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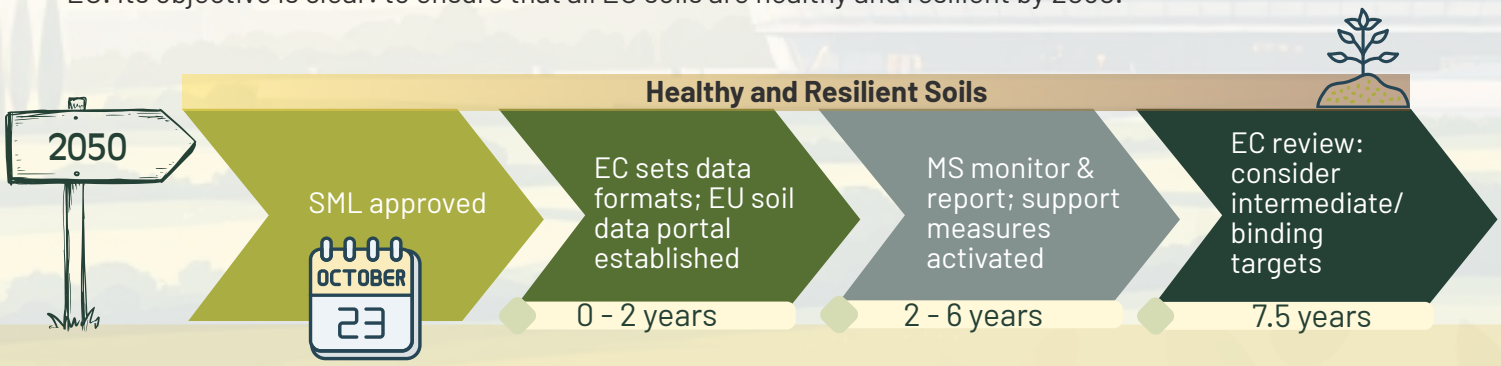
Europe Adopts its First Soil Health Law: Creating a Common Ground for Europe's Soil Resilience

On 23 October 2025, the European Parliament (EP) has given its final approval to the Directive on Soil Monitoring and Resilience (SML)— **Europe's first-ever law dedicated to soil health**. This landmark legislation crowns more than a decade of scientific advocacy and delivers on a key promise of the European Green Deal: a shared legal framework for protecting, monitoring, and restoring soils across the EU. Its objective is clear: to ensure that all EU soils are healthy and resilient by 2050.



The SML requires Member States (MS) to conduct regular soil monitoring, assess trends, and report every six years to the European Commission (EC). The EC will carry out an evidence-based evaluation seven and a half years after entry into force and, where relevant, review of the Directive.

While the final text represents a political compromise, with flexibility for Member States and non-binding targets, it introduces an EU agreed framework for soil monitoring and assessment soil health, soil resilience and management of contaminated sites.

AI4SoilHealth's research in support of the SML's implementation

The SML provides the policy framework for AI4SoilHealth's scientific and technological innovations, linking soil data, monitoring, and decision-making.
AI4SoilHealth delivers insights to support the translation of policy into practice.

In **5 critical areas**, mentioned by the SML, AI4SoilHealth has produced scientific inputs to help the European Union and Member States turn policy into practice.

- Soil Districts & Units
- Monitoring & Assessment Framework
- Measurements & Methodologies
- Data Infrastructure & EU Support
- Soil Resilience & Stakeholder Engagement

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Each section explores how AI4SoilHealth's research addresses specific priority areas and provisions of the SML Directive, providing scientific advancements that will support its implementation.

