Soil quality at your fingertips

Two projects led by the Soil Science Cluster developed tools for land users and managers to get a better grip on soil quality, and understand the consequences of management decisions: iSQAPER (http://isqaper-project.eu/) and LANDMARK (http://landmark2020.eu/). They illustrate many of the clusters' strategies in action and their societal relevance.

Summary

Intensive agriculture has maximised production of food and fibre at often significant expense of soil quality, undermining resilience and future productivity. Farmers and other land managers must hence balance the societal need for food and fibre with the increasing need and demand for sustainability. However, there are barriers to implementing new sustainable practices, one of which is the lack of comprehensive tools for land managers to understand the consequences of management practices on soil health or quality. Two EU-funded projects led by the Soil Science Cluster developed tools for land users and managers to get a better grip on soil quality and impacts of management decisions: iSQAPER and LANDMARK. The two projects followed different innovative approaches, combining established methodologies and state of the art technology with heavy involvement of final stakeholders. The projects also put substantial efforts into communicating scientific results with the broader public, for greater impact.

Case Description

Background

We rely on soils for the production of almost all agricultural products. However, conventional agricultural practices come with significant environmental consequences (Tilman et al., 2001). This presents challenges for farmers and other land managers who must balance the societal need for food and fibre with the ever-growing need and demand for sustainability. The number of organically managed farms has been slowly increasing, underlining the societal interest in sustainable practices and a willingness to adopt them (Willer and Lernoud, 2019). However, there are barriers to implementing new practices, one of which is the lack of tools that can help land managers understand the consequences of management practices on soil health or quality (Schröder et al., 2020). In fact, the concept of soil quality itself is challenging. Historically, and due to society's focus on producing food, soil quality has been closely bound to soil fertility. In recent years, however, the notion of soil quality has moved to include aspects related to other ecosystem services that are delivered by the soil, such as water quality and supply, carbon storage and climate regulation (Bünemann et al., 2018). Some researchers refer to this rearticulated concept of soil quality as soil health. As with human health, a healthy soil must be able to perform multiple functions simultaneously, i.e., be multifunctional.

Research objectives

Amongst the core objectives of both projects was the development of a tool that could be used by interested parties to understand soil quality and aid decision making. More specifically, the iSQAPER project, coordinated by the SLM group of the soil cluster, aimed to develop and provide an Interactive Soil Quality Assessment app, based on data existing in the academic domain in conjunction with available data at the farm level, to provide land users targeted recommendations for improved soil management at the field level to increase soil quality. LANDMARK, coordinated by the SBL group of the cluster, aimed to quantify the current and potential supply of soil functions (and therefore assess soil quality) across the EU and Brazil, using a collection of input variables that include soil and environmental properties as well as information regarding soil management.

Research approaches - Two sides of the same coin

While the research objectives of these projects were closely linked, they each followed different approaches. These approaches have been both diverse and innovative, combining established and new methodologies and inclusion of state-of –the-art technology.

iSQAPER

iSQAPER was funded by the European Union, the Chinese Ministry of Science and Technology and the Swiss State Secretariat for Education, Research and Innovation, and brought together 26 partner organizations including universities, research institutes, foundations, and small and medium-sized enterprises from all over Europe and China. Four research institutes from China participated in the project, showcasing the international role of the Soil Science cluster in soil quality research. The iSQAPER project analysed soil quality and locally appropriate agricultural management practices in different farming systems and pedoclimatic zones underpinning the creation of the soil quality assessment app – SQAPP (Fleskens et al., 2020; Figure 1).

