Umwelt Bundesamt

German Environment Agency

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Funding climate-friendly soil management – key issues

Impacts on biodiversity[1]

1 Background

Definition: Soil management practices can improve soil structure and soil fertility, increase water holding capacity, reduce compaction risk and soil erosion which can ultimately lead towards improving biodiversity above (mammals, bird, amphibians, vascular plants) and below ground (bacteria, fungi, macrofauna). Biodiversity means the variability among living organisms from all sources including terrestrial ecosystems. This includes diversity within species, between species and of ecosystems.[2]

Importance: Soils are a product of biodiversity, while biodiversity is a product of soil with direct and mutual impacts on climate regulation and carbon sequestration (Daba and Dejene 2018).

Relevance: The impact on biodiversity is relevant for all types of soil carbon mitigation including removals and emissions reductions. All types of financing can lead to climate mitigation activities that affect biodiversity (including results-based and action-based mechanisms[3]). Safeguards need to be in place to ensure that biodiversity objectives are taken into consideration, in line with the cautionary principle.

2 Key issues

Soils are a product of biodiversity with soils containing more species diversity than aboveground ecosystems. Moreover, numerous species living below and above ground, for example termites, ants, spiders and larvae of insects, partake in the decomposition of organic matter ultimately leading to the soil organic matter cycling and soil carbon sequestration for climate change mitigation. According to Decaëns et al. (2006), at least one quarter of all living species belongs to strict soil or litter dwellers, with bacteria and fungi not covered by these estimations. Hence, soil is a decisive factor shaping all terrestrial ecosystems and a key factor regulating both above- and belowground biodiversity. Soil management practices can influence the degree of biodiversity within ecosystems. Accordingly, it is important to consider how soil management practices can affect biodiversity, and vice versa, while measuring and monitoring these effects is crucial but challenging on all taxonomic levels (Anderson 2018). Ecosystem-specific biodiversity has to be part of the consideration, since there are ecosystems with specifically adapted biodiversity such as peatlands and marshes.

Soils are nonlinear and complex systems, characterised by a large number of interconnected components. This interaction of soil ecosystems takes place from the micro level to the macro

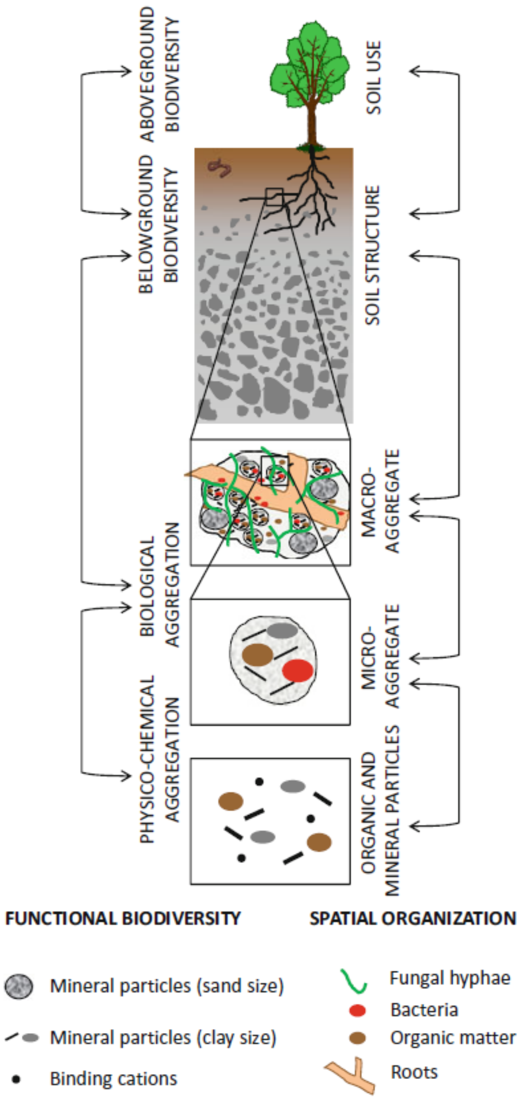
[1] This factsheet was also published as part of the UBA report "Funding climate-friendly soil management", available at http://www.umweltbundesamt.de/publikationen/Funding-climate-friendly-soil-management.

[2] Convention on Biological Diversity, available at https://www.cbd.int/doc/legal/cbd-en.pdf.

[3] Results-based payment approaches make a payment dependant on the achievement and verification of a mitigation (or other environmental) result. Under action-based approaches/direct payments, the payment depends on certain actions being taken or practices being avoided and can be made ex ante.

level to the landscape level with two-directional feedback-loops (see Figure 1). This complexity means that assessing the impacts of soil management practices is difficult and not always well quantified (de Graaff 2019) with the need for further research regarding the direct linkage between soil management activities and biodiversity. To simplify this complexity, we can think of soil as a product of biodiversity and biodiversity as a product of soil, as below.

Figure 1 Interlinkage between macroscopic surface and microscopic soil surface



Source: Havlicek and Mitchell (2014).

Interpretation: The left shows relations between biodiversity at different strata, down to physical-chemical processes at the microbial scale; the right illustrates soil use and the organisation of organic and mineral soil components.

