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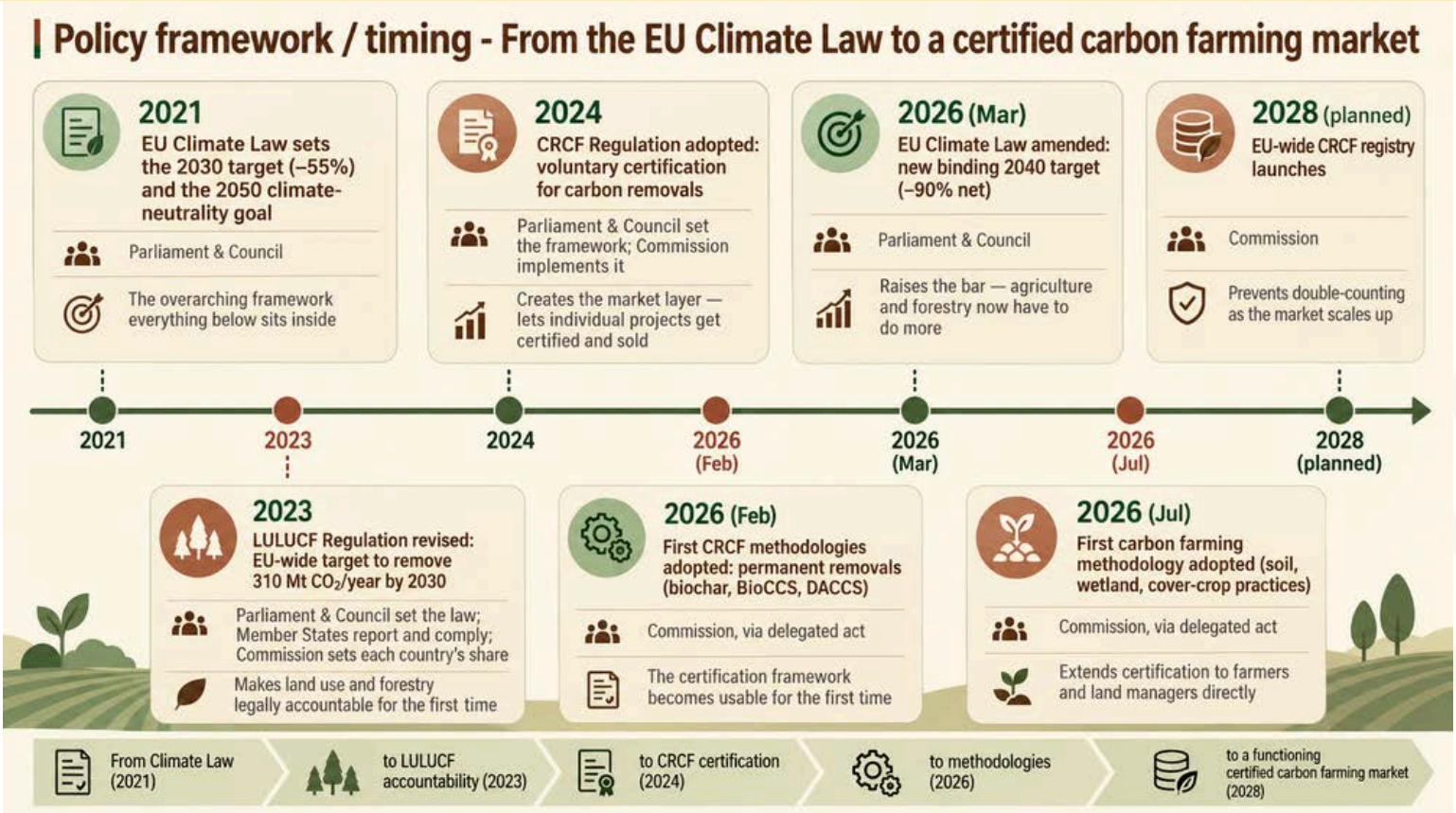
DIALOGUE 3

Soil Health in Climate and Carbon Policy

Carbon and climate policies - Why these matters for soil health

In 2021, the EU Climate Law set two goals: a **2030 target** of cutting net greenhouse gas emissions by 55% compared to 1990 levels, and a **2050 goal of climate neutrality**. In March 2026, the law was amended to add a binding **2040 target** of a 90% net reduction, also measured against 1990 levels — an intermediate step between the 2030 and 2050 goals.

The 2023 revision of the Regulation on land use, land use change, and forestry (LULUCF) makes land use and forestry legally accountable within that framework, setting a binding EU-wide target of removing 310 Mt of CO_2 per year by 2030 through soils, forests and land management. The 2024 Carbon Removal Carbon Farming Regulation then adds a voluntary certification layer on top, so that individual carbon-farming and removal activities can be verified and, in time, help meet those targets.



