2. Synergies and Trade-offs between Soil Improving Management, Climate Change Mitigation and Agri-Food Productivity

MACSUR Science-Policy Knowledge Forum

The health of our soil is fundamental to the delivery of essential ecosystem services; agricultural productivity, food security and environmental welfare (e.g. ecological integrity and conservation, crop nutrition, carbon sequestration (balancing) and animal welfare etc.). Moreover, soils are an integral part of developing agricultural policies, e.g. UK Agricultural Bill, 2020; Environmental Land Management Scheme. This policy brief delivers the output of the UK 'Capturing the Potential of Soil' workshop (held on 23 March 2021) which focused on the link between soil health, primarily soil organic carbon, and productivity. Emphasis is placed on the research challenges to improve soil health, the implementation priorities that must be held and what the potential co-benefits could be.

Key Messages

Barriers:

Knowledge to deliver soil health benefits within productive and resilient agri-food systems, avoiding trade-offs for other environmental and production outcomes.

C-benefits:

Contributions to climate change mitigation, the natural capital approach, and the recent interest in soil carbon trading. It will improve crop yield and animal and human health through nutrition.

Solutions:

Sector-wide collaboration and data integration facilitating robust soil monitoring, reporting and verification protocols.

Relevance:

Agricultural intensification will lead to efforts in satisfying the demand for increased food production. However, further exploitation of soils will raise significant concerns that this may accelerate soil degradation. Degradation has led to a loss of 11% of arable topsoil in Britain since the 1970s (i.e. 0.4% loss per year), in 2010, soil degradation in England and Wales was estimated to cost £1.2 billion a year.

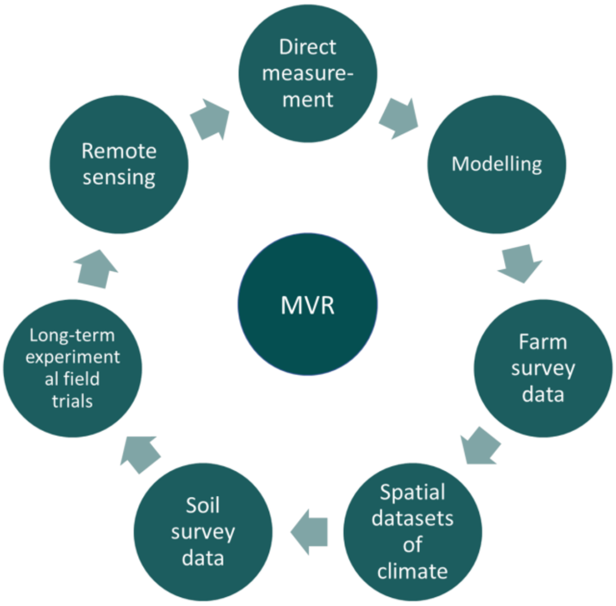
- Soils are the source of 98.8% of global food production.
- In the UK, agricultural production from soils is worth £5.3bn per year.
- Global population growth projected to be ~9.7 billion people in 2050.
- We must raise global food production by ~70 per cent between 2005 & 2050.

The Challenge:

UK cropland soils are depleted in SOC – mainly due to changes in land use. Land-use change from native forest to crop results in a ~40% reduction in SOC whilst pasture to crop results in a ~60% reduction.

- 9.8 billion tonnes of carbon are stored in Britain's soils.
- Net emissions from UK soils were 6.75 $MtCO_2e$ (soil carbon balance) in 2013—1.45% of the UK's total emissions, with peatlands storing around 40% of soil carbon.

After a management change, initial SOC sequestration declines over time and reaches saturation after 20–100 years. Soil carbon storage is reversible and sensitive to poor management; maintaining higher SOC sequestration requires consistent addition of organic material over time. Issues may arise with sourcing this additional organic material, and in the competition for land use and risks to food security.



The Priorities:

- SOC sequestration is not infinite (equilibrium level after 20-100 years), but globally, with improved management, the sequestration potential of SOC is equivalent to ~1.3 Gt Ceq/year – ~ 5–10% of annual global GHG emissions.
- Robust **monitoring, reporting & verification (MRV)** is required through robust soil sampling strategies. These should include:
  i. iControl for climate, soil type, hydrology, topography, land use, management and history;
  ii. Sampling depth of at least 30 cm; accounting changes in soil bulk density, all samples georeferenced;
  iii. Sampling frequency should occur at least 4 to 5 years apart.

The potential of soil:

Increasing SOC is beneficial for **food productivity** as well as many important **ecosystem services**, such as soil carbon storage, water holding and biodiversity. Globally, increasing SOC by 1 MgC/ha may result in a yield increase of 100–300 kg/ha/ Mg C for maize—and a potential increase of 30 50 million tonnes of food per year in developing countries.
Sustainable soil management will play an important part in the solution to mitigating carbon emissions from agriculture – it is one of many actions necessary to reduce emissions while addressing competing pressures on land.

How to Improve SOC:

- Farmyard manures (FYM) (i.e. 35 t/ha to soils with <2.5% SOC), sewage sludge, ley-arable, green manures, straw and nitrogen fertiliser. According to Poulton et al., (2018), the UK showed that FYM could deliver SOC increases of 1.8% and 4.3% per year (23 cm depth), though this required high rates of manure additions every year.
- Soil degradation prevention practices include residue retention, increasing N_2-fixing legumes, multispecies swards, and precision fertiliser application.
- There is no 'critical threshold' of SOC, the limits for which strongly relate to soil type: a ratio of 1:10 SOC/clay is widely considered "good". Land use, soil type, annual precipitation and soil pH explain variance in SOC/clay ratio.

Sustainable Soil Management:

1. Protecting and increasing existing carbon stores in permanent grasslands, moorlands, wetlands and woodlands.

2. Avoiding mechanical tillage, using conservation tillage/no till systems instead, and enhancing organic cover on soil using cover crops/residues.

3. Enhancing crop nutrition through crop rotations with N-fixing crops, judicious use of organic and inorganic fertilisers and targeted lime applications.

The MACSUR SciPol knowledge forum is a pilot exercise initiated by the Joint Programming Initiative for Agriculture, Food Security and Climate Change (FACCE-JPI) to bring science and policy actors together for the strategic design of climate change adaptation and mitigation solutions in the agri-food sector in Europe. This policy brief contributes to this mission by providing evidence-based information to policy for achieving carbon neutrality by 2050, adapting to climate change and understanding synergies and trade-offs in achieving these targets.

Writing and research: Ryan McGuire[1]; Nigel Scollan[1]; Christine Foyer[2]; Luke Spadavecchia[3]
Editing: Dorri te Boekhorst

[1]Queen's University Belfast, Belfast, UK. 19 Chlorine Gardens, Belfast BT9 5DL, [2]University of Birmingham, Birmingham, UK. Edgbaston, Birmingham B15 2TT, [3]The Department for the Environment, Food and Rural Affairs, London, UK. Seacole Building 2 Marsham Street London SW1P 4D.

MACSUR Science-Policy Knowledge Forum
Coordinated by zalf
FACCEJPI