SML's Priority Area	AI4Soil Health's Actions
Soil Districts & Units	Aarhus University's work in Denmark tested and validated a Soil Monitoring Unit approach using geostatistics and benchmarking - providing insights for other EU countries looking to set up soil monitoring programs.
Monitoring & Assessment Framework	The University of Aberdeen and the UK Centre for Ecology & Hydrology have built an indicator-selection framework that might help Member States in the definition of soil-health targets, operational trigger values linking descriptors indicators, and policy goals.
Measurements & Methodologies	Stockholm University leads the work directed to create a scalable, SML-aligned in-situ toolbox—covering OC%, soil compaction, water retention, salinity, and biodiversity (eDNA, enzymes)- which will enable cost-effective, comparable monitoring.
Data Infrastructure & EU Support	OpenGeoHub is building a Soil Health Data Cube (30 x 30 m resolution) integrating Landsat/Copernicus time series with soil, crop, and degradation layers—enabling hotspot detection, scenario analysis, and climate-aware, long-term assessment.
Soil Resilience & Stakeholder Engagement	Soil Association and ISINNOVA collaborate to ensure that stakeholder engagement is built into the science—through interviews, training, bilateral meetings, and pilot-site testing—so AI/ML tools and indicator frameworks are validated, ethical, and usable, reaching diverse communities via a broad outreach effort and enabling policy-ready, practice-relevant soil health solutions.

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The AI4SoilHealth project, funded by Horizon Europe, is building an AI-powered soil health monitoring system to accelerate the collection and use of soil information.

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Soil Districts & Units

SML requirements

To design monitoring and for reporting soil health, Member States will establish one or more soil districts and designate competent authorities.

Each soil District will cover one or several Soil Units which will be set to reflect a certain degree of homogeneity, taking into consideration the extent of their soil districts, soil type as defined in the map of the soil regions of the European Union and Adjacent Countries and land-use categories under the LULUCF Regulation. Due to spatial variability in soil properties and land use, a soil unit may consist of non-adjacent areas. Where available, they may rely on more detailed or updated datasets and may consider additional layers such as climate and environmental conditions.
The grid of sampling points, determined using geostatistical methods and aligned to soil units, shall be sufficiently dense to estimate, for each soil unit, the area (share) of degraded soils with ≤5% relative uncertainty.

AI4SoilHealth's Actions

Aarhus University's work in Denmark tested and validated a Soil Monitoring Unit approach using geostatistics and benchmarking and —proving insights for other EU countries application.

Aarhus University, Department of Agroecology, lead the work directed to develop and test a national-scale tools for soil-health monitoring aligned with the proposed SML. They delineated stable Soil Monitoring Units (SMUs) and benchmarked indicators locally (e.g., SOC, bulk density, pH, Electrical Conductivity, clay-to-SOC ratio, nitrogen leaching, water erosion), combining field and model-informed measures. Statistically robust sampling controlled a defined uncertainty at soil-unit scale, while integrated national datasets produced SMU baselines and threat maps. The workflow proved scalable for other Member States' assessments. To know more

Monitoring & Assessment Framework

SML requirements

Member States shall monitor soil health on basis of the 13 aspects of soil degradation, reported in the table below. The Directive (Annex I Part A, B, C) specifies the soil descriptors and criteria to be applied for each aspect.

Member States shall assess soil health against (a) non-binding sustainable target values and (b) operational trigger values. A descriptor is in good condition when its sustainable target value is met; moderate and poor condition thresholds are set with reference to operational trigger values.
Where appropriate, Member States may establish additional soil descriptors and indicators. Any setting or adaptation of descriptors, indicators, or criteria under these provisions must be communicated to the EC to ensure transparency and comparability across the Union.
Member States must monitor heavy metals and selected organic contaminants, for which they can take into account a watchlist which will be established by the European Commission (Part B – Annex 1). Under Part C, Member States must, at minimum, monitor PFAS-21 or PFAS-43 or selected PFAS set by Member States, as well as concentrations of selected active substances in pesticides and their metabolites. The Commission will set the watchlist considering criteria such as toxicity, persistence, mobility and exposure and update it as needed on the basis of monitoring, scientific, technical progress. To monitor biodiversity loss is mandatory for Member states to use DNA metabarcoding for fungi and bacteria, which could be coupled with additional descriptors listed in Annex 1.

Member States shall analyse the values of the soil descriptors to determine whether there is a critical loss of ecosystem services. They shall also assess the impact of soil sealing and soil removal on ecosystem services and on targets set under LULUCF Regulation, and may identify areas of improvement for each descriptor. Based on these assessments, competent authorities shall identify areas within each soil district where soil health criteria are not met and where support measures are needed. Aggregated results will be made publicly available, and the findings will inform the development of soil health programmes and measures (Annex IV). In addition, competent authorities shall identify areas with high potential for soil health improvement, particularly through de-sealing or soil reconstruction, considering technical feasibility, cost-efficiency, and achievable benefits. Member States shall also, in line with national law, share soil health data and assessments with landowners and land managers upon request, notably to support the provision of soil management advice.

