German Environment Agency

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Funding climate-friendly soil management – key issues

Impacts on soil health[1]

1 Background

Definition: Soil quality and soil health are scientific terms and are mostly used interchangeably for describing the characteristics of an intact soil; we use soil health throughout this factsheet[2]. These terms encompass the prerequisites for the functioning of a soil as a part of an ecosystem or entire landscape to sustain environmental quality, biological productivity and healthy plants and animals (Doran and Parkin 1994). Any measure or management practice on the soil has multiple effects on the biological, biophysical and biochemical integrity of the soil as a complex structure of organic and inorganic compounds and thus on the carbon storage capacity and nutrient cycling.

Importance: A healthy soil is the basis for agriculture and essential for sustainable food production. Soil organic carbon (SOC) is one of the structural elements of healthy soil, since a high organic matter content of a soil enhances soil life, improves nutrient retention and water infiltration. A healthy soil is important to maintain the soil's integrity and agroecological function.

Relevance: The issue of soil health is relevant for all types of soil carbon mitigation (including removals and avoided emissions), as all measures of climate-friendly soil management affect soil health, and because soil health contributes to maintaining and sequestering soil carbon. Soil health also affect other GHG emissions.

2 Key issues

Complexity and interaction of management practices:

- **Soil health depends on both natural factors and management practices. Soil physical treatment** (e.g. tillage) and **organic input** either by plant vegetation or organic fertilisers affect the soil organic carbon content either directly (via organic matter input) or indirectly (by disturbance) and have therefore the greatest impact on soil health from a soil management perspective, along with natural soil and climatic factors..
- **Soil health is affected by soil management practices that interact across various scales,** from single plot to farm to even territorial level. For example, silvoarable agroforestry systems with diverse and improved crop rotations can enhance the overall effect of single management practices, while reduction of tillage in combination with intensive use of herbicides can diminish the success of carbon sequestration in the soil by environmental pollution and loss of above- and belowground biodiversity.

Impact of soil health on carbon storage and sequestration:

- Healthy soils produce higher yields and therefore have the potential to increase the organic and inorganic carbon stock by plant root production and microbial transformation (the

[1] This factsheet was also published as part of the UBA report "Funding climate-friendly soil management", available at http://www.umweltbundesamt.de/publikationen/Funding-climate-friendly-soil-management.

[2] The term soil fertility seems to be mostly used by practitioners (Andreas Gattinger, personal communication).

degree to which this holds depends in part on the use and initial carbon saturation of the soil). Additionally, the carbon stocks enhance resilience against natural disturbances (Lorenz and Lal 2015).

Management practices to enhance soil carbon stocks can have undesirable side effects on soil health, which should be avoided. For example:

- Cultivation of cover crops contributes to carbon sequestration but their removal prior to main crop cultivation is associated with the widespread use of herbicides, with possible adverse effects to the environment, e.g. to water quality and soil life.
- Organic inputs from external providers, e.g. organic municipality waste and biochar, can be contaminated with non-degradable or toxic compounds, e.g. plastic or heavy metals, that impair soil life and plant growth. On-farm production of organic inputs may meet higher quality standards.
- Biochar application can increase the pH of the soil and thus nutrient deficiencies that can negatively affect plant growth.
- Manure from livestock (mainly from conventional farming), but also grey water from municipalities can be contaminated with hormones or antibiotics or their degradation products. Their release to the field affects soil biodiversity and can increase resistance of pathogenic strains.

3 Examples

Land-use change, such as the conversion of arable cropland to grassland or the integration of tree lines as in **agroforestry,** impacts soil health (Golicz et al. 2021). The interaction of different permanent and annual species leads to self-regulating processes resulting in reduced pesticide use, which positively affects soil, biodiversity and groundwater (Tscharntke et al. 2021). Land-use change may even affect microclimatic conditions and the hydrological balance of the watershed. While many of these effects are desirable, some can also result in unwanted side effects and ecological imbalances (e.g. if not adapted to the local site). These measures also increase carbon sequestration due to the reduced soil disturbance and permanent tree or grass cover.

The use of **critical inputs,** such as municipality composts, may have negative effects on soil health with potential environmental toxicity. Municipalities produce large amounts of organic material that can be decomposed under controlled conditions to result in humus-like products, but organic residues from mixed waste can contain high levels of heavy metals and physical and biological contaminants (Farrell and Jones 2009). Due to the separation of food waste from other kinds of municipal waste as in Germany, the contamination of compost with toxic materials is negligible nowadays. However, the integration of other critical inputs such as biochar can possibly lead to an input of toxic compounds such as polyaromatic hydrocarbons.

4 Relevance for the EU

EU Soil Strategy for 2030: Establishes a framework for the management of soil health , sets EU soil health objectives, and will prepare concrete measures and actions. This builds on the **EU Biodiversity Strategy for 2030**, which also establishes objectives and procedures related to soil health. The EU Soil Strategy acknowledges that degraded soils lose their capacity to provide ecosystem services, including climate mitigation.

Common Agricultural Policy (CAP): The CAP features many cross-compliance conditions (good agricultural and environmental conditions) and measures related to improving and protecting soil health. The new CAP, due to start in 2023, will even include stronger support for healthy soils in line with the goals of the **European Green Deal**.

5 Addressing challenges

Climate-friendly soil funding policies and mechanisms have options for managing some of the risks of negative impacts on soil health. Potential approaches include:

- **Negative/positive lists:** Mechanisms allow only mitigation activities that have a low risk of decreasing or high chance of enhancing soil health, e.g. they avoid funding measures that pose risks to soil health, such as the input of contaminated municipal waste or the application of herbicides in the case of conservation agriculture.
- **Do-no-significant harm standards** can ensure that soil health is not negatively affected by mitigation activities.
- **Stakeholder consultation**: Involving stakeholders throughout methodology and project development, as well as implementation and monitoring can help safeguard soil health.

In addition, it is crucial to monitor impacts of measures on soil health, and to respond to new research and evidence disclosing that measures are having adverse effects.

6 Relevant literature

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