Impact of soil management on biodiversity

Soil management measures such as tillage, drainage, crop rotation, agroforestry, land use changes, use of pesticides and fertilisers can have a direct and immense impact on above- and belowground biodiversity:

- **Positive impact:** A global meta-analysis shows that crop diversification including cover-crops, crop rotation, intercropping, agroforestry and variety mixtures can enhance biodiversity by 24%[4] (non-cultivated plants and animals) (Beillouin et al., 2021). Other soil management methods such as manure management can also increase soil biodiversity, though care must be taken to ensure good quality manure is used (Köninger et al. 2021).
- **Negative impact:** Agriculture and soil management practices have an immense impact on terrestrial ecosystems including above- and belowground biodiversity (IPBES 2019; de Graff 2019). Especially agricultural intensification has led to a dramatic loss in biodiversity over the past decades (Thiele-Bruhn et al. 2012). According to a meta-analysis by de Graff et al. (2019), synthetic N fertilisation has negative impacts on arbuscular mycorrhizal fungal and faunal diversity, and tillage has negative impacts on soil faunal and bacterial diversity.

Impact of biodiversity on climate change mitigation

Biodiversity plays an important role in climate regulation and carbon sequestration (Daba and Dejene 2018). A literature review by Daba and Dejene (2018) found that biodiversity plays a great role in carbon sequestration and GHG mitigation. The sequestration and storage of carbon is one of the many ecosystem services supported by biodiversity. The ability to adapt to climate change highly depends on the diversity of species, while species diversity increases the effectiveness of aboveground sequestration (Daba and Dejene 2018). Vegetation and well managed soils can remove carbon from the atmosphere (Daba and Dejene 2018). Overall, natural ecosystems are usually rich in both biodiversity and carbon. Protecting one can ultimately lead to the protection of both (Campbell et al. 2008).

3 Examples

Silvoarable agroforestry[5] is a system where woody perennials such as trees or hedges and agricultural, usually annual crops are grown on the same cropland. Enhancing tree structures across croplands such as in agroforestry systems means to support biodiversity-friendly landscapes by achieving a large-scale mosaic of more natural habitats (Tscharntke et al. 2021). According to a study by Beillouin et al. (2021), agroforestry has the highest potential to enhance biodiversity with an increase of around 61% compared to other management practices considered[6].

Crop rotation[7] means cultivating different crops in a temporal sequence on the same land, compared to monocultures continuously growing the same crop (Summer 2001). Diversification in crop rotation also improves agrobiodiversity at farm and landscape level in space and time, increasing habitat niches for wildlife biodiversity. According to Beillouin et al. (2021), crop rotation has the second highest potential to enhance biodiversity with an increase of 37%[5].

Critical external inputs[8] involve the application of off-farm organic nutrients derived from plant biomass and organic waste materials (plant and animal wastes) for the purpose of soil

[4] This study synthesises other meta-analyses; the 24% improvement is relative to non-intervention as it is defined in each study.

[5] See factsheets on silvoarable agroforestry and silvopastoral agroforestry, see www.umweltbundesamt.de/publikationen/Role-of-soils-in-climate-change-mitigation.

[6] The study examined the crop diversification practices cover crops, crop rotation, intercropping, agroforestry and variety mixtures.

[7] See factsheet on crop rotation, available at www.umweltbundesamt.de/publikationen/Role-of-soils-in-climate-change-mitigation.

[8] See factsheet on critical external inputs, available at www.umweltbundesamt.de/publikationen/Role-of-soils-in-climate-change-mitigation.

amendment. This can have positive or negative consequences for biodiversity, depending on the level of application and specific context, with further research required.

4 Relevance for the EU

The EU has a number of policies directly addressing biodiversity that recognise its impact on climate mitigation including the **EU Biodiversity Strategy for 2030,** which has the objective of reducing the use and risk of pesticides by 50% and to increase high-biodiversity landscape features by 10% by 2030; the **Common Agricultural Policy (CAP)**, which features a number of measures targeting biodiversity and climate mitigation on farmland, including cross-compliance conditions (good agricultural and environmental conditions, GAEC). Additional CAP measures (such as eco-schemes or agri-environmental measures) are defined by member states and have the potential to concurrently improve biodiversity and deliver mitigation.

Some voluntary carbon markets operating within the EU also recognise the link between mitigation and biodiversity enhancement, such as MoorFutures[9], which has developed a methodology for rewetting peatlands in return for mitigation certificates that also monitors biodiversity improvement.

Funding of climate-friendly soil management practices can support or decrease biodiversity posing both a risk and opportunities for funding mechanisms. Existing mechanisms have different methods for quantifying and managing broader sustainability impacts (see next chapter).

5 Addressing challenges

Safeguards on biodiversity are crucial to ensure that funding of climate-friendly soil management practices do not have negative impacts on above- and belowground biodiversity. Potential safeguards include:

- **Negative/positive lists:** Climate-friendly soil management funding mechanisms can allow only mitigation activities that have a low risk of decreasing or a high chance of enhancing biodiversity.
- **Quantitative or qualitative monitoring of biodiversity:** Monitoring biodiversity impacts and then disclosing this information, e.g. on offset credits, can create incentives for biodiversity enhancement alongside mitigation.
- **Do-no-significant harm standards** can ensure that biodiversity 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 biodiversity.

6 Relevant literature

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