33 Farming intensity
- C34 Natura 2000 areas
- C35 Farmland birds index (FBI) (\*)
- C36 Conservation status of agricultural habitats (grassland)
- C37 HNV (high nature value) farming (\*)
- C38 Protected forest
- C39 Water abstraction in agriculture /WEI+ (\*) **NEW**
- C40 Water quality (\*)
- C41 Soil organic matter in arable land (\*)
- C42 Soil erosion by water (\*)
- C43 Production of renewable energy from agriculture and forestry
- C44 Energy use in agriculture, forestry and food industry
- C45 Emissions from agriculture / GHG per LSU & GHG per ha (\*) **NEW**
- C47 Sales/Use of antimicrobials in food production





# Support to research and innovation

## Research & Innovation

Developing further the JRC in-house research and development capacity on soils (> 45 publications of EUSO group in peer review journals in 2023 – 40 publications in 2023)

Co-hosting and mentoring 6 PhD candidates.

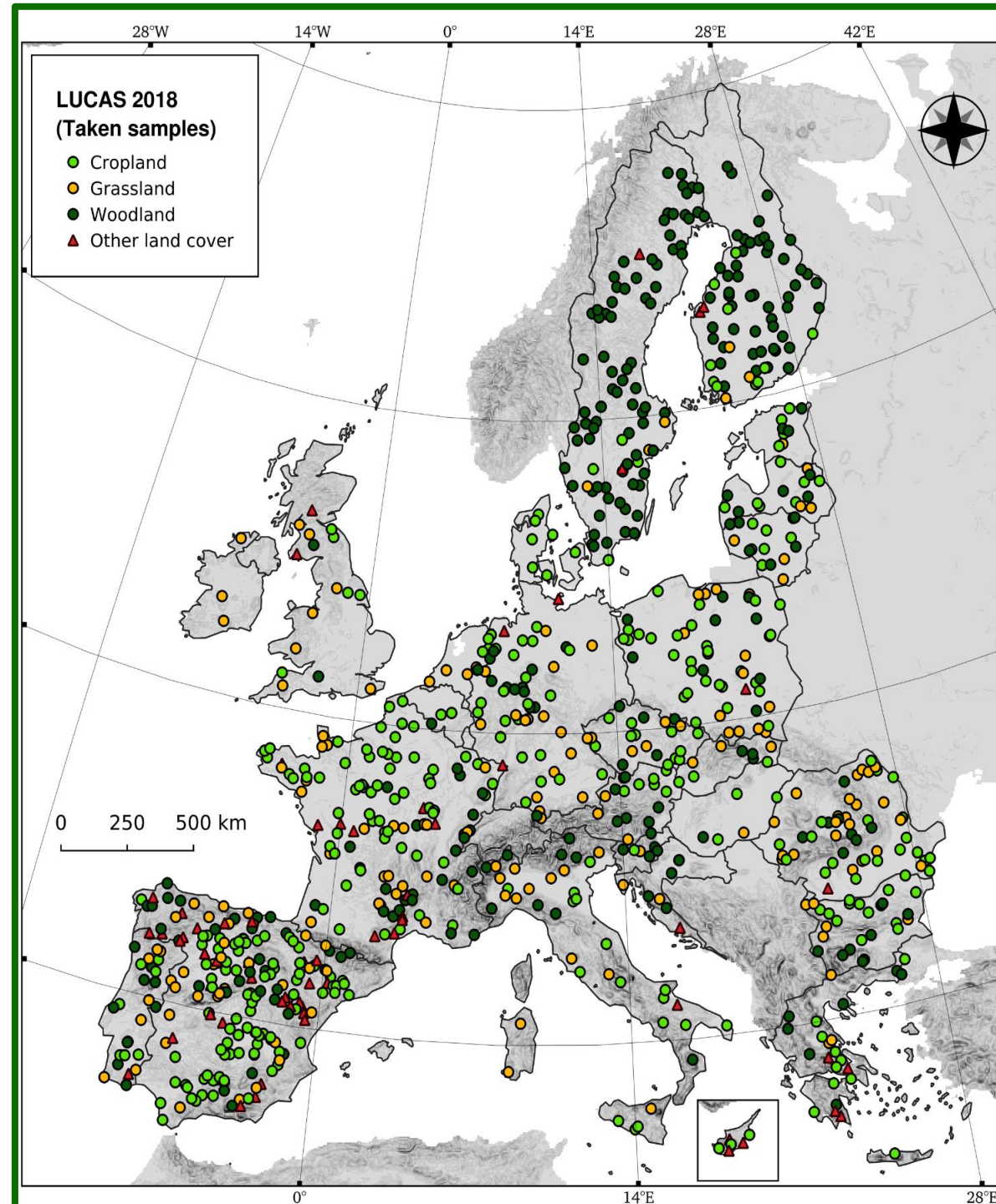
Support the **implementation of Soil Mission** (novel approached on soil monitoring, new methods for data acquisition, metrics for measuring indicators, etc)

