frontiers | Frontiers in Environmental Science

TYPE Editorial
PUBLISHED 28 November 2022
DOI 10.3389/fenvs.2022.1093226

Editorial: Eurosoil 2021: Sustainable management of soil functions as a basis to avoid, halt, and reverse land degradation

Jörg Luster[1]*, Lucy Crockford[2], Thomas Keller[3,4], Miriam Muñoz-Rojas[5,6] and Ute Wollschläger[7]

[1]Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), Birmensdorf, Switzerland, [2]Agriculture and Environment, Harper Adams University, Newport, United Kingdom, [3]Soil and Environment, Swedish University of Agricultural Sciences, Uppsala, Sweden, [4]Agroscope, Zürich, Switzerland, [5]Departamento de Biologia Vegetal y Ecologia, Facultad de Biologia, Universidad de Sevilla, Sevilla, Spain, [6]Centre for Ecosystem Science, School of Biological, Earth and Environmental Sciences, University of New South Wales, Kensington, NSW, Australia, [7]UFZ-Helmholtz Centre for Environmental Research, Halle (Saale), Germany

KEYWORDS

sustainable development goals, soil functions, land degradation, restoration, sustainable land use management, integrated water-resources management

Editorial on the Research Topic
Eurosoil 2021: Sustainable management of soil functions as a basis to avoid, halt, and reverse land degradation

OPEN ACCESS

EDITED AND REVIEWED BY
Yuncong Li,
University of Florida, United States

*CORRESPONDENCE
Jörg Luster,
joerg.luster@wsl.ch

SPECIALTY SECTION
This article was submitted to Soil Processes, a section of the journal Frontiers in Environmental Science

RECEIVED 08 November 2022
ACCEPTED 10 November 2022
PUBLISHED 28 November 2022

CITATION
Luster J, Crockford L, Keller T, Muñoz-Rojas M and Wollschläger U (2022), Editorial: Eurosoil 2021: Sustainable management of soil functions as a basis to avoid, halt, and reverse land degradation.
Front. Environ. Sci. 10:1093226.
doi: 10.3389/fenvs.2022.1093226

Introduction

This Research Topic (RT) is related to the Eurosoil 2021 conference, focusing on the contributions of soil science to reach the targets of the UN Sustainable Development Goals SDG 6 (Clean Water and Sanitation) and SDG 15 (Life on Land). The overall aim of SDG 15 is to sustainably use and manage terrestrial ecosystems and to halt and reverse land degradation. The particular role of forests, wetlands, and mountains as water-related ecosystems makes their protection and restoration also a target of SDG 6, with the overall aim of improving the quality of drinking water resources through integrated water-resources management.

In this RT, we want to highlight the role of soil functions to achieve these targets. Soil functions (SF) are related to SDGs *via* their contributions to respective ecosystem services (ES, Keesstra et al., 2016). Soils *per se* are multifunctional and contribute to various ES. However, this multifunctionality is threatened by two main factors, leading to degradation. Firstly, the optimization and exploitation of soils for productivity compromises other SF such as water filtration, nutrient balance, C pool regulation and habitat provision (Kopittke et al., 2021). Secondly the changing climate, in particular rising temperatures and more frequent extreme events (droughts, heavy rainfalls), affects SF directly and indirectly (Hamidov et al., 2018).

The understanding of SF and how they can be improved and maintained sustainably, how they are affected by and can be made resilient against disturbances, and how they can be restored if impaired, is key to locally adapted land-use management (Hamidov et al., 2018), e.g., for use in conservation and integrated agricultural systems (Stavi et al., 2016), or for successful nature-based catchment restoration (Keesstra et al., 2018). The quantification of SF relies on sound relations with measurable state variables and properties (e.g., Greiner et al., 2017; Vogel et al., 2019), however many of these relationships are not well established yet (Lorenz et al., 2019). The overall capacity of soils to fulfil their functions and thus to contribute to ES can be summarized in the term soil quality or soil health (e.g., Bünemann et al., 2018; Bonfante et al., 2020; Lehmann et al., 2020).

