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From process understanding via soil functions to sustainable soil management – a systemic approach

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Fertile soils are central resources for the production of biomass and the provision of food and energy. A growing world population and latest climate targets lead to an increasing demand for both, food and bio-energy, which requires preserving and improving the long-term productivity of soils as a bio-economic resource. At the same time, other soil functions and ecosystem services need to be maintained: filter for clean water, carbon sequestration, provision and recycling of nutrients, and habitat for biological activity. All these soil functions result from the interaction of a multitude of physical, chemical and biological processes that are not yet sufficiently understood. In addition, we lack understanding about the interplay between the socio-economic system and the soil system and how soil functions benefit human wellbeing. Hence, a solid and integrated assessment of soil quality requires the consideration of the ensemble of soil functions and its relation to soil management to finally be able to develop site-specific options for sustainable soil management.
We present an integrated modeling approach that investigates the influence of soil management on the ensemble of soil functions. It is based on the mechanistic relationships between soil functional attributes, each explained by a network of interacting processes as derived from scientific evidence. As the evidence base required for feeding the model is for the most part stored in the existing scientific literature, another central component of our work is to set up a public “knowledge-portal” providing the infrastructure for a community effort towards a comprehensive knowledge base on soil processes as a basis for model developments. The connection to the socio-economic system is established using the Driver-Pressure-Impacts-States-Response (DPSIR) framework where our improved understanding about soil ecosystem processes is linked to ecosystem services and resource efficiency via the soil functions.