1
POLICY
BRIEF

Scaling Soil Carbon Monitoring with Earth Observation

A trusted, field-validated approach to complement soil sampling and support monitoring implementation of the Common Agricultural Policy and the EU Soil Monitoring Law

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2 Highlights

THE ISSUE	Field sampling remains essential but is costly and difficult to repeat frequently across large agricultural regions. Authorities need more timely and comparable information on soil organic carbon (SOC) trends.
THE EVIDENCE	The Soil Health RI Lab combines hyperspectral observations, Sentinel-2 imagery, environmental data and laboratory measurements. Federated AI enables joint model development while participating organisations retain control of their data.
THE ACTION	Recognise validated Earth observation (EO)-based SOC maps as complementary evidence; agree common quality and uncertainty requirements; and establish trusted data-sharing arrangements for operational pilots.
THE IMPACT	More targeted field campaigns, earlier detection of declining soil condition, stronger CAP and carbon-farming evidence, and practical soil information for farmers and advisers.

3 Context of the Issue

Policy question: How can public authorities expand SOC monitoring without weakening scientific credibility, data control or the role of field measurements?

Policy landscape. Directive (EU) 2025/2360 requires Member States to monitor and assess soil health and to transpose the law by 16 December 2028. The CAP supports sustainable soil management, while the EU Mission "A Soil Deal for Europe" promotes a harmonised soil-monitoring framework. LUCAS Soil supports harmonised EU-wide monitoring aligned with the Directive.

The challenge. Laboratory analysis provides the reference evidence for SOC, but repeated sampling is resource intensive. Infrequent or fragmented observations make it harder to detect trends, target measures and evaluate environmental outcomes.

The project gap. Satellite or hyperspectral signals alone are not sufficient. Reliable regional products require local calibration, field validation, transparent uncertainty, interoperable data and governance that gives data holders confidence to collaborate.

WHO SHOULD ACT?

- European Commission: DG AGRI, DG ENV and DG CLIMA
- European Soil Observatory and national soil authorities
- CAP managing authorities and paying agencies
- Agriculture and environment ministries
- Advisory services and agricultural data-space initiatives

4 Policy Recommendations

Actions are ranked by urgency and designed for national and regional implementation of the Soil Monitoring Law, CAP monitoring and related soil-health programmes.

1

Use EO-based SOC maps as complementary supporting information

By 2028, define where validated regional SOC maps may support screening, trend detection, stratified sampling and evaluation of agri-environmental measures. Keep laboratory sampling as the reference. Do not use modelled maps alone for parcel-level sanctions or individual compliance decisions.

Lead: national soil authorities, CAP managing authorities and paying agencies.

2

Set minimum quality, validation and transparency requirements

Adopt a harmonised specification covering calibration data, independent validation, uncertainty maps, spatial resolution, update frequency, data provenance, model versioning and fitness for each intended use. Require testing across different soils, crops, seasons and regions before operational uptake.

Lead: European Commission, European Soil Observatory, Member States and standards bodies.

3

Enable trusted data sharing and federated AI

Use clear agreements on purpose, access, reuse, ownership, liability and retention. Require secure access controls, model and data documentation, and audit trails. Support federated AI so regional models can learn from distributed datasets without routinely transferring raw farm or institutional data.

Lead: agricultural data-space initiatives, research organisations, authorities and technology providers.

4

Fund operational pilots and integrate results into workflows

Launch multi-region pilots with agreed acceptance criteria and user testing. Connect outputs to national soil-monitoring systems, CAP evaluation processes and advisory services. Budget for maintenance, recalibration, user support and long-term access - not only one-off map production.

Lead: European and national R&I programmes, ministries and regional authorities.

Suggested implementation milestones

BY END-2027	BY END-2028	FROM 2029
Agree priority use cases and a shared quality specification. Select pilot regions and governance arrangements.	Complete cross-region validation and publish uncertainty, metadata and acceptance results. Link pilots to national transposition work.	Operationalise only those applications that meet the agreed criteria; maintain periodic field validation and model review.

Considerations: Implementation should be proportionate and purpose-specific. Public investment is needed for reference data, validation and maintenance. Governance must protect legitimate commercial and institutional interests while making public-interest outputs understandable and reusable.

Conditions for success

TECHNICAL

- Sufficient high-quality satellite, hyperspectral and ground-truth data.
- Harmonised methods, interoperable standards and reliable models.
- Regular recalibration, validation and visible uncertainty information.

GOVERNANCE AND OPERATIONS

- Clear data rights, trusted sharing mechanisms and preservation of data sovereignty.
- Long-term cooperation among authorities, research organisations, providers and end users.
- Sustainable funding for deployment, maintenance, support and service continuity.

5 Evidence and Analysis

The ScaleAgData Soil Health RI Lab tests how local sensor and soil data can be upscaled into regional SOC information without treating modelled products as a substitute for reference measurements.