A shared Monitoring Reporting Verification system — based on field measurement, Earth observation and modelling — underpins both LULUCF's mandatory national reporting and CRCF's voluntary project certification throughout this timeline, managed by Member States for LULUCF reporting and by the Commission (via the planned Carbon Farming Database) and independent certification bodies for CRCF verification.

Webinar at a glance: takeaways and recommendations

The third AI4SoilHealth Cross-Policy Soil Dialogue examined **how European climate and carbon-farming policies can be translated into credible action for soil health**. The Land Use, Land-Use Change and Forestry (LULUCF) Regulation, the Carbon Removals and Carbon Farming Certification Framework (CRCF) and the Soil Monitoring Law (SML) increasingly connect climate objectives with the need to measure, monitor and manage soil organic carbon. The challenge is to link policy ambition with credible baselines, monitoring systems and workable approaches at farm level.

The dialogue brought together complementary perspectives from **Christian Holzleitner (European Commission, DG CLIMA)** on the EU policy and certification framework for carbon removals and carbon farming, **Emilio Folli (CIB)** on practical farming experience with integrated production, biogas and digestate management, **Ichsani Wheeler (OpenGeoHub)** on open geospatial data, Earth observation and AI-supported monitoring, and **Rastislav Skalský (IIASA)** on modelling soil organic carbon across regional and European scales.

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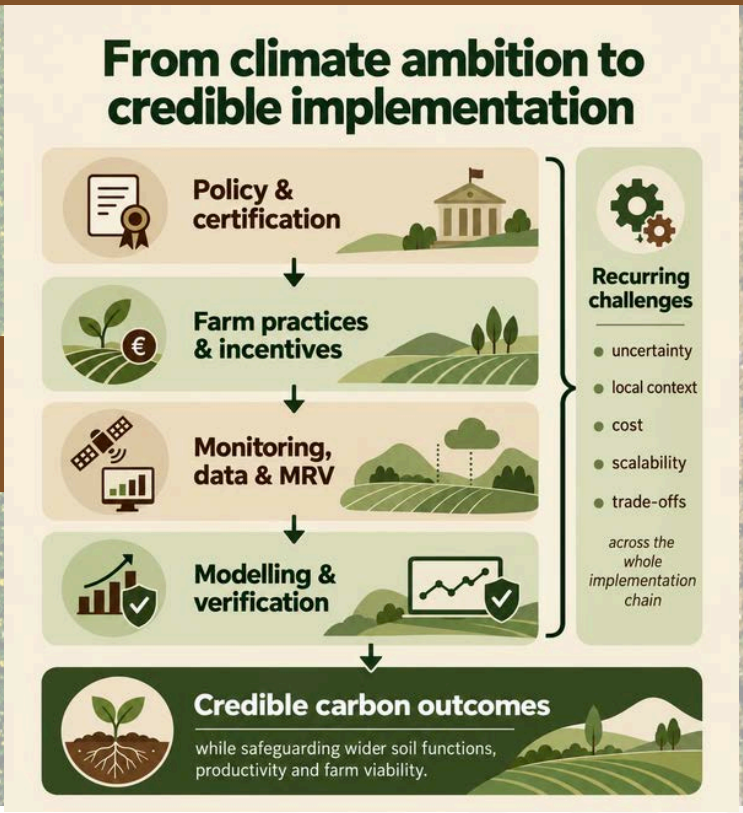
Carbon outcomes need to be credible, measurable and affordable — without losing sight of wider soil functions, productivity and farm viability.



Key Takeaways

Carbon farming is entering the implementation phase. The CRCF certification framework is turning policy ambition into operational certification, raising the bar for credible, affordable and workable monitoring.
No single monitoring method is sufficient. Field measurements, Earth observation, process-based modelling and AI-supported tools each bring complementary strengths; a robust MRV system depends on combining them, not choosing between them.
Uncertainty must be made visible, not hidden. Soil-carbon estimates depend on data quality, sampling design, management history and modelling assumptions; certification and policy should communicate ranges rather than imply false precision
Local specificity and EU-wide comparability must be reconciled. Carbon outcomes are generated by highly local management decisions, while certification and climate reporting require consistent, comparable standards across territories.
Monitoring should become shared enabling infrastructure, not parallel systems. Carbon certification, the CAP, climate reporting and soil-health monitoring increasingly draw on the same environmental data, which can be reused rather than duplicated.
Carbon outcomes cannot be assessed in isolation. Practices such as improved nutrient and manure management, reduced soil disturbance and diversified cropping can support carbon goals, but their effects on fertility, biodiversity, water and productivity need to be measured, not assumed.
Implementation depends on collaboration across policy, science, farming, technology and finance. Carbon farming's credibility and uptake are not only a technical challenge — they depend on coordination among the actors responsible for monitoring, investment and governance. The Commission's new AgRI 2040 strategic research framework, launched in September 2026, now gives this kind of interdisciplinary work a defined home within EU-funded research through 2034.