Close collaboration with **Soil Mission Projects** (such as AI4SoilHealth, BENCHMARKS, Soil-Olive, Prepsoil, ECHO, MARVIC, etc) – EUSO as a beneficiary of research activities in Soil Mission Projects



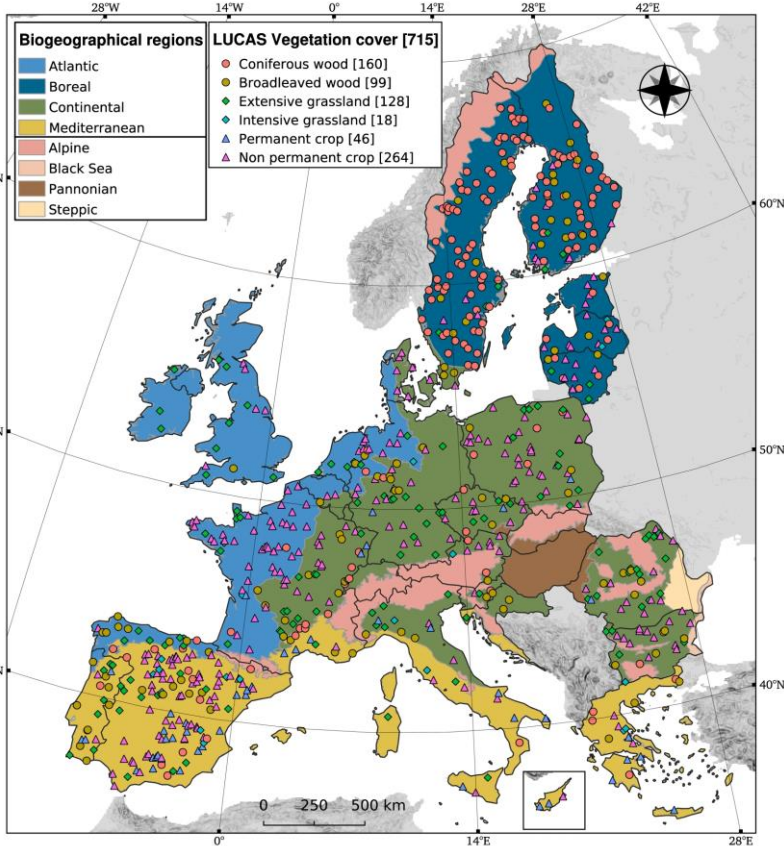
# LUCAS Soil Biodiversity

- 2018
- 1,000 selected points
- 885 collected samples
- DNA metabarcoding (bacteria, fungi, etc.)
- DNA metagenomics (soil genome)
- Largest EU soil bio (DNA) dataset





# Novel assessments of Soil Biodiversity



Diversity increases with land use intensification

Increase in pathogens in agricultural soils

Strong effect of soil properties on biodiversity

pH is the strongest driver among soil properties

Climate and Land cover are also relevant

nature communications

Received: 6 March 2023 | Revised: 5 June 2023 | Accepted: 12 June 2023

DOI: 10.1111/gcb.16871

Global Change Biology WILEY

Article

<https://doi.org/10.1038/s41467-023-29146-7>

RESEARCH ARTICLE

## Patterns in soil microbial diversity across Europe

## Ecosystem type drives soil eukaryotic diversity and composition in Europe

Received: 25 August 2022

Accepted: 6 April 2023

Published online: 08 June 2023

Maëva Labouyrie<sup>1,2,3</sup>, Cristiano Ballabio<sup>2</sup>, Ferran Romero<sup>3</sup>, Panos Panagos<sup>2</sup>, Arwyn Jones<sup>2</sup>, Marc W. Schmid<sup>4</sup>, Vladimir Mikr<sup>5</sup>, Olesya Dulya<sup>5,6</sup>, Leho Tedersoo<sup>5</sup>, Mohammad Bahram<sup>5,7</sup>, Emanuele Lugato<sup>2</sup>, Marcel G. A. van der Heijden<sup>1,3</sup> & Alberto Ordoñez<sup>1</sup>

