Addressing the energy transition challenge: Soil carbon

CSIRO actively researches the challenges associated with the transition of energy, industrial, manufacturing, agricultural and transport sectors to meet Australia's net zero emissions ambitions.

As Australia's national science agency, CSIRO is well positioned to support governments, industries and communities through the energy transition.

Science and innovation will be critical in supporting Australia's transition, which is being driven by new technologies, changing consumer preferences, and efforts to reduce greenhouse gas emissions.

As we move towards a net-zero emissions future the four key components of the energy sector – electricity, industry, transport and exports – are evolving rapidly. In this dynamic landscape, CSIRO provides reliable, actionable, evidence-based research.

Here we look at the role of soil carbon.

The role of soil carbon sequestration in Australia

What is soil organic carbon?

Soil organic carbon (SOC) is a complex and varied mixture of materials that makes up a small but vital part of all soils.

Plants capture carbon dioxide from the atmosphere and – through photosynthesis – convert it into organic material. When the plants die, carbon is added to the soil. Although some carbon returns to the atmosphere, over time and under the right conditions, a significant amount can be stored in the soil.

Soil carbon sequestration means adopting practices – most often in the agricultural sector – that increase the amount of carbon stored in soils.

Agricultural management practices might include:

- increasing plant growth or cover
- adding compost or mulch
- decreasing losses through reduced stubble burning or minimal till practices
- increasing the clay content of sandy soils.

Why is soil carbon important?

The amount and form of organic carbon plays an important role in soil process and function, the underpinning ecosystem service for agricultural and landscape productivity.

Farmers who adopt management practices that sequester soil carbon stand to gain a benefit from a more productive, sustainable and resilient farming system.

There are also opportunities for farmers who utilise management practices that build carbon to earn additional revenue from carbon credits and gaining market entry.

Soil carbon sequestration is a key component of the Australian Government's technology-led emissions reduction policy. It isalso included in Australia's National Soil Strategy as a crucial part of efforts to improve soil health.

What are the challenges?

Soil carbon sequestration is a promising way for Australia to reduce emissions, especially if it's used as part of a broader suit of tools and technologies.

However, there are a number of key challenges that need to be addressed.

- The current cost of measuring soil carbon is prohibitively high. The process is laborious, using manual processing to prepare soil for analysis, and costs around $30 per hectare per year. The goal outlined in the technology roadmap is to reduce this cost to under $3 per hectare per year.
- Diversity of soils and agricultural systems across Australia means that estimates of how soil sequestration translates to national abatement potential are highly variable – both in terms of what is technically feasible and what is economically realisable.
- We need operational models at project scale to estimate changes in soil carbon through the integration of different data streams.
- Even with financial incentives for farmers, there are high levels of uncertainty around risks and transactional costs that are a barrier to participation.

What is CSIRO is doing to help?

CSIRO has a long history of collaborative soil science research and development of national soil information systems to track the state and trend of our soils.

We developed the science that currently underpins the soil carbon model incorporated within Australia's National Carbon Accounting model. This model undergoes continuous improvement through the integration of new digital datasets and model parameters.

We are taking an active role in the National Soil Strategy, and alongside our partners, aim for the next generation of digital soil information systems to enable resilient land systems.

The end goal is an affordable, flexible system that is underpinned by a robust state-of-the-art soil monitoring programme and soil data system that allows landholders to be recognised and rewarded for soil carbon sequestration activities.

Several key areas of research are underway to help achieve this.

Expanded use of remote and proximal sensing technologies

Physical soil sampling will always be required for validation, but other methods of measurement will bring increased efficiency. New advances in soil sensing with instruments like CSIRO's SCANS technology that rapidly scan the spectral signature of soil cores has the potential to rapidly drive down these costs.

CSIRO is also working to develop dynamic space-time soil carbon models for agricultural systems at a national scale, driven by remotely sensed datasets and ground-truth data to enable better estimates of soil carbon stocks and stock changes. Remote sensing will play a key role in next-generation soil carbon models as model drivers.

Improved national soil carbon datasets and monitoring

Extensive work has taken place to build the underlying digital infrastructure that can support national assessments and help us progress to a carbon market approach supported by modelling.

There has been significant research undertaken by CSIRO and other organisations, including in the nationally coordinated Soil Carbon Research Program (SCaRP), to map Australia's SOC levels and determine how these are related to environmental conditions, soil properties and agricultural management.

Updating and hosting the Australia's National Soil Information System

CSIRO is involved in implementing the Australian Government's National Soil Strategy for the management of the Nation's soils data. Improved access to geospatial information will allow researchers and industry to develop solutions to the key soil carbon challenges.

Creating tools and approaches that link to on-farm practices and allow those managing the land to assess and explore available options

Empowering farmers to evaluate options for carbon sequestration on their own land is an important step. To help achieve this, CSIRO has worked on developing digital tools such as LOOC-C, which launched in late 2019 to help farmers identify what Emissions Reduction Fund (ERF) projects might be suitable for their land.

Further reading

Soil carbon sequestration potential: A review for Australian agriculture
https://doi.org/10.4225/08/58518c66c3ab1

How to measure, report and verify soil carbon change to realize the potential of soil carbon sequestration for atmospheric greenhouse gas removal.
https://onlinelibrary.wiley.com/doi/full/10.1111/gcb.14815

CSIROpedia: The Soil Carbon Research Program (SCaRP)
https://csiropedia.csiro.au/soil-carbon-research-program/

CSIRO Publishing: Soil Research
https://www.publish.csiro.au/sr/issue/10395

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