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Monitorare e salvaguardare la qualità e la salute dei suoli: l'esperienza Agritech nell'ottica della strategia UE per il suolo

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SPOKE

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Council of the EU | Press release | 17 June 2024 13:45

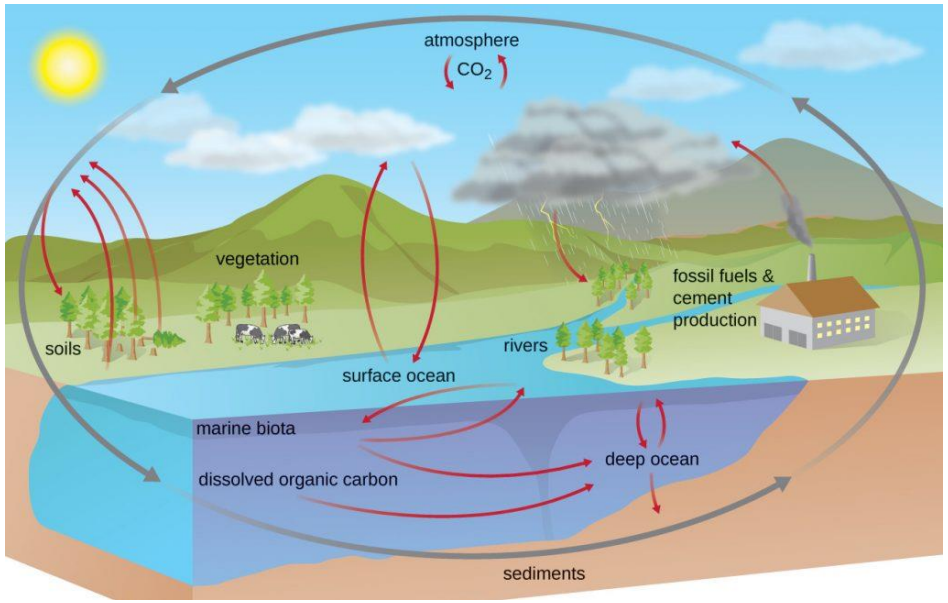
Soil monitoring law: EU on the pathway to healthy soils by 2050

The general approach reached by the Council today aims to make soil health monitoring obligatory, provides guiding principles for sustainable soil management and addresses situations where soil contamination poses unacceptable health and environment risks.

Introduction

Soil is probably the most undervalued element of nature

The same level of protection as air and water and marine environment must be granted to soil as well as the same attention to soil inhabitants as we do for above-ground biodiversity is needed



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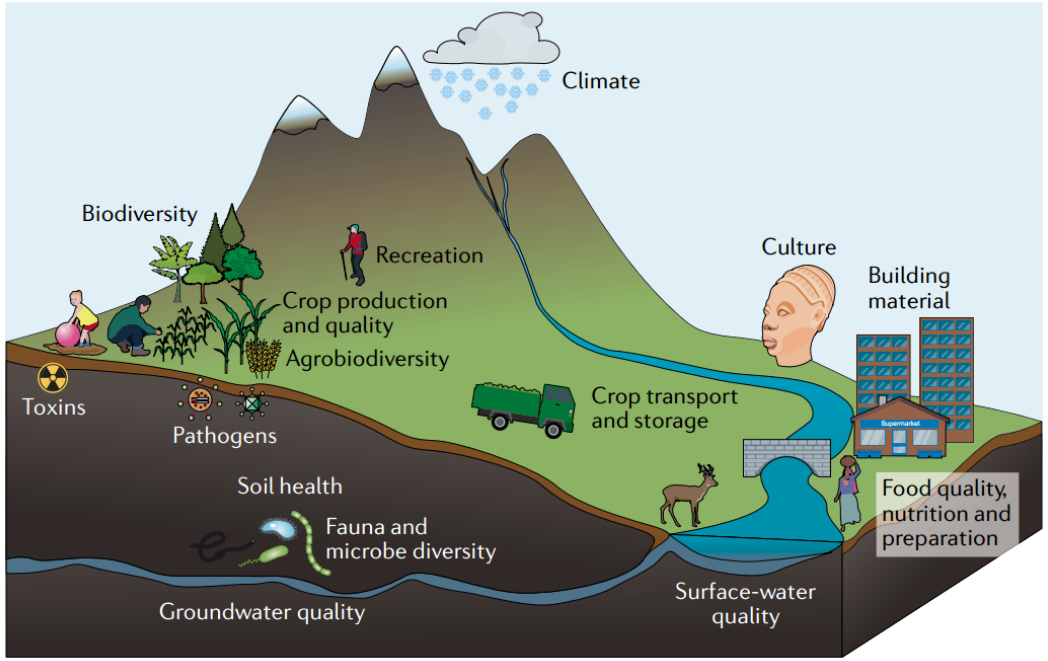
What is a healthy soil?