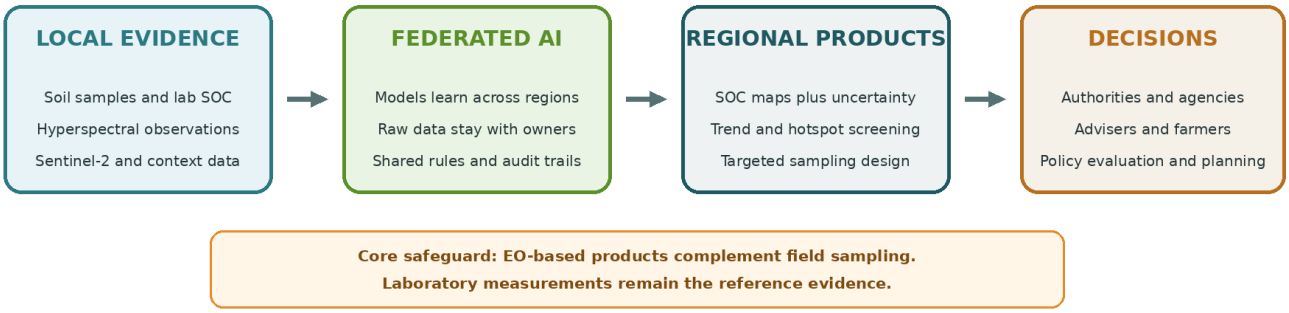
WHAT THE RI LAB DEMONSTRATES

- A workflow that combines hyperspectral observations, satellite imagery, environmental variables and laboratory SOC measurements.
- Regional and national model development using federated AI, allowing collaboration without routinely centralising raw datasets.
- Use of standardised data flows and interoperable products to improve comparability, controlled sharing and reuse.
- Potential to guide sampling, identify areas needing attention and provide repeatable regional information for policy and farm advice.

CURRENT PILOT EVIDENCE

- Work is being tested in Flanders, Belgium, and Central Macedonia, Greece.
- At the time of drafting, the Soil Health RI Lab work included around 100 sampling locations in Flanders with laboratory results for 80. In addition, 44 samples with laboratory results were available in Central Macedonia.
- Planned outputs include regional EO-based SOC maps, field-level soil-health estimates and recommendations on federated AI and standardisation.
- The main policy value is regional screening and monitoring support, not a stand-alone compliance decision at individual parcel level.

From measurements to policy insight



Methodology. Hyperspectral surface observations and Copernicus Sentinel-2 imagery are combined with soil characteristics, environmental data and laboratory measurements. Local models are calibrated and validated against measured SOC. In a federated workflow, participating organisations can train or improve models while keeping source data under local control; only agreed model information is exchanged.

Interpretation. The approach can reduce unnecessary sampling and improve where and when sampling is carried out. It cannot remove the need for ground truth, quality assurance or expert interpretation.

LIMITATIONS AND RISKS

- SOC estimates are affected by soil moisture, vegetation or residue cover, surface roughness and regional soil differences.
- Long-term trend analysis needs repeated observations and stable protocols.
- Reference data may be too limited or unevenly distributed.
- Results remain pilot-stage and require wider independent validation before official operational use.

6 Strategic Alignment

The service supports existing monitoring and policy processes; it should not create a parallel reporting system.

POLICY / INITIATIVE	CONTRIBUTION
EU Soil Monitoring Law	Supports the SOC-related monitoring and assessment required by Directive (EU) 2025/2360 through repeatable regional screening, transparent uncertainty and more targeted field sampling.
Common Agricultural Policy	Provides additional evidence on soil condition and SOC trends for programme monitoring, evaluation of agri-environmental measures and more efficient targeting of advisory or support actions.
European Green Deal / Farm to Fork	Strengthens the evidence base for sustainable soil management, carbon sequestration, climate resilience and more efficient use of agricultural inputs.
EU Mission: A Soil Deal for Europe	Contributes to harmonised soil monitoring, living-lab validation and reusable digital infrastructure for collaboration across European regions.
Sustainable Development Goals	Supports SDG 2.4 (sustainable food production), 6.3 (water quality), 12.2 (resource efficiency), 13.2 (climate action) and 15.3 (land degradation neutrality).

7 References

1. European Union. Directive (EU) 2025/2360 on soil monitoring and resilience (Soil Monitoring Law).
2. European Commission. Soil Monitoring Law - overview, objectives and implementation timeline.
3. European Commission. Healthy soil and the Common Agricultural Policy.
4. European Commission. EU Mission: A Soil Deal for Europe.
5. European Commission, EU Soil Observatory. LUCAS Soil.
5. ScaleAgData. Soil Health Research and Innovation Lab.
6. ScaleAgData. Deliverable D5.1: Piloting Plan and Evaluation Methodology, v1.

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This policy brief presents pilot-stage evidence and recommendations from the ScaleAgData Soil Health RI Lab. Operational use requires purpose-specific validation and governance.