From evidence to implementation

Taken together, the presentations showed that carbon farming is moving into a more operational phase, where policy credibility increasingly depends on the **quality of implementation**. No single monitoring method — field measurement, Earth observation, modelling or AI-supported tools — can deliver the full picture; a credible MRV architecture needs to combine them, while communicating the uncertainty inherent in soil-carbon assessment rather than implying false precision.

A central challenge is reconciling local relevance with European comparability. Carbon outcomes are generated by highly local management decisions, while certification and climate reporting require common, EU-wide standards. **Greater interoperability** between carbon certification, climate reporting, CAP implementation and soil-health monitoring could reduce duplication and support more coherent, results-oriented policy.

Finally, carbon performance cannot be assessed in isolation from wider soil and farm outcomes. Practices that increase carbon storage may also affect fertility, biodiversity, water and productivity — sometimes as **synergies, sometimes as trade-offs** — so these effects need to be measured rather than assumed. Realising this potential also depends on whether public and private incentives can reward measurable outcomes while giving farmers the long-term certainty to invest.

Policy Recommendations

The forthcoming CRCF review (due Q4 2026) offers a natural point to address the uncertainty and methodological-pluralism questions raised in the dialogue — defining how uncertainty is quantified and reported, and how different combinations of field measurement, Earth observation and modelling can satisfy a common quality standard.
The soil-health and trade-off lens discussed for carbon-farming practices could usefully extend to livestock and fertiliser emissions, an area the Commission has also flagged as central to agriculture's contribution to the 2040 climate target.
As the planned Carbon Farming Database takes shape, it may be worth clarifying which datasets — CAP, GHG inventories, Corporate Sustainability Reporting Directive CSRD — it should prioritise first, and where legal or data-governance barriers still limit reuse.
The EU Buyers' Club and the proposed EU CRCF Facility, still under development, are worth monitoring as potential sources of the long-term financial certainty farmers need to invest in management change
AI-supported and digital MRV tools should remain transparent and traceable to their underlying data, assumptions and validation, particularly as Earth-observation-based soil mapping becomes more central to lowering MRV costs.
Better access to farm-management and historical land-use data would support credible baselines and additionality assessments under the newly adopted carbon farming methodology.

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DIALOGUE 3

Soil Health in Climate and Carbon Policy

Opening & Framing

ISINNOVA

ISINNOVA research innovation sustainability

"How can soil monitoring, modelling and farm-level evidence support credible carbon accounting and turn European climate objectives into action on the ground?"

The dialogue opened by positioning the third AI4SoilHealth Cross-Policy Soil Dialogue at the **intersection of soil health, climate policy and carbon farming**. The LULUCF Regulation, the Carbon Removals and Carbon Farming Certification Framework (CRCF) and the Soil Monitoring Law were presented as an increasingly **connected policy chain**: LULUCF sets binding national responsibilities for land-sector emissions and removals, the CRCF establishes criteria for certifying carbon-farming outcomes, and the Soil Monitoring Law strengthens the monitoring basis needed to assess soil condition and support implementation.

Against this backdrop, the dialogue was structured around a question: *how can soil monitoring, modelling and farm-level evidence support credible carbon accounting and turn European climate objectives into action on the ground?* This perspective provided the conceptual thread for the discussion, connecting questions about baselines, MRV and Earth observation with farm-level practices, soil-carbon modelling, and uncertainty and trade-offs across scales. The dialogue brought together **policy, farming, data and modelling perspectives** to explore these connections and the practical challenges of turning soil evidence into credible, policy-usable carbon accounting.

Scan the QR code or click here to watch the full webinar and listen to the complete contributions from the speakers.