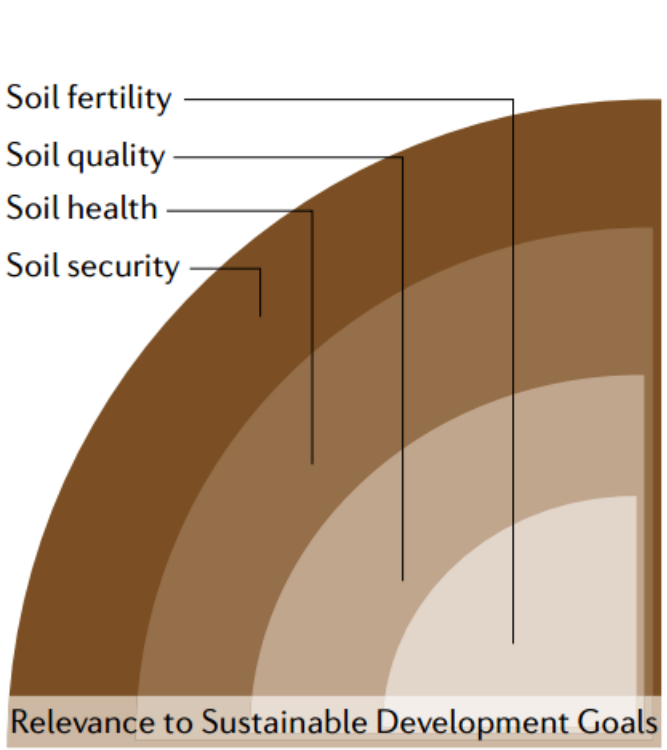
Soils are healthy when they are in good **chemical, biological and physical** condition, and thus able to continuously provide as many of the following **ecosystem services** as possible:
- provide **food and biomass production**, including in agriculture and forestry;
- **absorb, store and filter water** and **transform nutrients and substances**, thus protecting groundwater bodies;
- provide the **basis for life and biodiversity**, including habitats, species and genes;
- act as a **carbon reservoir**;
- provide a **physical platform** and **cultural services** for humans and their activities;
- act as a **source of raw materials**;
- constitute an **archive of geological, geomorphological and archaeological heritage**.



Soil health or soil quality?

Soil quality (1990s): «Ability of a soil to function for agriculture and its immediate environmental context»

Soil health (2000s): «The continued capacity of soil to fuction as a vital ecosystem that sustains plants,animals and humans»



Scale	Functions	Services	Primary stakeholders
Global	Habitat provisioning	Policy Culture	Global and national policymakers
National	Carbon sequestration	Human health	Public
Regional	Water cycling	Biodiversity	Neighbours
Local	Nutrient cycling	Climate control	
Field Pedon	Primary productivity	Recreation	
		Water quality	
		Economic viability	Farmer, land user
		Plant production	

Common good	Private property	Rights
Qualitative	Multi-dimensional	Quantitative — Assessment

Lehmann, J., Bossio, D.A., Kögel-Knabner, I. et al. The concept and future prospects of soil health. Nat Rev Earth Environ ***1****, 544–553 (2020). https://doi.org/10.1038/s43017-020-0080-8*

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Soils under threat

It has been estimated that about **60 to 70% of soils in the EU are not healthy**

Major soil threaths:

Erosion (about 1 billion tonnes of soil per year are washed away by erosion in Europe; between 2012 and 2018 more than 400 km² of land was taken per year in the EU on a net basis)

Compaction

Organic matter decline

Pollution

Loss of biodiversity

Salinization

Sealing

EU Soil Strategy

Cropland and grasslands in the EU provide **EUR 76 billion** worth of ecosystem services **per year** (less than 1/3 by agriculture)

Halting and reversing current trends of soil degradation could generate up to **EUR 1.2 trillion per year** in economic benefits globally.
The cost of inaction on soil degradation, which outweighs the cost of action by a factor of 6 in Europe.

Long-term objectives by 2050
- Reach **no net land take**.
- **Soil pollution** should be reduced to levels no longer considered harmful to human health and natural ecosystems.
- Achieve a **climate-neutral** Europe
- Achieve for **EU a climate-resilient society**, fully adapted to the unavoidable impacts of climate change by 2050

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Soil and Climate Change

In relation to climate change, these two main types of soils play an important role:

- **Organic soils** (including peatlands): have a high carbon content of **more than 20% in dry weight** and cover 8% of the EU
- Mineral soils feature a carbon content **below 20%,** although more generally it is below 5%.

Carbon sequestration in mineral soils, while depending on soil type and climatic conditions, is a cost-effective emission mitigation method with significant potential to sequester **between 11 to 38 $MtCO_2eq$ annually in Europe**

Actions:

- **Organic soils**: limit drainage of wetlands and organic soils and to restore managed and drained peatlands, in order to maintain and increase soil carbon stocks. Furthermore, the EU is committed to the protection of wetlands and peatlands