Julia Köninger<sup>1,2</sup> | Cristiano Ballabio<sup>2</sup> | Panos Panagos<sup>2</sup> | Arwyn Jones<sup>2</sup> | Marc W. Schmid<sup>3</sup> | Alberto Orgiazzi<sup>2</sup> | Maria J. I. Briones<sup>1</sup>

Check for updates

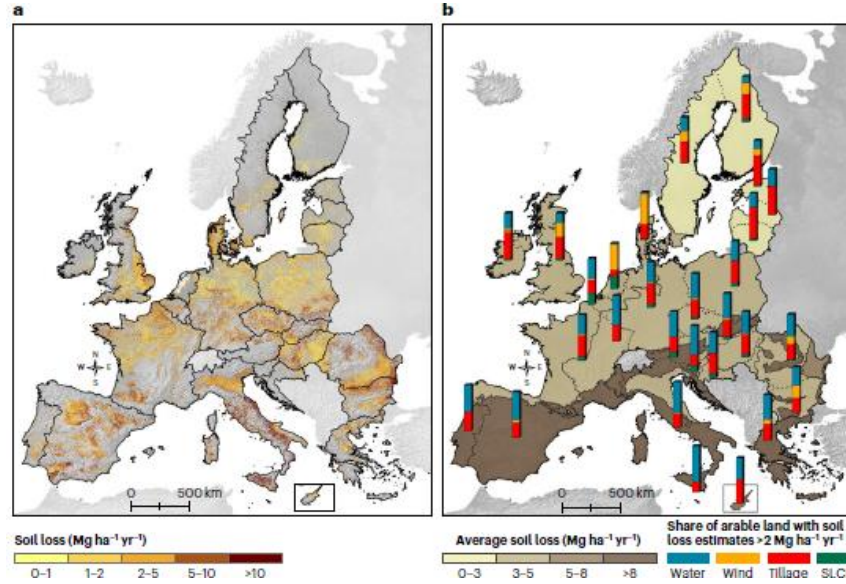
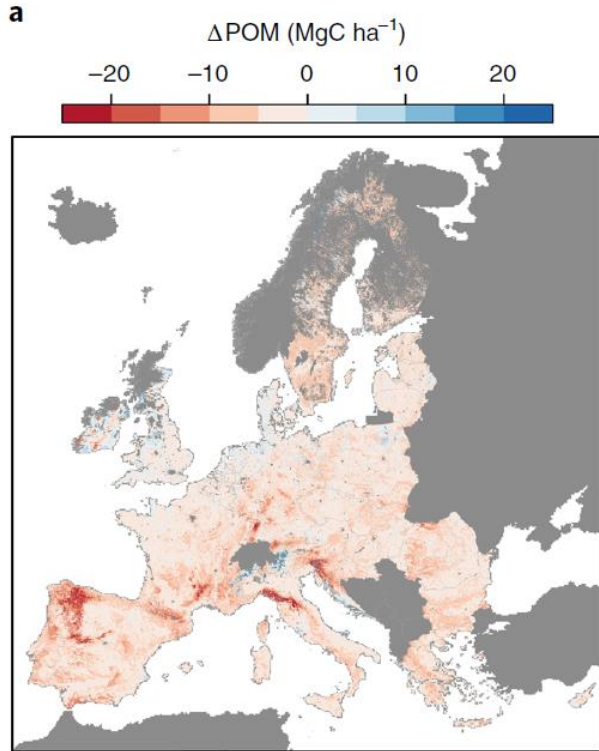


INCREASING LAND-USE PERTURBATION

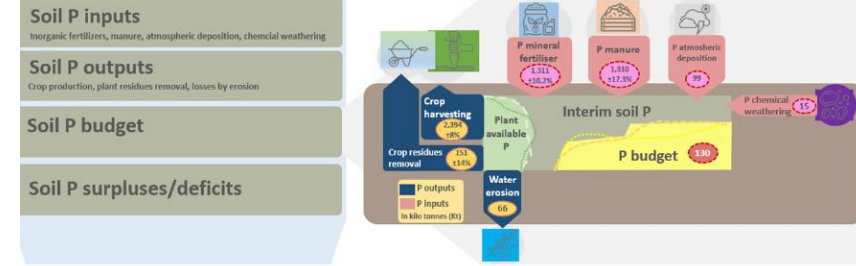


Research & Innovation

# Novel assessments of Soil Health



## Improving the Phosphorus budget of European agricultural soils



Science of the Total Environment 853 (2022) 158706



Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: [www.elsevier.com/locate/scitotenv](http://www.elsevier.com/locate/scitotenv)