Part	Aspect of soil degradation	Criteria for healthy soil	Monitoring scale
A	• Salinisation • Loss of Soil Organic Carbon • Subsoil compaction	Descriptors with criteria established at EU level EU: Non-binding target values. MS: Operational and one or more trigger values for each descriptor.	Soil Unit
B	• Excess nutrient content • Soil erosion • Soil contamination • Reduction of soil water retention & infiltration • Loss of soil organic carbon	Descriptors with criteria established at MS level MS: target values and one or more operational trigger values per descriptor.	Soil Unit
C	• Excess of nutrient content in soil • Acidification • Topsoil compaction • Loss of soil biodiversity • Soil contamination	Descriptors without criteria No target/trigger criteria yet; monitoring/analysis only.	Soil Unit

AI4SoilHealth's Actions

The University of Aberdeen and the UK Centre for Ecology & Hydrology have built an indicator-selection framework that might help Member States defining soil-health targets, operational trigger values under the Soil Monitoring Law, linking indicators, descriptors and policy goals.

University of Aberdeen and UK Centre for Ecology & Hydrology coordinated research activities to build a robust, SML-aligned indicator-selection framework to support national soil-health monitoring. The team defined clear selection criteria (relevance to soil functions/threats, sensitivity and signal-to-noise, measurability and cost, and the judicious use of surrogate indicators/pedotransfer functions) and organised indicators in tiers mapped to policy needs (targets/triggers/benchmarks) and to SML descriptor logic. The protocol favoured question-led, probabilistic monitoring capable of detecting state and change, using benchmarks where thresholds are absent and remaining compatible with target/trigger values where they exist. It provides a practical pathway from method selection to national roll-out under the Directive.
To know more read here.

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Measurements & Methodologies

SML requirements

The Commission will provide reference maps, baseline samples, and legacy survey data, and —upon request—assist via the LUCAS programme, which will be enhanced and aligned with SML quality requirements, subject to agreement with Member States.

The level of support will be set in a written agreement with the Member State(s) concerned.

Member States shall collect, process, and analyse data to determine the soil descriptors, following the minimum field survey criteria in Annex II. Sampling is not required for sealed or removed soils. For salinisation, areas not at risk may be excluded from electrical conductivity measurements, with justification to the Commission. For soil contamination, sampling may be limited to a relevant subset of points; for loss of soil biodiversity, measurements shall cover at least 5% of the total sampling points established under Article 8(1).

AI4SoilHealth's Actions

Stockholm University leads the work directed to create a scalable, in-situ toolbox—covering the SML indicators OC%, soil compaction, water retention, salinity, and biodiversity (eDNA, enzymes). The toolbox will enable cost-effective, comparable monitoring and gives Member States a practical path for the implementation of those soil descriptors.

Stockholm University leads the development of an in-situ soil health assessment toolbox for scalable observation. Across AI4SoilHealth pilot sites, 10 novel methods are being validated through coordinated field campaigns, with protocols designed for cost-effective uptake by land managers and authorities. The toolbox includes sensor-fusion approaches—spectroscopy, genomics (eDNA), and in-field measurements—spanning on-site tests (e.g., water infiltration), home-lab kits, and professional-lab workflows (e.g., laboratory eDNA). Methods align to SML descriptors, covering OC%, soil compaction, water retention, salinity, and biodiversity (eDNA, enzyme activity). A harmonised Protocol for Soil Spectroscopy and a FAIR backend in-situ database will be able to support pan-European data integration and provide a practical pathway for cross-country comparability.