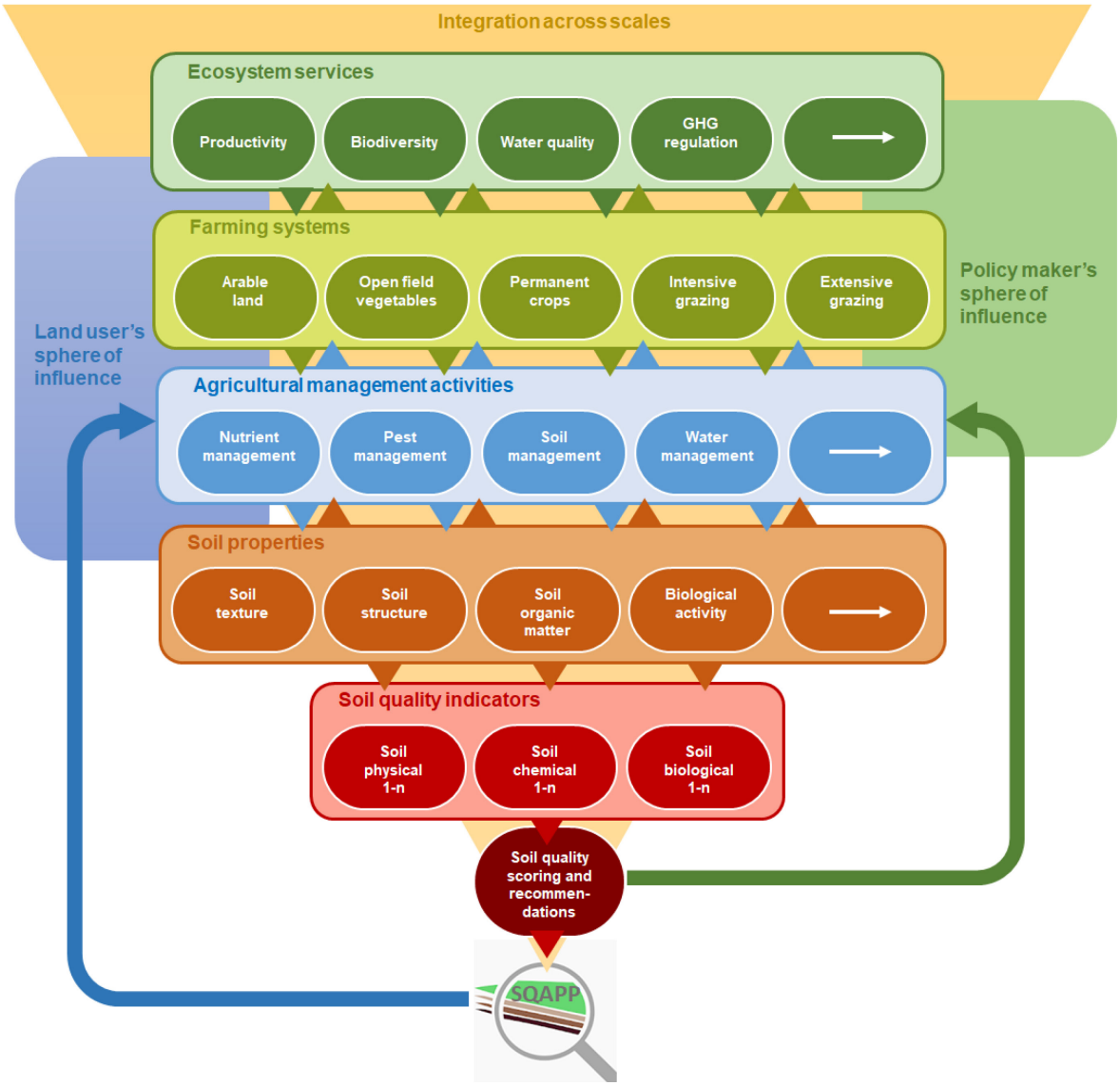

Figure 1: iSQAPER approach to soil quality assessment converging in the soil quality assessment app - SQAPP

The project started with a comprehensive review of soil quality (Bünemann et al., 2018), a valuable task, given that the publication has already received more than 400 citations. Thereafter, the project explored cost-effective and novel biological methods for assessing it (Bongiorno et al., 2019a-c; 2020). Soil quality information was gathered from experimental fields and case studies on operating farms all over Europe (Zai et al., 2018; Alaoui et al., 2020). The goal was to explore the effects of management practices on soil quality, across climatic zones and under different soil textures and farming systems. This allowed addressing questions such as: Is the effect of tillage on nutrient cycling significant despite differences in pedoclimatic zones? Effects that are observable in a variety of systems and conditions are of particular importance when developing suggestions for more sustainable farming practices.

These studies led to the development of the SQAPP, an app that uses global or European soil property and soil threat indicator maps as a base to find site-specific scores for diverse variables, whose values can also be refined by the users. These are then put into perspective, by comparing them with scores observed in other locations in the same pedo-climatic zone and land use type. In this way a score is obtained for each indicator and the SQAPP recommends alternative agricultural land management practices (AMPs) to increase overall soil quality by addressing those indicators that scored low. To put the analysis into a broader societal perspective, the iSQAPER project examined the consequences of widespread implementation of land management practices, providing recommendations for integrating and promoting soil quality and sustainable land management in farming practices and policy recommendations (Figure 1).

As SQAPP was intended for independent use by different end users, a multi-actor approach underpinned its development. The app was developed, tested, evaluated and improved by farmers, scientists, practitioners, agricultural service providers and policy makers. SQAPP[1] is freely available for download on mobile devices, can be used anywhere in the world and can be deployed in education and citizen science initiatives.