## nature sustainability

Analysis

<https://doi.org/10.1038/s41893-022-00988-6>

# Policy implications of multiple concurrent soil erosion processes in European farmland

Received: 4 May 2022

Accepted: 27 September 2022

Published online: 27 October 2022

Check for updates

Pasquale Borrelli <sup>1,2</sup>, Panos Panagos <sup>3</sup>, Christine Alewell <sup>4</sup>, Cristiano Ballabio <sup>5</sup>, Hugo de Oliveira Fagundes <sup>6</sup>, Nigussie Haregeweyn <sup>6</sup>, Emanuele Lugato <sup>3</sup>, Michael Maerker <sup>7</sup>, Jean Poesen <sup>8,9</sup>, Matthias Vanmaercke <sup>8</sup> and David A. Robinson <sup>10</sup>

nature geoscience

ARTICLES

<https://doi.org/10.1038/s41561-021-00744-x>

Check for updates

## Different climate sensitivity of particulate and mineral-associated soil organic matter

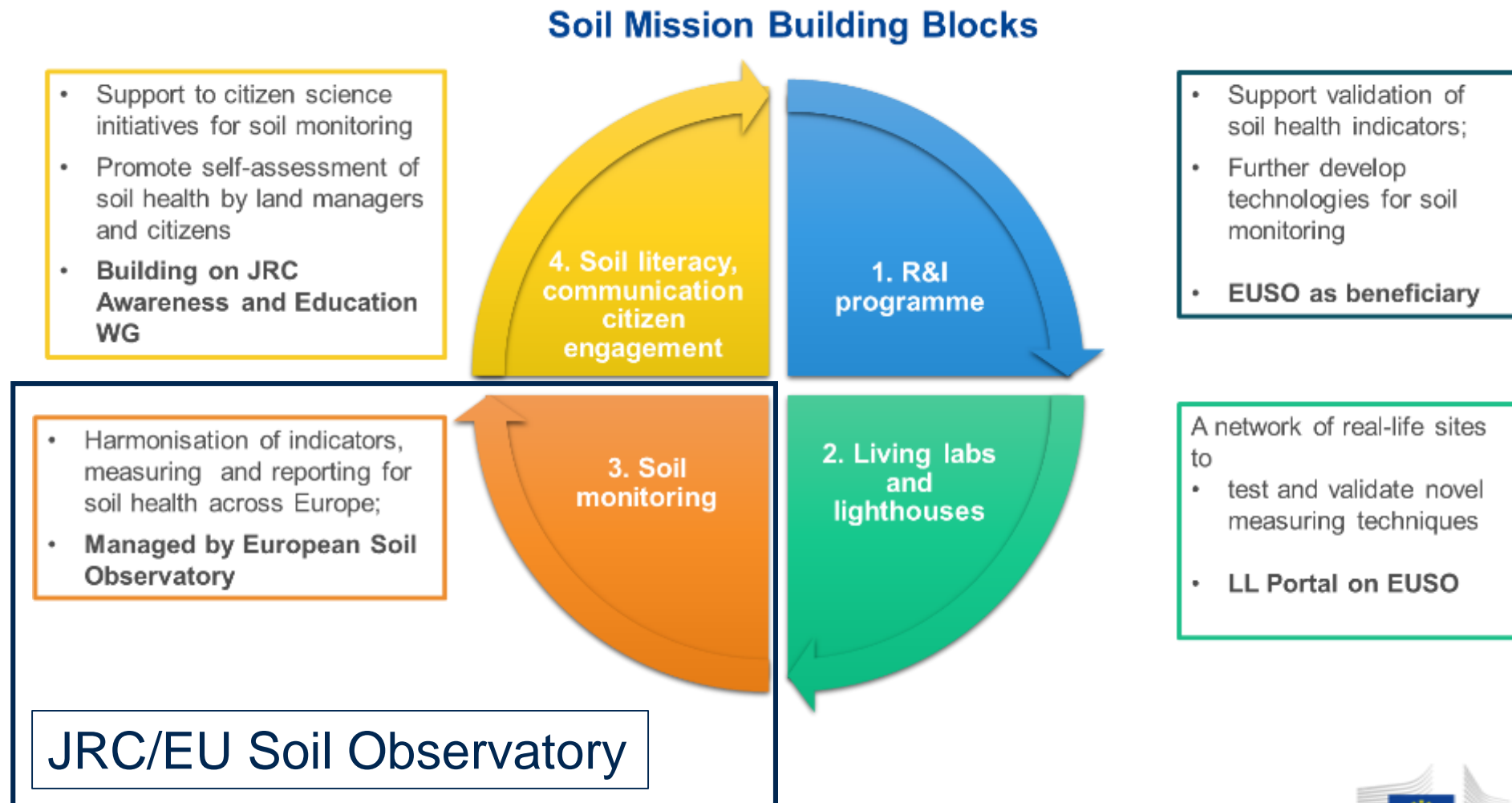
Emanuele Lugato <sup>1,5</sup>, Jocelyn M. Lavalley <sup>2</sup>, Michelle L. Haddix <sup>2</sup>, Panos Panagos <sup>1</sup> and M. Francesca Cotrufo <sup>2</sup>