Data Infrastructure & EU Support

SML requirements

Beyond assisting, upon request, with regular in-situ soil sampling, the European Commission shall support implementation of the Soil Monitoring Law by: (i) jointly with the EEA, developing Copernicus remote-sensing products to monitor soil sealing and soil removal and to support relevant descriptors and indicators; (ii) establishing, within two years of entry into force, a digital soil health data portal—building on the EU Soil Observatory—to provide georeferenced access to soil health data aggregated at soil-unit level; (iii) ensuring Member States have an early opportunity to review and correct data before publication; and (iv) adopting implementing acts setting formats and methods for data sharing and integration, and developing scientific tools and guidance in cooperation with Member States and stakeholders. The EC's actions are directed to ensure comparability, data quality and interoperability across the Union.

AI4SoilHealth's Actions

OpenGeoHub has implemented a Soil Health Data Cube (30 x 30 m resolution) integrating Landsat/Copernicus time series with soil, crop, and degradation layers—enabling hotspot detection, scenario analysis, and climate-aware, long-term assessment.

The Soil Health Data Cube integrates Earth-observation time series (Landsat/Copernicus, 2000–2023+), soil and crop maps, land-degradation layers, and management-oriented spectral indices at 30 m resolution. The cube reconstructs past trends, quantifies current conditions, and supports scenario analysis from farm to continental scale—enabling users to identify degraded or at-risk soils, assess change, and make data-driven land-use and soil-management decisions. Designed to support soil monitoring with indicators relevant to soil sealing, soil removal, and degradation status, it underpins the opportunities for long-term assessment and climate-aware projections. Published as open data via EcoDataCube.eu and designed to interface with the EU Soil Observatory, the Data Cube might offer interoperable inputs for MS' SML assessments and reporting. To know more, read here.

Soil Resilience & Stakeholder Engagement

SML requirements

Member States shall encourage, facilitate, and support landowners and land managers to improve soil health and resilience.

They must ensure easy and equal access to impartial, science-based advice and provide information, training, and capacity-building on sustainable soil practices. Awareness-raising will focus on the long-term benefits of healthy soil management and the costs of practices detrimental to soil health. Member States will promote research and innovation on soil regeneration and management adapted to local conditions, and provide locally relevant guidance based on soil health assessments and the scientific tools. Regularly updated mapping of available funding, instruments, and other support measures shall be made accessible to those managing land and soil.

In addition, Member States shall regularly assess the technical and financial needs to enhance soil health and resilience, engaging early and effectively with landowners and land managers to define the level of support required. They must also evaluate the expected effects of measures taken under the programmes, plans, targets, and actions listed in Annex IV of the Directive. These provisions aim to ensure that support systems are responsive, evidence-based, and aligned with both local soil conditions and the overarching goals of the EU Soil Monitoring and Resilience framework.

AI4SoilHealth's Actions

Soil Association and ISINNOVA collaborate to ensure that stakeholder engagement is built into the science—through interviews, training, bilateral meetings, awareness-raising, and pilot-site testing—so AI/Machine Learning tools and indicator frameworks are validated, ethical, and usable, reaching diverse communities via a broad outreach effort and enabling policy-ready, practice-relevant soil health solutions.

Together with all project partners, Soil Association and ISINNOVA have led the development of a multi-layered stakeholder engagement strategy to ensure that AI4SoilHealth's scientific outputs are relevant, transparent, and usable for policy and practice. The approach connects decision-makers, scientists, and land managers, focusing on ground-truthing AI/ML tools, ensuring the relevance of indicator frameworks, integrating ethical considerations in soil monitoring and land use, and fostering two-way dialogue between policymakers and practitioners. Stakeholder engagement activities, implemented across the consortium, include Living Labs, high-level interviews, training workshops, bilateral meetings, and testing of tools and methods at pilot sites across 11 pedo-climatic regions. Public outreach comprises over 28 scientific papers, 21 press releases and blogs, 11 podcasts, 3 webinars, 49 awareness videos, 2 international conferences, and around 280 social media posts, reaching diverse communities of farmers, researchers, SMEs, NGOs, and foresters across Europe, with more planned in 2026.

LOOKING AHEAD

Policy → Practice

The SML marks a shift from fragmented soil policies to a coordinated, data-driven framework. Its success will hinge on Member States' ability to operationalise soil units, build interoperable data systems and engage land managers at scale.

AI4SoilHealth's scientific results, including AI methodologies, FAIR data infrastructure, and user-centred frameworks, provide evidence for measurable improvements in soil health and resilience.

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