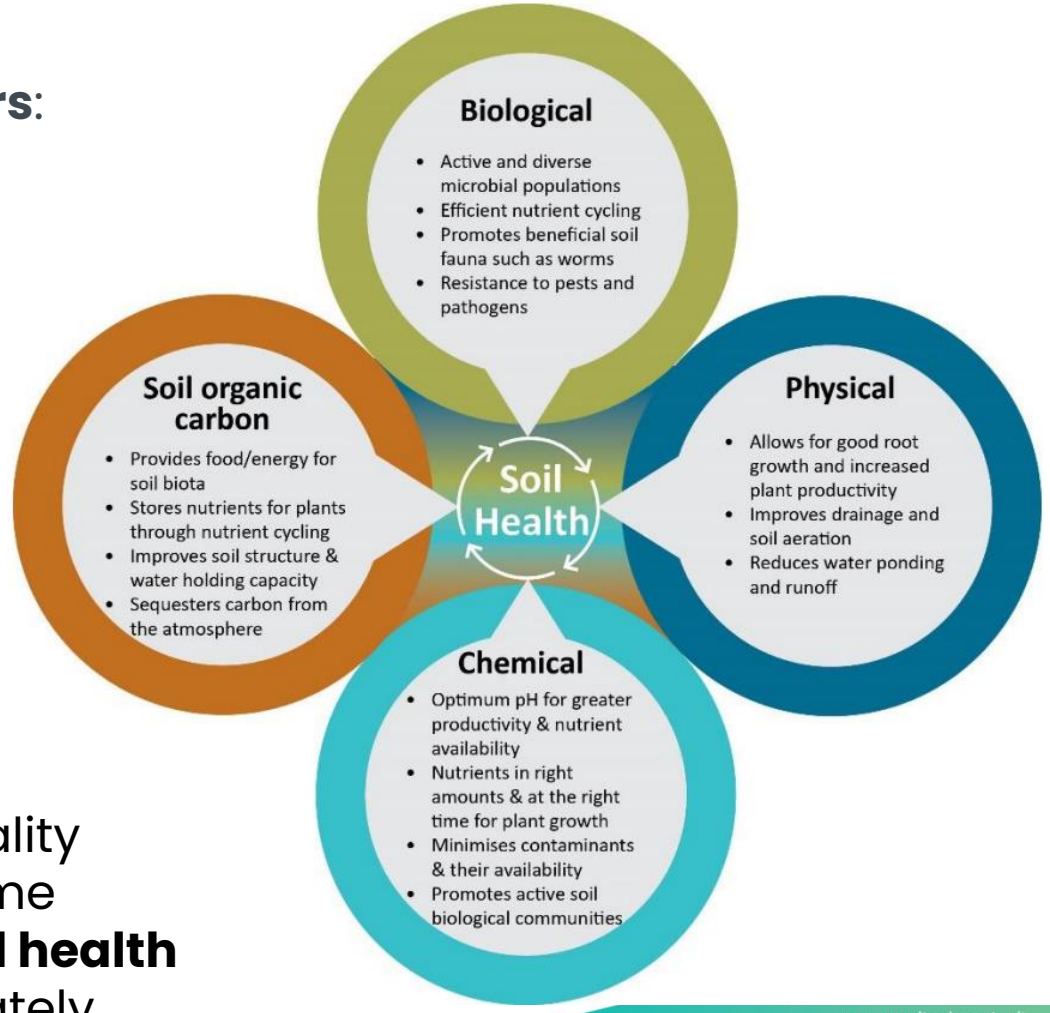
- **Mineral soils**: enhance biodiversity in agricultural land that would contribute to conserving and increasing soil organic carbon. EU carbon farming initiative and a legislative proposal on carbon removal certification to promote a new green business model rewarding land managers, such as farmers and foresters, for climate–friendly practices

How is soil health/quality assessed?

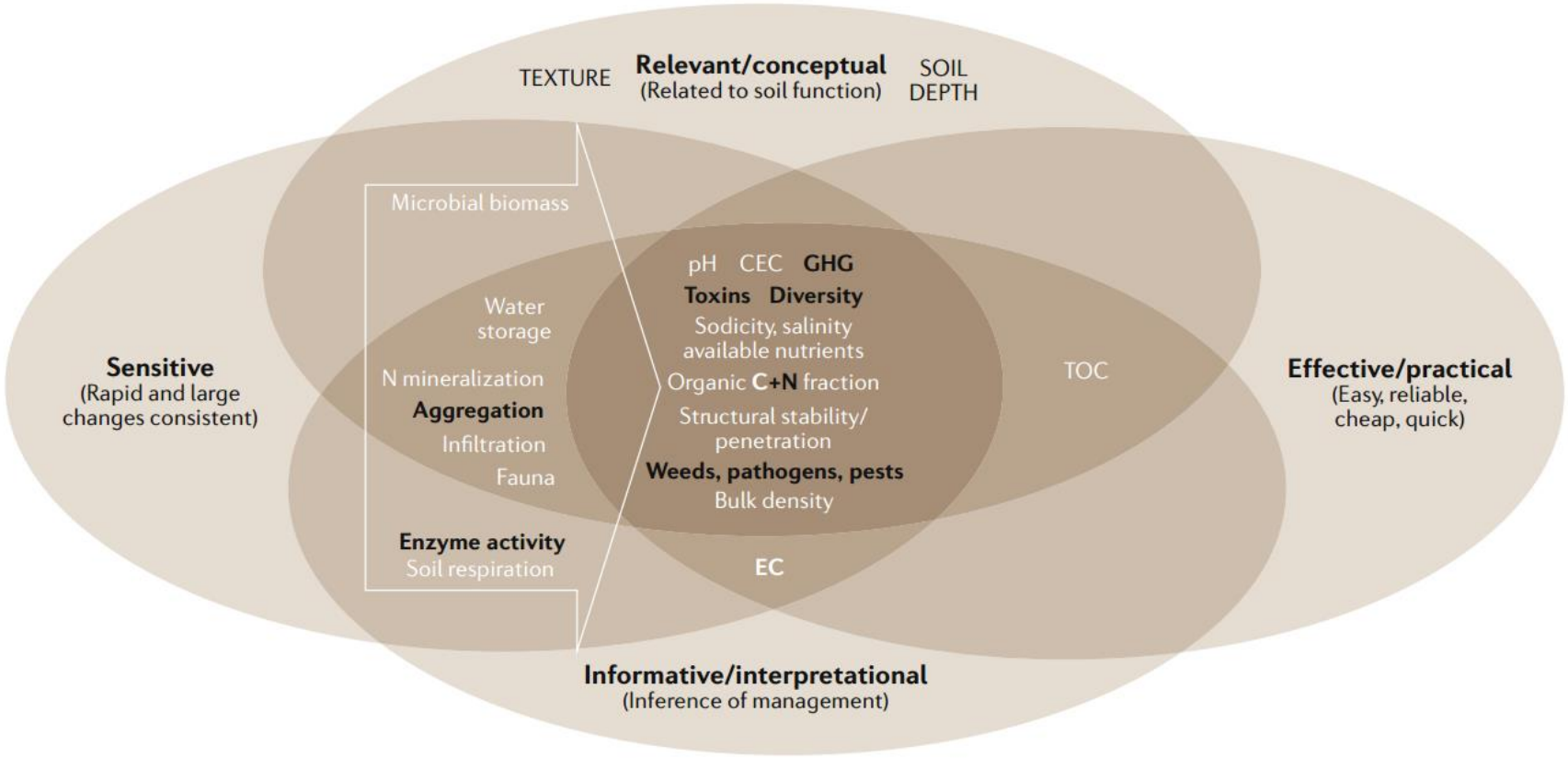
Determination of **soil health descriptors/indicators**: **physical, chemical and biological** parameters.