## Improving the phosphorus budget of European agricultural soils

Panos Panagos <sup>1,\*,</sup> Julia Königinger <sup>1</sup>, Cristiano Ballabio <sup>1</sup>, Leonidas Liakos <sup>1</sup>, Anna Muntwyler <sup>1</sup>, Pasquale Borrelli <sup>1</sup>, Emanuele Lugato <sup>1</sup>



# JRC is part of the Horizon Europe Soil Mission: a major partnership that will fill knowledge gaps



# Framework for Soil Protection in the EU



# ESDAC in 2015 – EUSO in 2030

Top-down mapping

Bottom-Up mapping



European Journal of Soil Science

OPINION | Open Access | CC BY

**A 1 billion euro mission: A Soil Deal for Europe**

Panos Panagos, Pasquale Borrelli, Arwyn Jones, David A. Robinson

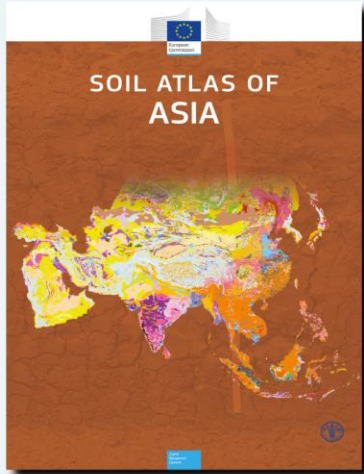
First published: 26 February 2024 | <https://doi.org/10.1111/ejss.13466>