AI4SoilHealth Cross-Policy Soil Dialogues

DIALOGUE 3

SOIL HEALTH IN CLIMATE AND CARBON POLICY: MONITORING, ACCOUNTING & ACTION



Christian Holzleitner

Head of Unit, DG CLIMA (European Commission)



Emilo Folli

Agronomist, CIB-Consorzio Italiano Biogas



Ichsani Wheeler

Research Coordinator, OpenGeoHub



Rastislav Skalský

Senior Research Scholar, International Institute for Applied Systems Analysis (IIASA)

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AI 4 Soil Health

DIALOGUE 3

Soil Health in Climate and Carbon Policy

Policy & Governance

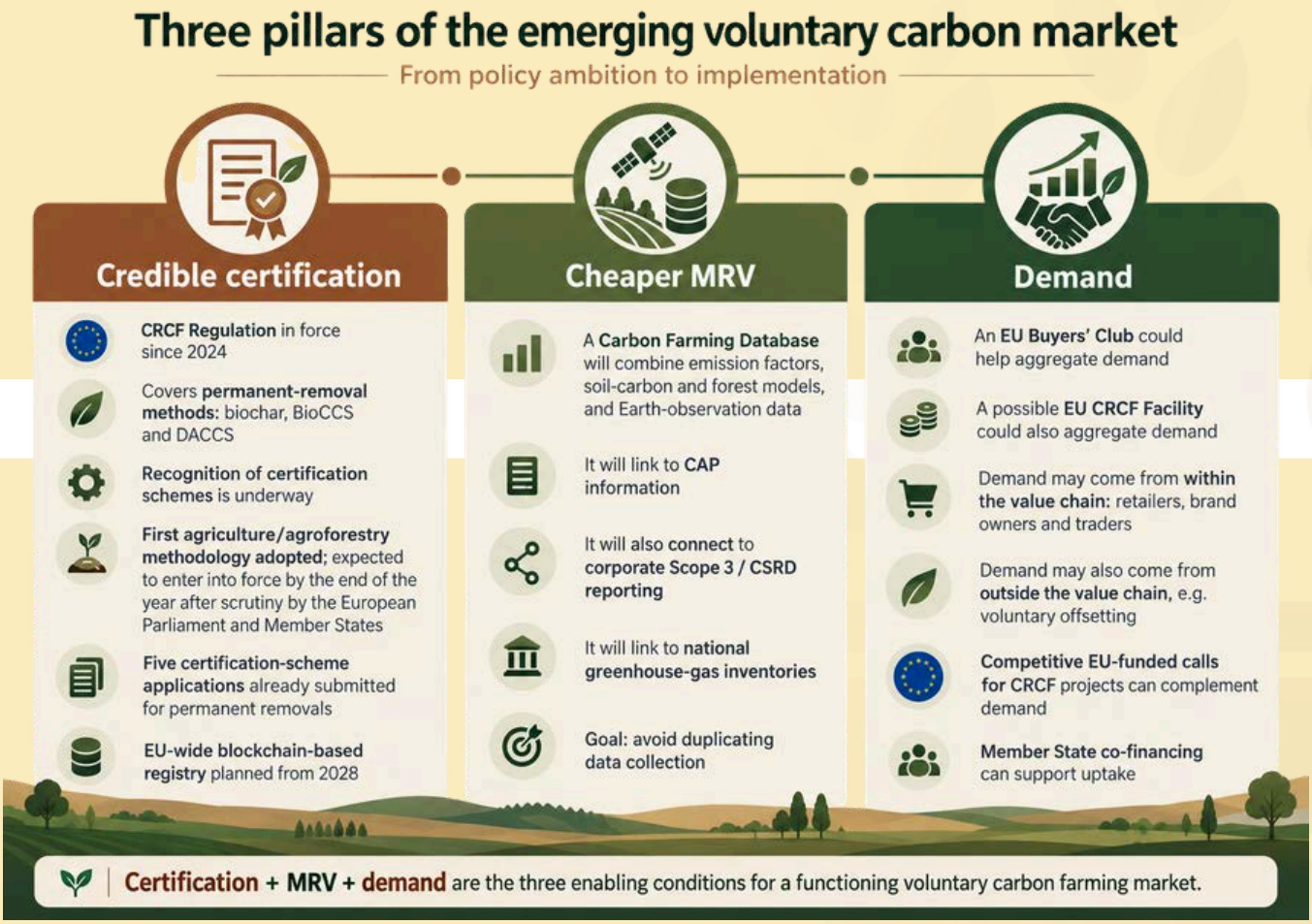


EU Carbon Farming – latest developments and outlook

Christian Holzleitner | Directorate-General for Climate Action (DG CLIMA), European Commission

"A credible certification is the starting point: you need to know whether what you do actually delivers a benefit for the climate."

Holzleitner set carbon farming within the **EU's pathway to climate neutrality**. The EU has already cut fossil-fuel emissions by 40% since 1990 and is on track for its 2030 target (–55%), driven mainly by energy, industry, transport, buildings and renewables. Meeting the 2040 target (–90% net) will require agriculture and forestry to do more — reducing livestock and fertiliser emissions, and increasing removals through soils, forests, durable bio-based products and permanent storage options such as biochar, biogenic emissions with carbon capture and storage (BioCCS) and direct air capture and storage (DACCS).