As there is a multitude of soil-health indicators, an appropriate desire exists among scientists and stakeholders to integrate them into one single test score or '**soil-health index**'. However, relatively few indices exist; in the 2020 database compiled on soil health, SoilHealthDB, which assessed over 500 studies on soil health and quality, only five studies included a single soil-health index.

There is an increasing interest for a refined soil quality index, e.g. in the financial and industrial sector. Some Member States have developed **certificates of soil health** to be provided during land transactions to adequately inform the buyer.



Soil-health indicators and relevance to assessments



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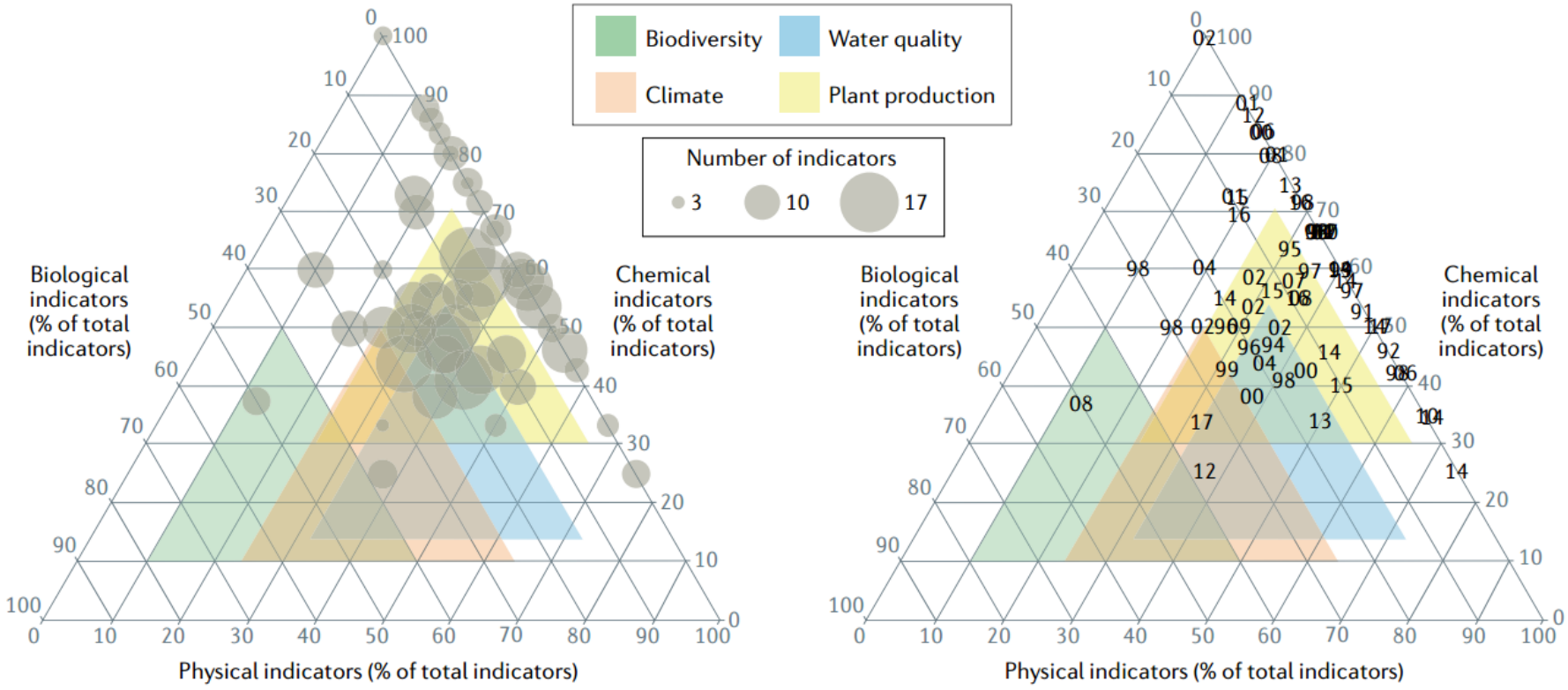
Biological, chemical and physical indicators included in soil-health-assessment schemes



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Which soil health indicators should be monitored?

Soil monitoring law: EU on the pathway to healthy soils by 2050 (17 June, 2024)

Proposal for a Directive of the European Parliament and of the Council on Soil Monitoring and Resilience (Soil Monitoring Law)

European approach:
- make **soil health monitoring obligatory**
- provide **guiding principles for sustainable soil management**
- addresses situations where **soil contamination** poses unacceptable health and environment risks

Member states, supported by the Commission, will first **monitor and then assess** the health of all soils in their territory, so that **sustainable soil management practices** and other appropriate measures can be taken by authorities and landowners across the EU. Member states will determine **sampling points** for monitoring, on the basis of an **EU common methodology**.

It also sets out the **minimum quality requirements** for **laboratories** analysing soil samples to ensure the comparability of soil measurements.