SECTIONS

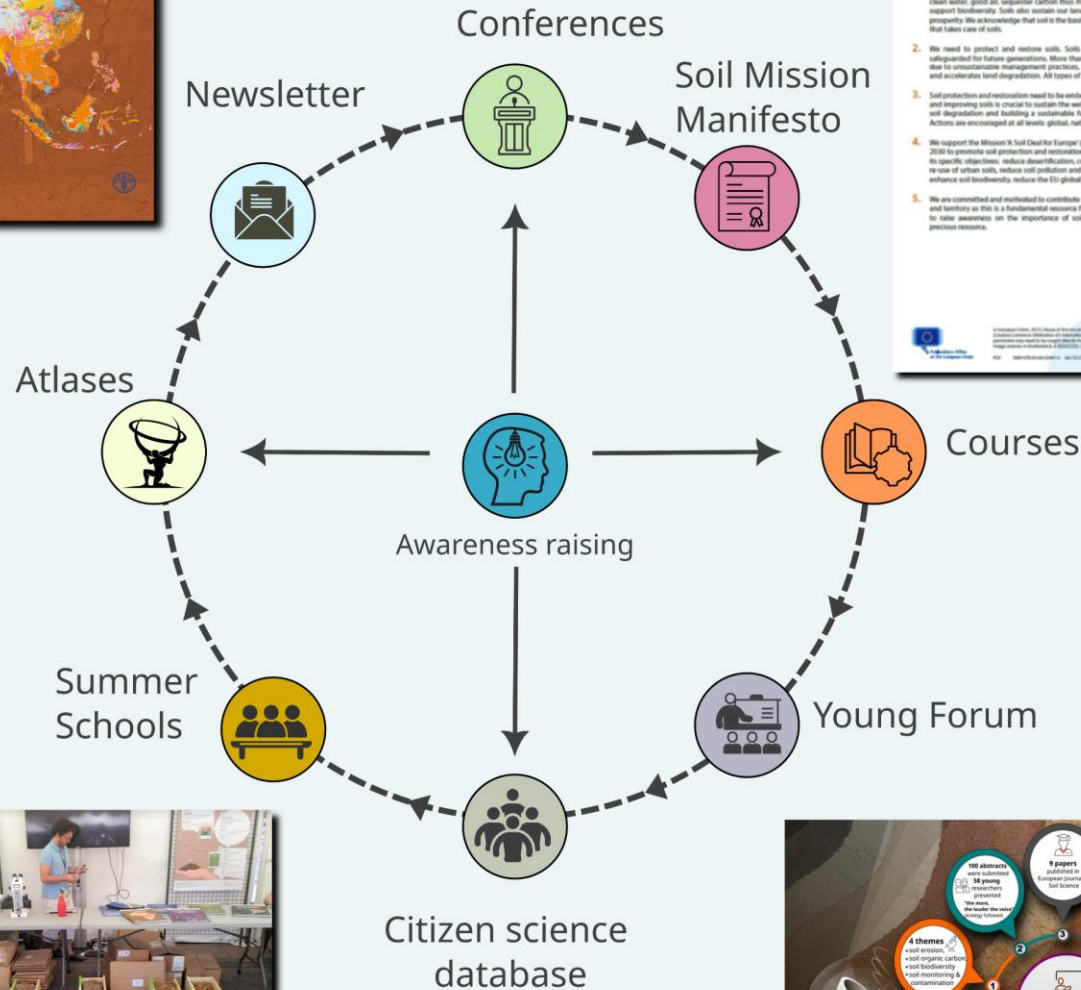
PDF TOOLS SHARE

Abstract

Soils have achieved prominence in the political agenda of the European Commission with the proposal for a Soil Monitoring Law and the ambitious Soil Mission research framework. The EU Soil Observatory (EUSO) used the latest state-of-the-art pan-European datasets to propose a preliminary assessment of soil health in the EU based on 18 soil degradation proxy indicators. The body of knowledge will soon be enriched thanks to the investment of 1 billion euros towards the Mission 'A Soil Deal for Europe', which



# Supporting Citizen Engagement & Awareness Raising





# EUSO Stakeholders Forum

- 1,000 participants in 2021, 2022 & 2023
- High-level participation
- 70+ presentations over three days
- 2023 Forum: Presentation of Soil Mission funded projects
- 1<sup>st</sup> European SOIL Mission Week (21-23 November, Madrid)
- Establishment of 6 Technical Working Groups - Lead to a more complete knowledge base for policy

## EU Soil Observatory Working Groups



**Third EUSO Stakeholders Forum**

15-17 November 2023  
Online Working groups meeting

21-23 November 2023  
European Soil Mission Week  
Madrid, Spain

#EUSO  
<https://esdac.jrc.ec.europa.eu/euso>

EU SOIL OBSERVATORY

JRC Technical Report

EUSO Annual Bulletin  
ISSN 1831-9424

JRC TECHNICAL REPORTS  
EU Soil Observatory 2021

Review and reflections

Maschal, A., Jones, A., Panagos, P., Beirland, D., De Medici, D., De Rosa, D., Jimenez, J.M., Koeniger, J., Labeyrie, M., Liakos, L., Lugato, E., Mathew, S., Montanarella, L., Murty, A., Orzago, A., Scarpa, S., Schiavon, C., Wędek, P., Van Liedekerke, M., Viera, D.