LANDMARK

The LANDMARK project, coordinated by SBL, was a collaboration between experts from 14 European countries belonging to a total of 21 research institutes, universities and governmental agencies, and Brazil and China. To quantify soil multifunctionality, LANDMARK built upon the framework of Functional Land Management (Schulte et al., 2014). This framework is based on the idea that while one soil cannot perform *all* soil functions at a high level, it can provide a number of them at a medium to high level. This could result in landscapes with varied soils providing, overall, all soil functions (Schulte et al., 2014).

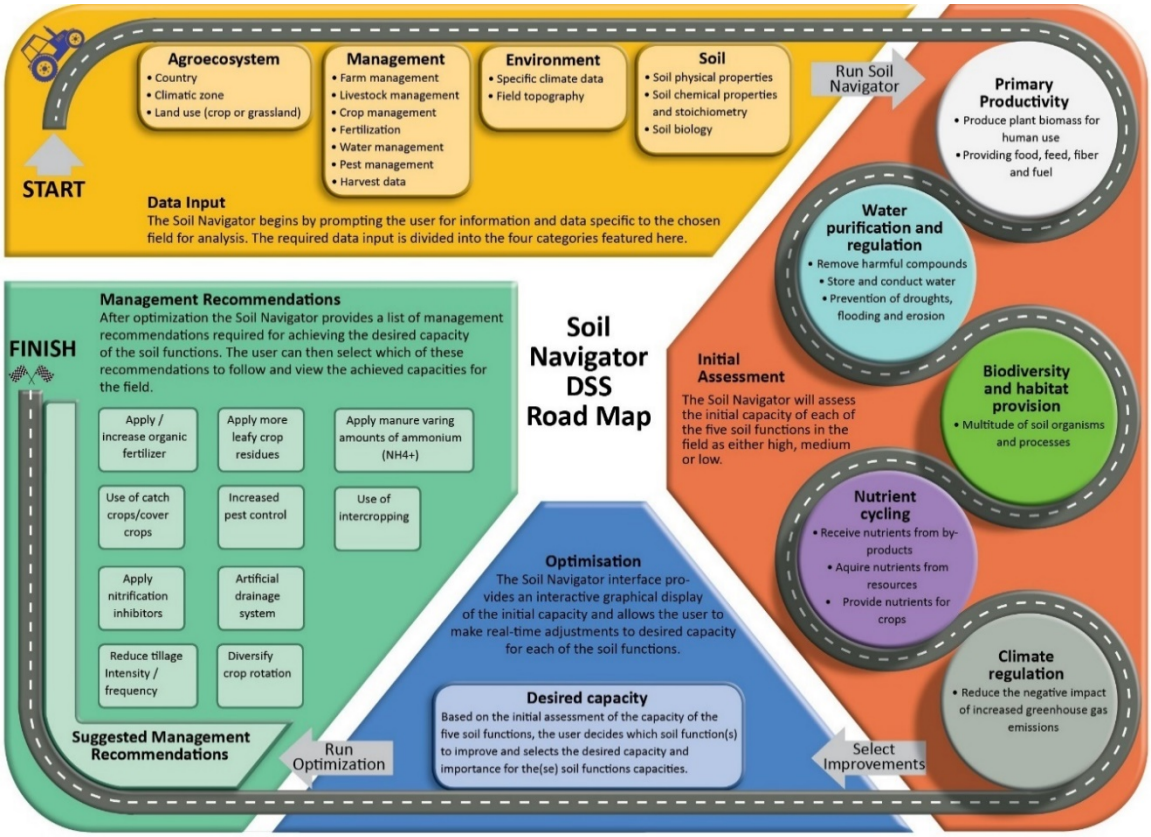

Figure 2: Overview of the Soil Navigator road map developed in the LANDMARK project

[1] https://www.isqaper-is.eu/sqapp-the-soil-quality-app

The first task was to understand the needs and drivers of different stakeholders. The project conducted many workshops involving more than 400 stakeholders spread across different realms (farmers, policy makers, advisory agencies, etc.) to gain insight into their understanding of soil functions (Bampa et al., 2019). The project put particular effort into ensuring that the project outcomes were relevant and well communicated to all stakeholders. A team of experts worked together with stakeholders gathering soil function data from a combination of European field experiments and survey efforts to create models for assessing five essential soil functions: nutrient cycling, water purification and regulation, biodiversity and habitat provision, climate regulation and primary productivity (Schröder et al., 2016; Van de Broek et al., 2019; van Leeuwen et al., 2019). These efforts culminated in the creation of a decision support system tool, the Soil Navigator[2], aimed at helping farmers, soil managers and advisory agencies with their decision making to maximize the multifunctionality of soils (Debeljak et al. 2019). The Soil Navigator also allows the user to input a desired score for a selection of soil functions, and provides suggestions to achieve that scenario (Figure 2).