In this context, the contributions to this RT deal with various issues in quantitatively assessing SF on a local basis. They can be grouped into 1) methodological improvements of measurements and monitoring, 2) testing indicators and indices for assessment of soil degradation and restoration success, and 3) policy frameworks and case studies related to land management and soil health.

Methodological improvements of measurements and monitoring

High-resolution monitoring of erosion dynamics, a prerequisite for establishing local soil-loss risk assessment, is difficult due to the lack of easy-to-use methods. Ehrhardt et al. successfully tested a method for the mm-scale mapping and monitoring of soil micro-topography using widely available cameras. Peatland degradation potentially contributes significantly to global warming. Carbon budgets are often based on point measurements of CO_2 fluxes using the closed-chamber method, and exhibit large uncertainties due to the need of gap-filling. Comparing various gap-filling techniques, Liu et al. developed a framework that can help to find the most suitable technique for a given case.

Indicators and indices

Evaluating the degree of peatland degradation, efforts to mitigate this process, or the success of restoration, relies on suitable indicators. Comparing several undrained, drained and rewetted sites in Northern Europe, Groß-Schmölders et al. conclude that the isotopic signature of the organic matter reflects well the microbial conditions that are characteristic for peatlands with different hydrology. Maretto et al. used microbial diversity as indicator to evaluate the success of restoring a highly degraded soil in a landfill. Soil quality indices (SQI) are widely used to evaluate locally adapted management options. Lenka et al. compared four quantitative approaches to calculate SQIs and showed that SQIs can be useful also on the scale of a larger region. One difficulty when assessing the compaction risk of soils is the large spatio-temporal dynamics of soil properties and states. Kuhwald et al. modeled the compaction risk for a 2000 km^2 area at high temporal and spatial resolution and were able to identify hotspots of high soil compaction risk.

Sustainable management

Adaptation of land-use management to local soil conditions requires data on key soil properties and information on legacy-effects related to soil development and previous land-use. Compiling a large data set of mechanical and physical soil properties, Schroeder et al. revealed relations between soil texture, precompression stress and saturated hydraulic conductivity. Their findings suggest that silty soils are highly sensitive to mechanical stress. In an on-farm study including 120 farm fields, Dupla et al. measured the impact of soil management on changes in soil organic carbon contents. Their results revealed that carbon sequestration is a function of tillage intensity and the soil carbon to clay ratio. On the Galápagos islands that have been influenced by agricultural activities for only a relatively short period, Strahlhofer et al. obtained baseline data on soil fertility for soils covering wide overlapping soil age and precipitation gradients. Historical land-use is another baseline information to be considered when assessing SF. Grahmann et al. investigated how varying intensity of historic agricultural management interacts with current conservation practices. Previously intensively managed soils were clearly more susceptible to erosion than more extensively managed ones. It is often hypothesized that integrated farming systems, e.g., combining cropping and forestry, improve SF compared to single farming systems. In an experimental study, Cavalieri-Polizeli et al. could not support this hypothesis for a subtropical region but found strong positive feedbacks between soil structure, soil organic carbon content and root growth. Although substances used in crop protection are well known to potentially have adverse effects on SF, there has been little integration of pest and disease management into concepts of soil health-based agricultural management. In a policy and practice review, Atwood et al. propose a framework for aligning crop protection innovation with soil health goals.