This architecture is expected to feed into the Commission's proposal for 2040 national climate targets, due in Q4 2026: because land-based mitigation is generally cheaper than industrial abatement, a functioning carbon farming market would give Member States a cost-competitive route to their targets.

Baselines and verification. It was asked how soil organic carbon baselines are set and how credits are validated, Holzleitner explained that CRCF uses a **three-year historical average as the baseline**, with validation carried out by an independent certification body, and climate-benefit calculations combining models, soil sampling and remote sensing.

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DIALOGUE 3

Soil Health in Climate and Carbon Policy

Circularity & Sustainable Agriculture



The Farming for Future model

Emilio Folli | Consorzio Italiano Biogas (CIB)

"The real opportunity here is therefore not simply to produce renewable gas, but to build a more circular, efficient and sustainable agricultural model."

Emilio Folli presented the **Farming for Future model** from the perspective of an agronomist and farmer, showing how renewable energy, nutrient management, soil fertility and agricultural productivity can be addressed within an integrated farming system. Rather than treating emissions reduction and agricultural production as competing objectives, the approach seeks to use better management, technology and innovation to reduce environmental impacts while maintaining food production, employment and economic viability.

Farming for Future builds on the Biogas Done Right approach, in which biogas production is integrated into normal farm activities rather than treated as an isolated energy technology. Livestock farming, crop production, renewable energy, digestate and soil management become **interconnected elements of a circular system** in which materials and nutrients are recovered and reused.



A particularly important link with soil health is **digestate management**. Folli explained that digestate retains the main nutrients contained in the original biomass, including nitrogen, phosphorus and potassium, while also providing stable organic matter. Its agronomic benefits depend on appropriate characterisation, timing and application. High-efficiency and low-emission techniques can improve nitrogen recovery and reduce ammonia losses, while digestate can replace part of the mineral fertiliser used on farms.

These practices are complemented by reduced or strip tillage, double cropping, intercropping and nitrogen-fixing crops. By extending the period during which soils are covered by actively growing vegetation, these approaches can reduce erosion and nutrient losses while increasing photosynthetic activity, root biomass and organic-matter inputs. Folli also highlighted the role of precision agriculture, sensors, robotics and Farm 4.0 technologies in improving the efficiency of water, fertilisers, energy and other inputs.

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DIALOGUE 3

Soil Health in Climate and Carbon Policy

Circularity & Sustainable Agriculture



The Farming for Future model

Emilio Folli | Consorzio Italiano Biogas (CIB)

"The real opportunity here is therefore not simply to produce renewable gas, but to build a more circular, efficient and sustainable agricultural model."

During the discussion, Folli stressed that demonstrating these improvements quantitatively remains challenging at farm level. Reconstructing long-term data on soil and digestate management is not straightforward, while farms need practical ways to assess their carbon balance and emissions per unit of agricultural product. This reinforced a wider webinar message: **practical innovations are already available**, but accessible and reliable monitoring is needed to make their climate and soil-health effects measurable.

Measuring farm-level results

The discussion highlighted the difficulty of **demonstrating improvements quantitatively** at farm level. Folli noted that reconstructing long-term information on soils and digestate management is not simple. On his own farm, for example, Folli is working towards closing its carbon balance and understanding emissions per unit of agricultural product, but doing so requires data and monitoring capacities that individual farms may not readily have.

The exchange therefore provided a practical link to the wider webinar discussion on **carbon-farming certification and monitoring**. Farm-level innovations can already contribute to renewable energy, nutrient efficiency and soil-carbon management, but credible recognition of these outcomes — including through emerging carbon-farming frameworks — will depend on monitoring approaches that are reliable, accessible and proportionate to farmers' capacities.



Farming for Future: integrating biogas, soil fertility and carbon management

The Farming for Future model illustrates how several farm-level practices can work together as part of a circular agricultural system.



Manure and residues → biogas: use livestock effluent, second crops, agricultural residues and agro-industrial by-products as feedstocks for renewable-energy production.



Biogas → digestate: recover digestate as an organic fertiliser providing nutrients and stable organic matter.



Efficient nutrient return: characterise digestate and apply it at appropriate times using high-efficiency, low-emission techniques to improve nitrogen recovery and reduce losses.



Soil-cover strategies: combine organic fertilisation with double cropping, intercropping and nitrogen-fixing crops to reduce erosion and nutrient losses and increase biomass inputs.



Reduced soil disturbance: use reduced tillage, strip tillage or no-tillage techniques where appropriate.



Farm 4.0: use precision agriculture, sensors, robotics and digital tools to optimise water, fertilisers, energy and other inputs.

Overall, the model treats carbon management not as a single farm practice but as an outcome of integrated energy, nutrient, crop and soil management.