Scientific and social highlights and impact

The projects produced a variety of scientific publications[3], some of which paved the way for future soil quality assessment schemes and research (Bünemann et al., 2018; Schulte et al., 2014). However, the projects' impact reaches beyond the scientific realm, with publications and policy briefs[4] that also focused on reaching policy makers at national and European level (O'Sullivan et al., 2017). All publications are Open Access to communicate scientific results and implication for policies to a broad audience.

As noted, both iSQAPER and LANDMARK intensively engaged stakeholders in order to bridge science and society. In both projects, various demonstration events were organized with stakeholders to present major findings (Barão et al., 2019). The projects' results were disseminated in a variety of formats and platforms, such as professional publications[5], infographics and videos, and a variety of media, for example, The Irish Times[6] and several policy-related blogs[7]. Recently, the Commission has published a special brief on soil health from a number of Horizon 2020 projects, which includes both articles from LANDMARK and ISQAPER[8]. The iSQAPER project has a Youtube channel[9], Facebook and Twitter[10] accounts, which are used to share news and information about the project to the wider public. The SQAPP has more than 2000 registered users who have applied SQAPP in more than 8000 locations worldwide. LANDMARK has more than 1700 followers on Twitter, 500 connections on LinkedIn, and videos to promote the importance of soils to ecosystem services as well as introduce the Soil Navigator (https://vimeo.com/landmark2020).

The Soil Navigator and SQAPP tools can greatly impact perception of soil functionality, and by taking stakeholders through steps in the evaluation of soil quality and functions, enhance sustainable agricultural management. These tools can also be used for educational purposes. For example, Soil Navigator was used during the Wageningen University Lab Skills course, and during the ISRIC Spring School, and SQAPP assignments have been incorporated in the curriculum of BSc and MSc courses.

[2] http://www.soilnavigator.eu/
[3] https://www.isqaper-is.eu/key-messages/publications and http://landmark2020.eu/publication-trees/
[4] https://ieep.eu/news/isqaper-ieep-s-role-in-exploring-policy-instruments-and-opportunities-for-soil-protection
[5] iSQAPER opinion article in the Dutch professional journal Gewasbescherming 'Lange termijn effecten van bodemmaatregelen op ziektewering' by J. Postma and Giulia Bongiorno; Landmark project published an article on the biodiversity of Dutch soils in the Dutch magazine Bodem
[6] https://www.irishtimes.com/news/environment/soil-is-too-small-a-word-for-it-1.2845602
[7] https://horizon-magazine.eu/article/cultural-cross-fertilisation-rescue-soils.html
https://sciencebusiness.net/international-news/access-information-obstacle-eu-china-joint-research
https://ec.europa.eu/research/infocentre/article_en.cfm?artid=49933
[8] iSQAPER: https://cordis.europa.eu/article/id/429351?WT.mc_id=exp; LANDMARK: https://cordis.europa.eu/article/id/429365?WT.mc_id=exp
[9] https://www.youtube.com/channel/UC7VDo8Z8t6eHjdKnoNe8TEQ/videos
[10] https://twitter.com/iSQAPER

Future perspectives and developments beyond the two projects

The two projects were concluded together with a workshop organised by both projects that took place during the Wageningen Soil Conference 2019. With this event, the projects highlighted their work toward a common goal, and provided a solid basis for further projects and collaboration. For example, the SoilGuard and MINAGRIS[11] projects will continue to advance knowledge about the effect of different agronomic practices on soil biodiversity and functions; new lab methods for soil biological indicators are in development; the BIOSIS platform, a selection tool for biological soil quality indicators is being developed; and collaborations are continuing with the China Agricultural University, WEnR and the Wageningen Student Farm. Further evidence of the quality, and scientific and social relevance and impact of the cluster's research in this area is the new project "Soil health and the potential of remote sensing" (2021 to 2024) which will explore soil quality using remote sensing. The project is funded by the private company Syngenta and will be a collaboration between the Soil Biology Group, the Remote Sensing Group, the Soil Water & Land Use Group of Wageningen Research, ISRIC World Soil Information Wageningen, and Syngenta.

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[11] http://www.minagris.eu

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