Conclusions

Taken together, the contributions to this RT emphasize an awareness within the soil science and related communities to translate systemic soil knowledge into information useful for practitioners and decision-makers. They also demonstrate that there are still many open issues with respect to linking soil properties and states to SF. A key question asked when setting up the program of the Eurosoil 2021 conference was whether application of relevant soil knowledge could make a significant contribution to reach the targets of the related SDGs. Considering the time constraint to do so by 2030, this application cannot only rely on studies that address soil property/state—function relationships. There is a large amount of data provided by the plethora of local-scale case studies that should be made accessible in open access data bases to be exploited in meta-analyses, statistical evaluations and systemic modelling. With such we should finally be able to quantitatively assess the site-specific impact of soil management measures on soil functions, ecosystem services and SDGs. Another issue is an adequate valuation of SF as prerequisite for funding and implementing sustainable land management options. This is emphasized in a perspectives paper by Crockford promoting integrated soil and water management to reduce the loss of soil, water, pesticides and nutrients from agricultural fields, and clean polluted water based on natural processes (e.g., riparian zones, artificial wetlands).

Author contributions

JL drafted a first version of this editorial. All authors contributed to the final version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

Bonfante, A., Basile, A., and Bouma, J. (2020). Targeting the soil quality and soil health concepts when aiming for the united nations sustainable development goals and the EU green deal. *Soil* 6, 453–466. doi:10.5194/soil-6-453-2020

Bünemann, E. K., Bongiorno, G., Bai, Z., Creamer, R. E., Deyn, G., De Goede, R., et al. (2018). Soil quality – a critical review. *Soil Biol. Biochem.* 120, 105–125. doi:10.1016/j.soilbio.2018.01.030

Greiner, L., Keller, A., Grêt-Regamey, A., and Papritz, A. (2017). Soil function assessment: Review of methods for quantifying the contributions of soils to ecosystem services. *Land Use Policy* 69, 224–237. doi:10.1016/j.landusepol.2017.06.025

Hamidov, A., Helming, K., Bellocchi, G., Bojar, W., Dalgaard, T., Bahadur Ghaley, B., et al. (2018). Impacts of climate change adaptation options on soil functions: A review of European case-studies. *Land Degrad. Dev.* 29, 2378–2389. doi:10.1002/ldr.3006

Keesstra, S. D., Bouma, J., Wallinga, J., Tittonell, P., Smith, P., Cerdà, A., et al. (2016). The significance of soils and soil science towards realization of the United Nations Sustainable Development Goals. *Soil* 2, 111–128. doi:10.5194/soil-2-111-2016

Keesstra, S., Nunes, J., Novara, A., Finger, D., Avelar, D., Kalanteri, Z., et al. (2018). The superior effect of nature based solutions in land management for enhancing ecosystem services. *Sci. Total Environ.* 610-611, 997–1009. doi:10.1016/j.scitotenv.2017.08.077

Kopittke, P. M., Berhe, A. A., Carrillo, Y., Cavagnaro, T. R., Chen, D., Chen, Q. L., et al. (2021). Ensuring planetary survival: The centrality of organic carbon in balancing the multifunctional nature of soils. *Crit. Rev. Environ. Sci. Technol.* 52, 4308–4324. doi:10.1080/10643389.2021.2024484

Lehmann, J., Bossio, D. A., Kögel-Knabner, I., and Rillig, M. (2020). The concept and future prospects of soil health. *Nat. Rev. Earth Environ.* 1, 544–553. doi:10.1038/s43017-020-0080-8

Lorenz, K., Lal, R., and Ehlers, K. (2019). Soil organic carbon stock as an indicator for monitoring land and soil degradation in relation to United Nations' Sustainable Development Goals. *Land Degrad. Dev.* 30, 824–838. doi:10.1002/ldr.3270

Stavi, I., Bel, G., and Zaady, E. (2016). Soil functions and ecosystem services in conventional, conservation, and integrated agricultural systems. A review. *Agron. Sustain. Dev.* 36, 32. doi:10.1007/s13593-016-0368-8

Vogel, H. J., Eberhardt, E., Franko, U., Lang, B., Liess, M., Weller, U., et al. (2019). Scientific data management in the age of big data: An approach supporting a resilience index development effort. *Front. Environ. Sci.* 7, 1–13. doi:10.3389/fenvs.2019.00072