2022

2024

EU SOIL OBSERVATORY

Joint Research Centre

EUR 31152 EN



# Support Young Soil Researchers



# EUSO beyond the EU

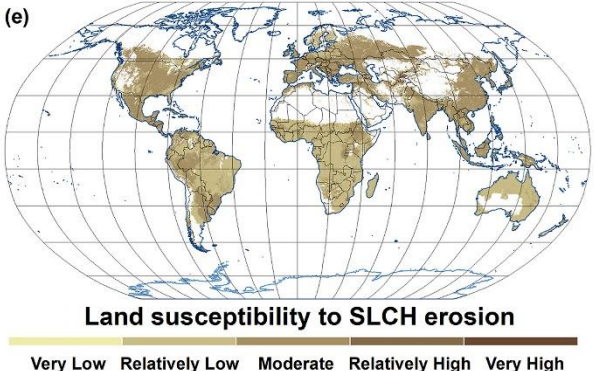
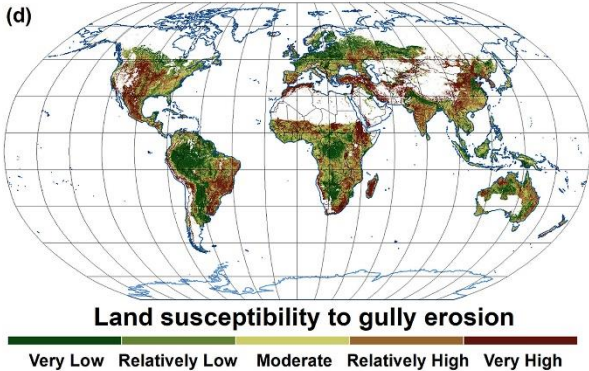
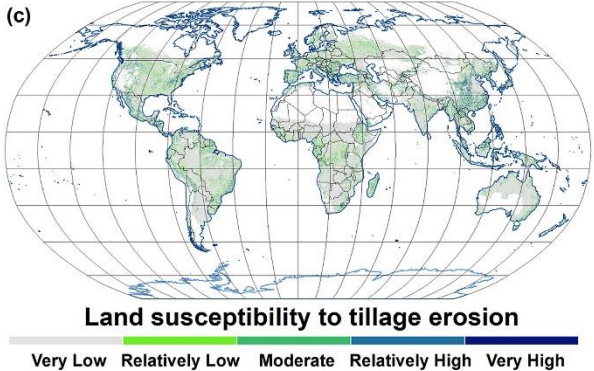
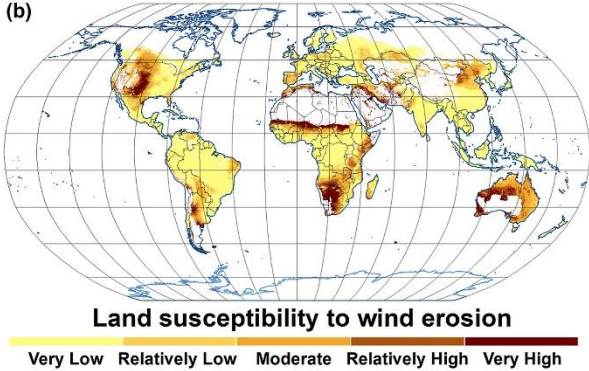
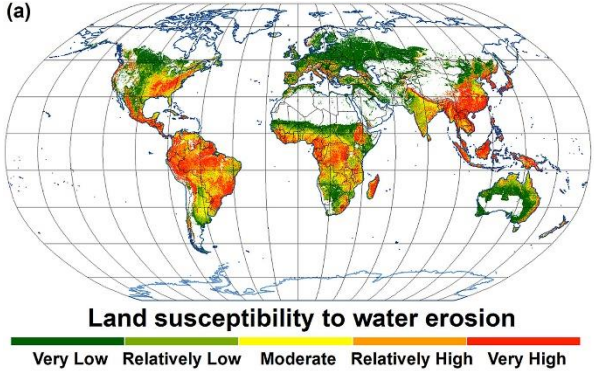
European Commission

SOIL ATLAS OF ASIA

Joint Research Centre

Sheet G | 5 Kazakhstan, Uzbekistan, Tajikistan, W Kyrgyzstan

Sheet 28 | 5 Myanmar, Central Thailand, Central Lao People's Democratic Republic, Central Viet Nam, N Andaman Islands (India)



# What's next for EUSO

- State of European Soils Report
  - FAO State of World Soil Resources 2025, SOER 2025
- LUCAS SOIL 2.0
- Updated EUSO Soil Health Dashboard – to mirror SML
- EU Biodiversity and Antimicrobial resistance (AMR) Assessments
- Soil Biodiversity and Pesticides
- Soil Fertility Report (for Taxonomy)
- Land Degradation / Desertification methodology
- Soil organic carbon baselines for Carbon Farming
- Innovative Soil Health Assessments

# Thank you

## Contacts



EU Soil Observatory: <https://esdac.jrc.ec.europa.eu>

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