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Soil descriptors and criteria for healthy soil condition

In order to adapt to local circumstances, a more **flexible double-value system** was agreed in the Council to assess soil health:

- **non-binding sustainable target values** at EU level to reflect the long-term objectives

- **operational trigger values**, set at member states level for each soil descriptor, in order to prioritise and gradually implement measures leading to a healthy soil status

Background

The **lack of a dedicated EU legislation** was singled out as a major cause for the alarming state of EU soils. To ensure the same level of protection to soil that exists for water, the marine environment and air in the EU, the Commission put forward the soil monitoring directive on 5 July 2023.

Descriptors with criteria established at Union level

Threat	Descriptor	Determination	Criteria	Exception
Salinization	Electrical Conductivity (dS/m)	1)**ISO 11265** (soil/water, 1:5) 2) saturated soil paste extract method (FAO method)	< 4 dS/m (saturated soil paste)	Naturally saline land areas
Loss of organic carbon	Soil Organic Carbon (g/kg)	**ISO 10694** - Determination of organic and total carbon after dry combustion (elementary analysis). **ISO 10693** - Determination of carbonate content, Volumetric method.	**Organic soils**: respect targets set at National level **Mineral soils**: SOC/Clay ratio > 1/13	Non-managed soils in natural land areas
Subsoil compaction	Bulk density in subsoil (B-horizon) (g/cm^3)	**ISO 11272** - Determination of dry bulk density **ISO 11277** - Determination of particle size distribution in mineral soil material (method by sieving and sedimentation)	Depending on **soil texture:** <1.80 sand to loam <1.75 sandy clay loam to silt loam <1.65 sit loam to silty clay loam <1.58 sandy clay to clay <1.47 clay	Non-managed soils in natural land areas and areas with naturally compacted soils

Descriptors with criteria established at Member States level

Threat	Descriptor	Determination	Criteria	Exception
Excess nutrient content in soil	Extractable phosphorous (mg/kg)	**ISO 11263** - Determination of phosphorus: spectrometric determination of phosphorus soluble in sodium hydrogen carbonate solution (Olsen method)	Member States shall define their own "maximum value", to a level that would not entail damage to the environment and human health.	non-managed soils in natural land areas
Soil erosion	Soil erosion rate (t ha^{-1} y^{-1})	Soil erosion shall be assessed by considering soil characteristics, climate, topography, vegetation cover, management practices, burned areas.	Member States shall define their own "maximum value", to a level that would not entail damage to the environment and human health.	badlands and natural land areas, except if they represent a significant disaster risk
Soil contamination	Concentration of heavy metals in soil (mg/kg) Concentration of a selection of organic contaminants established by Member States	**Heavy metals: ISO 54321** - Digestion of aqua regia soluble fractions of elements Optional: **ISO 17586** - Extraction of trace elements using dilute nitric acid **Organic contaminants**: Use European or International standards when available	Reasonable assurance that no unacceptable risk for human health and the environment from soil contamination exists.	No exception Natural and anthropogenic background levels should be taken into account in the risk assessment.

Descriptors without criteria

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Threat	Descriptor	Determination
Excess nutrient content in soil	Total nitrogen in soil (mg/g) Soil organic carbon to nitrogen ratio	**ISO 11261** - Determination of total nitrogen — Modified Kjeldahl method **ISO 13878** - Determination of total nitrogen content by dry combustion ("elemental analysis")
Soil acidification	Soil acidity (pH)	**ISO 10390** - Soil, treated biowaste and sludge, Determination of pH (KCl preferred)
Topsoil compaction	Bulk density in topsoil (A-horizon) (g/ cm^3)	**ISO 11272** - Determination of dry bulk density

Descriptors without criteria

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Threat	Descriptor	Determination
Loss of soil biodiversity	Member States shall select **at least one** soil descriptor: - metabarcoding of bacteria, fungi, protists and animals; - Phospholipid fatty acid analysis (PFLA) - abundance and diversity of nematodes; - abundance and diversity of earthworms; - abundance and diversity of springtails; - abundance and diversity of native ants; - bacterial diversity based on DNA; - soil biological quality based on arthropods (QBS-ar); - presence of invasive alien species and plant pests	Use European or international standards when available; if such standard is not available, the methodology chosen shall either be available in the scientific literature or publicly available.
Loss of soil biological activity	Member States may select soil descriptors for biological activity such as but not limited to: - soil basal respiration ($mm^3\ O_2\ g^{-1}\ hr^{-1}$) in dry soil - microbial biomass; - Soil respiration; - Enzyme activity.	Use European or international standards when available; if such standard is not available, the methodology chosen shall either be available in the scientific literature or publicly available.

