EJP SOIL INTERNAL PROJECT SIREN DELIVERABLE 2

STOCKTAKING FOR AGRICULTURAL SOIL QUALITY AND ECOSYSTEM SERVICES INDICATORS AND THEIR REFERENCE VALUES (SIREN)

EXECUTIVE SUMMARY

Soils are rapidly becoming a focal point for integrated environmental policy. The European Commission's proposal for a renewed EU Soil Strategy is anchored in the EU's 2030 Biodiversity Strategy, in the Climate Adaptation Strategy and in the EU Action Plan, and envisages that by 2050 all soil ecosystems in the EU will be in a healthy state and be protected. It rests on three pillars of the Green Deal: climate, biodiversity and circular economy. The Commission has therefore launched the coordination of soil policy as the fourth pillar to achieve healthy terrestrial and aquatic ecosystems through better soil and water management, including across borders. Part of the soil policy involves the objective that 70% of agricultural soils are under sustainable management by 2030, which will need to be evaluated on the basis of nationally established monitoring systems for soil health. Because soils are now recognised as a crucial environmental compartment in the pursuit of a range of very ambitious policy objectives, the European understanding of concept of soil quality is currently evolving from the more traditional foci on soil fertility and soil contamination towards a broader inclusion of soil functions and ecosystem services, both in view of combating soil threats and in pushing forward sustainable land management. National soil monitoring schemes and evaluation criteria will need inclusive development along this course, not only to facilitate future policy evaluation, but also to support the development of innovative management practices and to inform governance regarding economic incentives for sustainable land use.

The SIREN project has been carried out as a priority in the EJP SOIL Roadmap to establish an inventory of evaluation frameworks for ecosystem services and soil quality in use in Europe and of the associated knowledge and development needs. The project also was aimed take stock of desirable values and associated target values of soil quality indicators and identification of the knowledge needs for pedoclimatic and agricultural system contexts.

Stocktaking of soil data use and evaluation in ES assessment

The SIREN consortium has taken stock amongst the associated EJP SOIL Partners of the use of soil data in the assessment of ecosystem services, and of the implementation of evaluation criteria for soil quality indicator data in monitoring schemes predominantly at the national scale. Where performed by Partners, ES assessment serves either of two purposes: to assess, at a national scale, the status and functioning of ecosystems under environmental change, or to inform decision-making in spatial planning or payments for services. For the majority of Partners, soils are theoretically taken into account in these ES assessments by characterising soil functions. Soil Quality data are poorly specified in National Ecosystem Assessment reports, however, and evaluated by unclearly documented modelling approaches or expert judgement.

The use of soil quality indicator (SQI) monitoring data to assess soil functions and ES is not widely distributed across the participating EJP SOIL MS. Those countries who do use Soil Quality indicator data generally use ES classification based on CICES, or a modification thereof. The largest commonality in SQIs implemented between MS is for parameters to quantify soil organic carbon (stocks and changes). A clear omission for almost all MS relates to soil biological parameters, addressing soil biodiversity either with respect to structural aspects (species richness, etc.), or functional aspects (associated with soil functions and provision of ES), or both. SQIs for water regulation and organic contaminants are also implemented by few MS.

The ES concept has been incorporated in policy by few MS only, and only for a limited number of ES - never for an integrated full range as e.g. classified by CICES. The challenges that hinder policy implementation are diverse and highly variable among MS. Top common priorities are the development and enforcement of national soil monitoring program in MS where such program does not exist or are deemed insufficient for ES assessment, the development of national ES assessment using SQI data, and the identification of references and target values to interpret ES assessments.

National evaluation criteria for soil quality indicators such as references and target values have been implemented scarcely, and primarily concern soil contaminants or nutrient contents in association to allowable fertilisation quota, rather than soil functions relating to ES provision. Particularly, no reference values exist for soil organic carbon stocks and sequestering (except for 'no decline').

A key knowledge gap shared by most Partners is the selection and development of indicators that are fit for purpose (translatable to targeted ES) and robust (sufficient background data, variability understood), and the quantification of the relationship between SQIs and associated ES. Also, the contextualisation of evaluation criteria by soil type, land use, climate zone, or management practices is a widely recognised research priority.
In terms of governance, a limited structuring and coordination of soil monitoring between government bodies and academia is hampering integrated and effective data acquisition and assessment. Capacity building and financial resourcing was also considered limited by many Partners.