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DIALOGUE 3

Soil Health in Climate and Carbon Policy

Bridging AI-supported geospatial data



Data, trust and AI for Soil Health Monitoring

Ichsani Wheeler | OpenGeoHub

"Many environmental policies ultimately depend on the same underlying geospatial information."

Ichsani Wheeler approached the policy discussion from the perspective of the **digital infrastructure** needed to answer different environmental-policy questions. Her starting point was that although climate, soil, agricultural and restoration policies may formulate different questions and operate at different geographical scales, many ultimately depend on the **same underlying geospatial information**. The data may need to be queried at different resolutions or organised differently for particular policy purposes, but the underlying environmental information is often shared.
This creates an opportunity for greater policy coherence and efficiency. **Common environmental information** can potentially support multiple policy questions, reducing the need to repeatedly prepare and harmonise similar datasets for different uses.



Building an open European soil-health data infrastructure Wheeler described AI4SoilHealth as an effort to develop open digital infrastructure for understanding land condition across Europe. The approach combines field observations, Earth observation, machine-learning methods, harmonised soil-health indicators, open-source software and an **open data cube** in which information is aligned spatially and temporally.

A key design principle is **openness**. The project seeks to use open-source code and open-access data while protecting restricted training data, privacy and other information that cannot legitimately be made public.

The data-cube approach addresses a major constraint in environmental monitoring: much of the effort in conventional geospatial analysis is spent preparing, cleaning and harmonising datasets before they can be analysed. By organising information consistently across space and time, the data cube is intended to make subsequent analysis easier and more efficient. Wheeler noted that this preparatory work can otherwise account for a very large share of the effort required in GIS-based analysis.

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Soil Health in Climate and Carbon Policy

Bridging AI-supported geospatial data



Data, trust and AI for Soil Health Monitoring

Ichsani Wheeler | OpenGeoHub

"Many environmental policies ultimately depend on the same underlying geospatial information."

From data availability to usable information

The presentation emphasised that producing large quantities of environmental data is not sufficient. Information must also be usable by people without specialist expertise in GIS, programming or soil modelling.

AI-supported interfaces can provide a bridge. Users can formulate questions through natural language, while the system retrieves relevant datasets and executes the underlying analyses through dedicated computational tools. Wheeler stressed that the language model itself should not be relied upon to perform the scientific calculation: it functions primarily as an interface through which users specify what they want, while the actual analysis is carried out by scripts and analytical routines.

Trust was therefore a central theme. Users need confidence in the underlying data, the sources accessed by the system and the way in which results are generated and extracted.

Digital tools for accessible and trusted soil-carbon monitoring

The webinar highlighted a practical digital architecture that can reduce technical barriers to soil-health and carbon monitoring:

Open data cubes to organise soil, climate, vegetation and land-related information consistently across space and time.

Earth observation and field data used together within the same monitoring infrastructure.

AI-supported natural-language interfaces to help non-specialists query complex geospatial information.

Transparent analytical workflows in which calculations are executed by dedicated scripts and models rather than by the language model itself.

Open-source code and open-access information, where possible, to support transparency, reproducibility and trust.

User testing with farmers, landholders, national agencies and other potential users to identify what needs to be improved and ensure the tools are useful at different scales.

Emerging links to carbon registries and CRCF implementation, with the aim of making monitoring and related documentation less expensive, less burdensome and more routine.

Data governance and cross-policy coherence

In the final discussion, Wheeler returned to the governance dimension. She suggested greater support for independent perspectives and more **open governance of natural-resource information** involving a broader range of actors. She also highlighted tensions between different governance levels and the importance of finding ways for different institutions and communities to work towards shared evidence and understanding.

Importantly, she again observed that many environmental policies require essentially the same underlying information. This points to opportunities for greater efficiency and coherence across policy areas dealing with soil, climate, agriculture and nature restoration.

Her comments also raised a broader sustainability issue around digital infrastructure itself. Wheeler noted that **technologies supporting AI and environmental monitoring can create their own resource pressures,** including on water and energy, and argued that such infrastructure should be considered more carefully within wider planning decisions.