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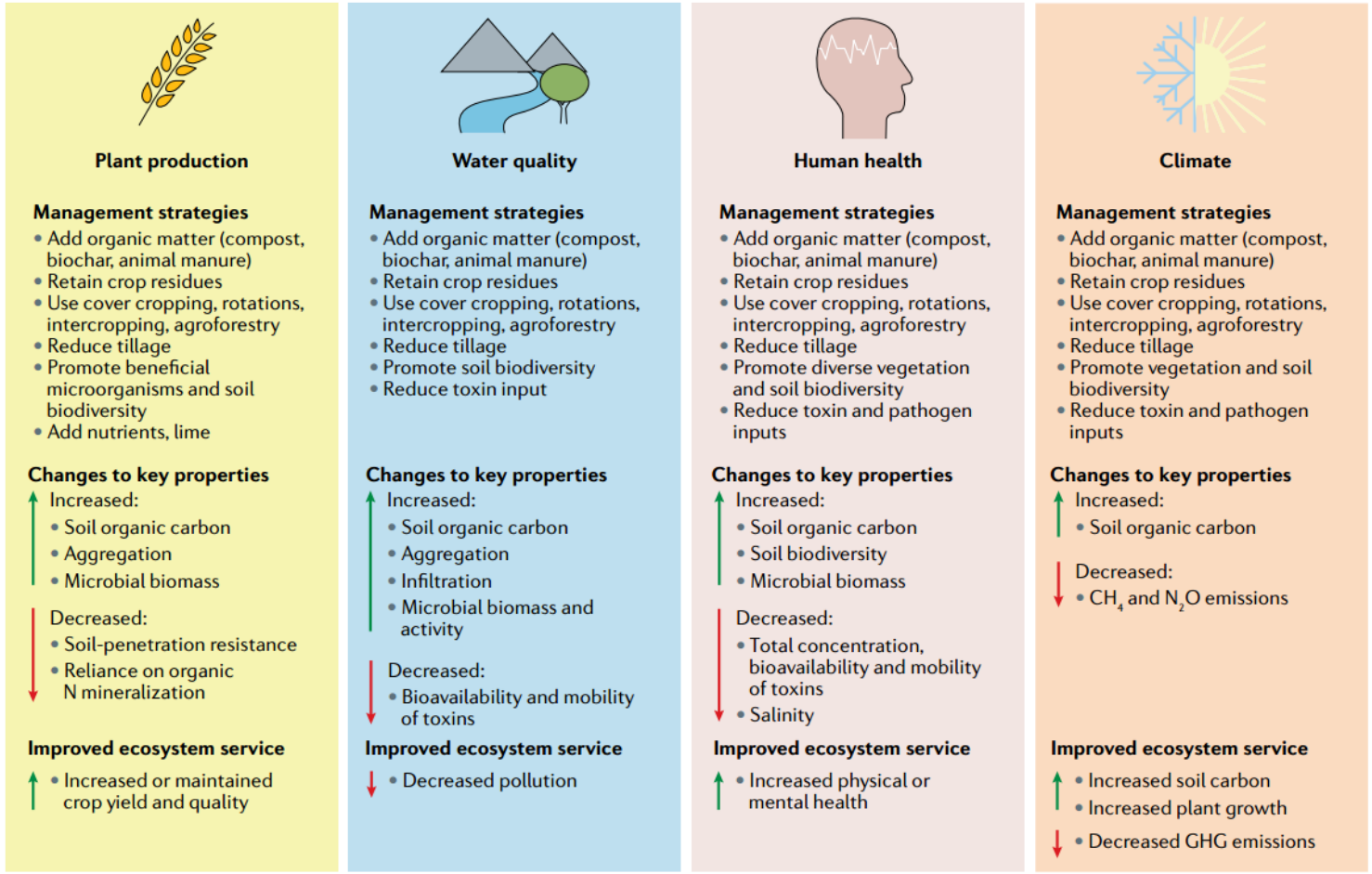
Soil-ecosystem-services management



According to the general approach, Member States will define practices on **sustainable soil management** within five years of the directive entering into force, taking into account the **guiding** sustainable soil management principles set out in the directive.

The ultimate aspirational objective of the proposed directive is to have all soils in a healthy condition by 2050, in line with the EU Zero Pollution ambition.

Lehmann, J., Bossio, D.A., Kögel-Knabner, I. *et al.* The concept and future prospects of soil health. *Nat Rev Earth Environ* **1**, 544–553 (2020). https://doi.org/10.1038/s43017-020-0080-8

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Agritech Spoke 3, Task 3.2.1

"Solutions for soil quality assessment and protection"

Task Coordinator: Francesco Gentile (francesco.gentile@uniba.it) and Roberto Terzano (roberto.terzano@uniba.it)

Soil quality assessment is crucial for *food safety and security*, and for soil ecological functions. This goal can be achieved through the development of a **multifactorial soil quality index** able to monitor and evaluate the efficiency and resilience of this natural resource in *different agricultural soil management systems*. Solutions for the *evaluation* of **soil organic carbon stock** and its *management* will be selected, evaluated and adopted at *farm and basin level* using **physical, chemical, biochemical, and microbiological methods**, and *modelling*. Strategies to protect and prevent soil pollution, loss of soil fertility, and biodiversity will be adopted. Soil quality assessment and protection will be monitored using **traditional and smart technologies**, **modelling and forecasting tools**, **real-time and sensor-based applications**.

SPOKE 3

Partner	Type of soil	Crop/cropping system	Soil management goals	Experimental scale	Investigated soil parameters
UniBA	Agricultural	Table grape	Productivity	Farm	(Bio)chemical, biological, physical
UniBO	Agricultural	Wheat and maize in rotation/Grapewine	Productivity, soil quality and organic C balance	Farm	(Bio)chemical, physical
CNR	Agricultural/Substrates	Vegetables/Model plants	Plant growth promotion	Controlled environments	Nutrient availability
UniNA Activity I	Forest/Agricultural	Chestnut/Olive trees/ Horticultural crops	Productivity	Catchment/Sub-catchment/Regional	Physical, chemical, hydraulic properties
UniNA Activity II	Agricultural	Horticultural crops	Productivity, sustainability, ecosystem services	Farm/vegetable gardens	(Bio)chemical, physicochemical
UniPG	Agricultural	Wheat/Maize	Productivity and sustainability	Farm	Physical, (bio)chemical, (micro)biological, hydraulic properties
UniRC	Agricultural	Crops	Productivity and crop quality	Glass house/Climatic chamber/Open field	(Bio)chemical, physical
IBF	Agricultural	Arable lands	Soil quality	Farm/Regional	Soil Organic Carbon
ISP	Agricultural	Arable lands	Soil quality	Farm	Soil Organic Carbon