Framework linking Soil Quality and Ecosystem Services

Terminology and definitions are different, and misunderstanding, miscommunication and segregation by schools of thought have slowed down cooperative development between the science realms of 'soil quality' (originally natural sciences) and that of 'ecosystem services' (originally socio- and environmental economics). Based on review of scientific literature and feedback from consortium Partners' on an earlier draft, SIREN has collated a conceptual framework linking soil quality to ecosystem services, featuring a consistent glossary of key terminology from environmental and socio-economic sciences.

As defined by the Soil Mission reports (Veerman et al. 2020, Giuffré et al. 2021), the European understanding of 'soil quality' appears to be developing towards a broader inclusion of soil functioning, and a wide array of ES provision with no increases in trade-offs, in the interest of an inclusive society. Observing that a range of definitions exists in the literature and amongst the MS, we consider that the concepts of soil quality and soil health need to be defined with a wide scope, integrating across land uses and soil functions, before being narrowed down for application in particular situations, for specific stakeholders and objectives (which in itself may justify specifically focused selections of fit-for-purpose indicators).

A general need for development towards policy implementation of the soil health and ecosystem approaches will require further integration of environmental policies, with consolidation of common concepts and frameworks, and harmonisation and synchronisation of monitoring in time and space, and between governance levels.
To use soil data in a harmonised assessment of ES at European level, the relationships between soil functions and ES need to be quantified under a harmonised conceptual framework and standardised terminology, and using a common classification of ES. The CICES classification system seems most appealing, but has been elaborated to specific requirements by many MS, and should be elaborated to become more inclusive for soils.

Towards harmonised pan-European SQ monitoring

First of all, it showed from the inventory amongst EJP SOIL MS that there is substantial support for harmonisation of SQ monitoring in Europe. This is expected to help "levelling the playing field" by stimulating the scientific exchange and capacity building across MS, as well as some standardisation in indicator selection. However, where some partners plead for simple, low-cost and replicable soil

indicators, others support the use of complex and integrated indicators. Simplicity and pragmatism seem key to success, however, for short-term harmonisation of a first generation of SQIs for national and pan-European monitoring of SQ. Moreover, a fifth of the MS phrased conditions to a harmonised approach. Flexibility in the choice of methods and protocols for harmonised SQIs (i.e. limited standardisation) was motivated by the desire to be able to continue long-term measurement series. A possibility for differentiation of evaluation criteria by regional context was also a strongly expressed condition, reflecting that soils, climate and agricultural systems can differ significantly between countries and SQ assessment would therefore require references and target values for SQIs tailored at a national or EU region level. Instead of homology, an approach by *analogy* is recommended for harmonisation, where the programming of monitoring and basic indicators are agreed upon but the actual implementation of specific methods and their protocols to assess indicators is left open to MS with regard to specific needs and historical usage. A tiered approach may alleviate the problem of countries moving at different speeds, and with different levels of detail.

Indicator selection should be a top-down process where policy-relevant SQIs are selected to inform on predefined policy objectives, rather than a bottom-up process where SQIs are preselected on the basis of localised experience from historical use, cheap costs rather than cost-effectiveness, or -worst of all- scientific lobbyism. It can be concluded that process guidance on the optimalisation of SQI selection is needed, especially regarding national and pan-European applications.

Based on a compilation from literature review, application in EU projects, stakeholder needs, and inclusion in national regulations and soil monitoring schemes (EJP SOIL stocktakes), SIREN has evaluated a longlist of most policy-relevant SQ indicators for application in pan-European soil monitoring. The result is a shortlist of commonly applied parameters that can be considered a ”minimum dataset” for a first tier of harmonised SQ monitoring. This set, however, still lacks some essential indicators for soil biodiversity, water regulation, and organic contaminants; these could not be selected from the longlist in an objective way, mostly for lack of wide application in national soil monitoring schemes.

Need for stakeholder participation in the development of national monitoring schemes.

Given the large heterogeneity in specific land use and management next to climatic and edaphic conditions, as well as substantial differences in political and social conditions among European countries, there is need to include local and regional stakeholders in the development of national monitoring schemes, as they can help identifying the issues they face in their home regions (representativeness) and can contribute in a multi-actor approach to the implementation of sustainable land management practices by participatory planning and decision-making at the national level and lower scales of governance. There is need for dialogue and co-construction between research and practice, and some countries have already recognised so and engaged accordingly.

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