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Soil Health in Climate and Carbon Policy

Regional soil-carbon modelling: connecting management, scale and policy



Regional SOC Sequestration Modelling Using EPIC-IIASA

Rastislav Skalský | International Institute for Applied Systems Analysis (IIASA)

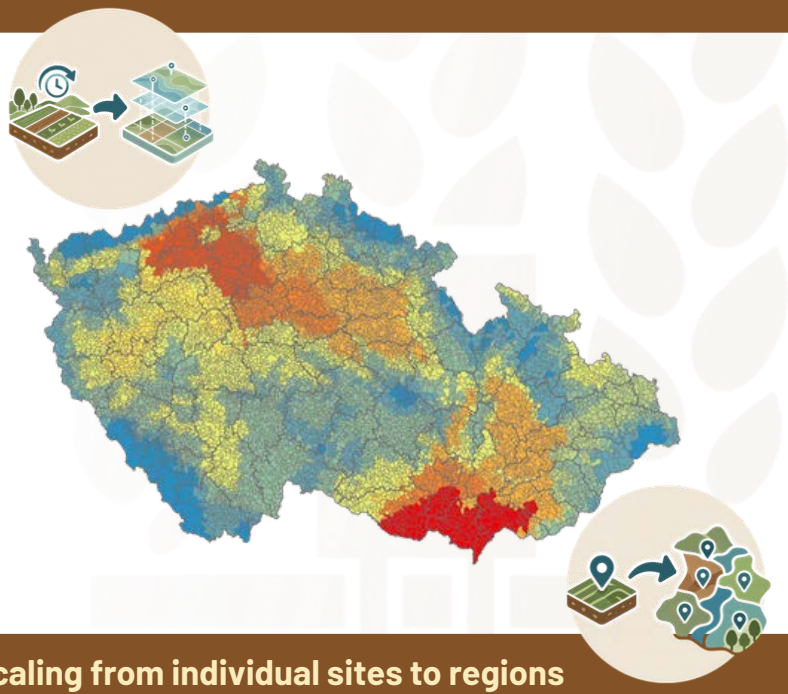
"At regional scale, good soil data and good crop-management data are critical for producing reliable results."

Rastislav Skalský approached carbon farming from the **perspective of regional soil-organic-carbon modelling**, showing how field experiments, process-based models and regional simulations can be combined to explore the effects of alternative land-management strategies. He presented work developed with Czech partners for the **Czech Ministry of Agriculture**, aimed at identifying crop-management systems for long-term carbon sequestration that could be applied by a significant share of agricultural enterprises, and at estimating carbon-sequestration potential across regions of the Czech Republic.

From long-term experiments to digital twins

Long-term field experiments provide an essential evidence base for understanding how soil organic carbon responds to different management practices. Skalský used the example of Czech long-term trials, including experiments established in the 1950s, to illustrate both their value and their limitations: measurements are often incomplete, historical series may begin later than the experiments themselves, and observed data inevitably contain uncertainty.

Process-based crop models such as EPIC can be used to create **digital representations** of these experiments. The model simulates crop growth, biomass production, nutrient and water cycling and management operations over long time periods using daily weather and detailed management information. Once calibrated and validated against observed data, these **"digital twins" can be used to explore management options** that were not directly tested in the original experiments and to extend analysis into future climate conditions.



Scaling from individual sites to regions

The next challenge is moving from individual experimental sites to regional and national assessments. Skalský described the **EPIC-IIASA regional modelling framework**, which combines process-based crop modelling with spatial information on soils, climate, topography and crop management.

For the Czech Republic, the national territory was divided into **simulation units** combining administrative areas, climate regions and relatively homogeneous soil conditions. These units were linked with the weather, soil, terrain and management data needed to run regional simulations. The modelling explored contrasting agricultural systems, including crop-production and integrated crop-livestock systems, as well as commercial and more regenerative management approaches.

The **scenarios** combined different levels of nitrogen application, manure use, crop-residue retention, irrigation and future climate conditions. This makes it possible to compare not only carbon outcomes, but also the trade-offs associated with different land-management strategies. Strategies that maximise soil-carbon storage may not maximise commercial output, while more production-oriented systems can produce higher yields but may perform less well in terms of carbon accumulation. The **purpose of the modelling** is therefore not to identify one universally optimal practice, but to **make these relationships visible** so that policy makers can assess different options and combinations.

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"At regional scale, good soil data and good crop-management data are critical for producing reliable results."

Data quality and uncertainty

A central message was that scaling changes the **sources of uncertainty**. At individual sites, model parameters and process representation play an important role. At regional scale, reliable soil information and crop-management data become particularly important.

The validation work presented by Skalský compared both site-specific and regional simulations with decades of measured soil-carbon observations. This showed that soil and management inputs contribute substantially to model uncertainty and therefore need to be explicitly represented. This is especially relevant for policy applications. Regional modelling can provide valuable estimates of soil-carbon potential, but outputs are only as reliable as the underlying information on soils, management practices and local conditions.

Towards faster and more accessible modelling

Skalský also highlighted a practical limitation of conventional regional crop modelling: it requires large amounts of input data, substantial calibration and computational effort, and can be **too slow to respond to rapidly evolving policy questions**.