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Subthemes/Activities

Activity 1 – Soil Quality Indicators and Indices (UniBA, UniBO, UniNA, UniPG)

Activity 2 – Innovative Practices for Soil Quality Improvement (UniRC, CNR)

Activity 3 – Innovative Sensors and Models for Soil Quality Assessment (UniNA, IBF, ISP)

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Investigated Soil Quality Indicators (UniBA, UniBO, UniNA, UniPG, UniRC)

Physical indicators: texture (sand, silt, clay), EC, bulk density, soil water storage capacity, hydraulic conductivity, soil temperature, soil moisture, soil aggregates stability

Chemical indicators: pH, Total organic C, Total N, Total S, available C, available N, CEC, Available P, carbonates, Micro/Macronutrients, organic matter pools (labile, stable, resistant), Total PTEs, Bioavailable/Bioaccessible PTEs, Phenols, PAHs

Biological indicators: Soil respiration, microbial biomass C & N, soil microbial activity (Biolog®), soil enzymatic activities (oxidative, hydrolitic), soil microartropodes (QBS-ar), soil microorganisms

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Investigated Soil Quality Indices

- Metabolic quotient (soil respiration/microbial biomass C)
- q_{mic} (microbial biomass C/soil organic C)
- Mineralization quotient (soil respiration/labile organic C)
- Metabolic index (dehydrogenase activity/extractable C)
- Organic C fractions (WEOM, POM, MAOM)
- Isotopic ratio $\delta^{13}C$/ $\delta^{15}N$

simple

- Ecosystems ratios (C, N, P cycles, Sinsabaugh et al. 2008, 2011)
- Alteration indices (AI 3, β-glucosidase – phosphatase – urease, Puglisi et al., 2006)
- Multifactorial Soil Quality Index (Soil Management Assessment Framework, Andrews et al., 2002)

complex

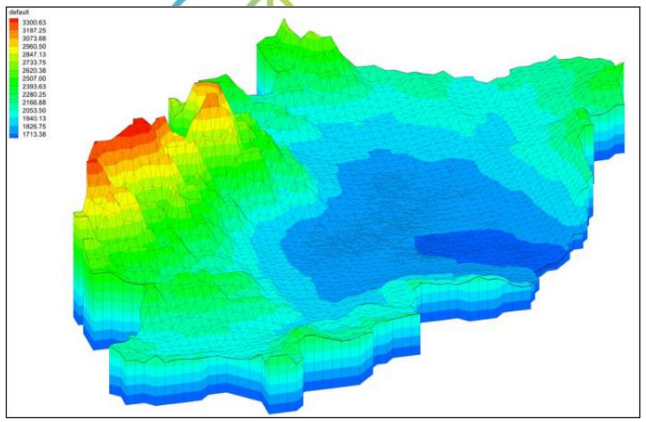
Spectral measurements

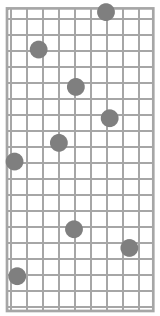
Soil physical/hydraulic properties

Map of the soil physical/hydraulic property

Simulation of water flow and solute transport

Simulated soil moisture patterns





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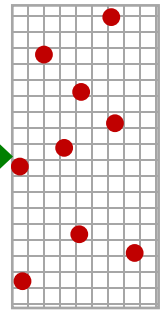
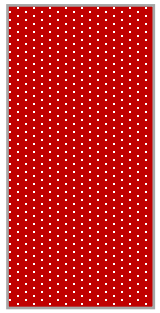
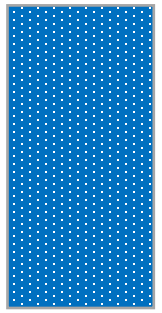


interpolation



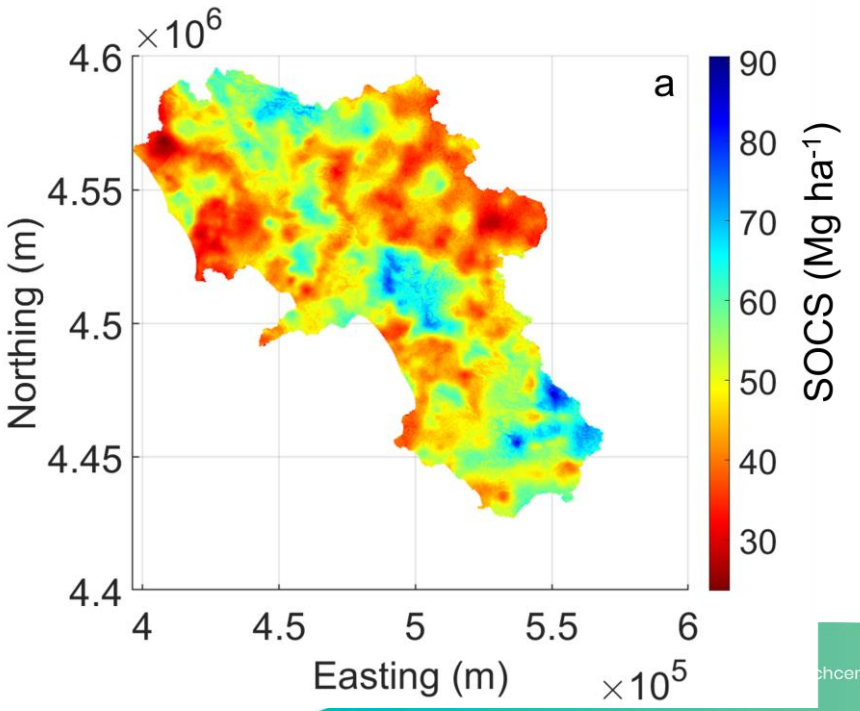
Hydrological model



indicator

$$SOCS = BD \times SOC \times D \times \left(1 - \frac{RF}{100}\right)$$

Soil Organic Carbon stock



UNINA

Soil quality estimation with remote sensing

Objective: Development and implementation of rapid methods for mapping **organic carbon content in topsoil** using remote sensing data and machine learning.