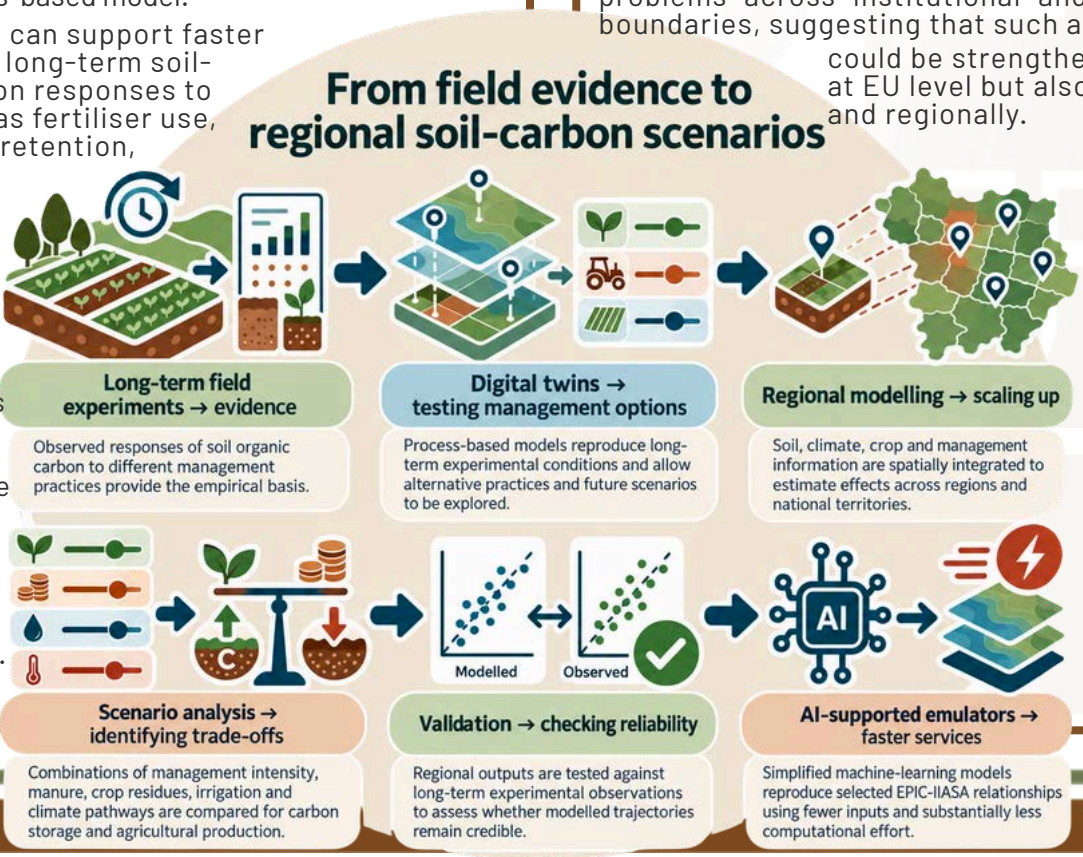
Within AI4SoilHealth, this has motivated work on model emulators or **surrogate models**. These data-driven models are trained on outputs from EPIC-IIASA and can reproduce selected relationships using only a fraction of the input data and computational effort required by the full process-based model.

The approach can support faster estimation of long-term soil-organic-carbon responses to factors such as fertiliser use, crop-residue retention, irrigation, climate and initial soil-carbon conditions. The emerging **SoilCast application** demonstrates how these simplified models can be translated into more accessible research and decision-support tools.

Discussion: linking models to policy

The discussion reinforced that modelling should not be seen simply as a tool for predicting one carbon value. Its main policy contribution is to **help compare alternative pathways**, trade-offs and consequences across scales. Skalský also emphasised the value of interdisciplinary Mission-oriented projects.

In his final remarks, he argued that projects bringing together policy makers, local stakeholders, associations and researchers create important spaces for addressing real problems across institutional and disciplinary boundaries, suggesting that such approaches could be strengthened not only at EU level but also nationally and regionally.



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Editorial note

*This Webinar Insight Brief has been prepared in the framework of the **AI4SoilHealth** Cross-Policy Soil Dialogues, a series of science–policy exchanges conceived and organised by **ISINNOVA** to foster dialogue across policy areas and explore how soil knowledge can better support policy implementation. This brief provides a concise summary of the webinar presentations and discussions, reflecting the main points raised by the speakers rather than providing verbatim records of their contributions.*

The key takeaways, cross-cutting insights and policy recommendations or implications presented in this brief are an interpretative synthesis developed by ISINNOVA, drawing on the webinar contributions and analysed within the project's science-for-policy framework. Unless explicitly attributed, these elements should not be understood as statements, recommendations or endorsements made by individual speakers or their organisations.

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