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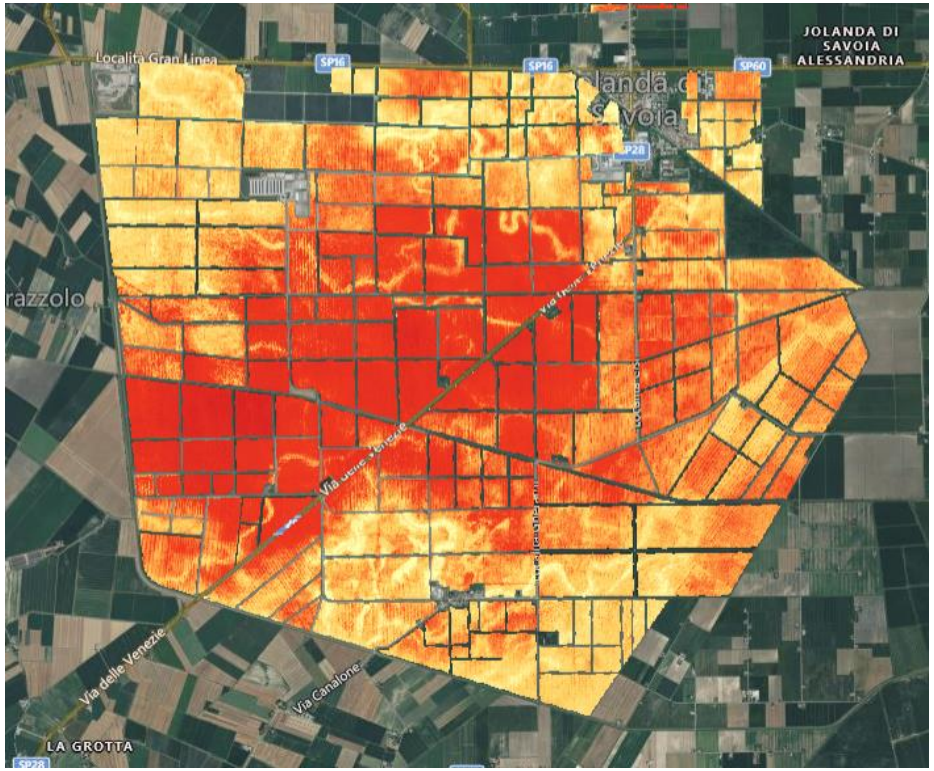
Methods

a) A model will be developed and validated using synthetic bare soil multitemporal images from Landsat 8, 9, and Sentinel 2 satellites.
b) Another model will be developed for predicting organic carbon using environmental covariates generated from multisource remote sensing data (SCORPAN model).



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Conclusions and opportunities (I)

A **multidisciplinary approach** is needed to assess and monitor soil health

EU guidelines still appear vague and not fully definded (role of Member States?)

Need of **field-based measuring systems** (e.g. hand-held spectrometers, portable DNA extraction, on-site chemical analysis), **digital and remote sensors**, and increasingly use of **machine learning techniques** and more **artificial intelligence** solutions from sensing systems.

Create with the Member States a network of excellence of practitioners, and an inclusive network of SSM (sustainable soil management) ambassadors, **connecting stakeholders beyond academia and agricultural actors**. For this **Living Labs** (experiments and innovation in a laboratory on the ground) and **Lighthouses** (places showcasing good practices) will be developed (i.e, AGRITECH)

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Conclusions and opportunities (II)

The feasibility of the introduction of a **soil health certificate** is under assessment. Such certificate will be very useful for **land transaction** to provide land buyers with information on the key characteristics and health of the soils in the site they intend to purchase. **Investors and banks** are becoming increasingly interested is such tools.

Farmers are more and more financially rewarded for the carbon that their soils capture and the application of **sustainable soil management practices** through carbon payment schemes (**carbon farming**). Banks are seeking for **tools to evaluate carbon sequestration**. **Companies** are increasingly offsetting carbon emissions by buying **carbon credits** from farmers.

'**TEST YOUR SOIL FOR FREE**' initiative is proposed by EU. Knowing more about soil characteristics (pH, bulk density, soil organic matter, nutrient balance, etc.) will help land users to adopt the **best management practices**. The Commission will assist Member States in setting up, with their own funds, a system to test soil for free for those land users that so wish, and who will receive the results of the tests.

EU will continue providing substantial funding to i) research solutions to **increase soil biodiversity**; ii) **address soil degradation**; iii) pilot **innovative technologies for decontamination**.

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Credits

UniBA: Roberto Terzano, Francesco Gentile, Franco Nigro, Carlo Porfido, Giovanni Francesco Ricci, Anna Maria Stellacci, Simone Pascuzzi
UniBO: Claudio Ciavatta, Martina Mazzon
CNR: Maurizio Chiurazzi
UniNA: Nunzio Romano, Paolo Nasta, Antonio Giandonato Caporale, Paola Adamo
UniPG: Alberto Agnelli
UniRC: Adele Muscolo
IBF: Matteo Petito
ISP

Thank You