iSQAPER

Interactive Soil Quality Assessment in Europe and China for Agricultural Productivity and Environmental Resilience

Periodic Report Period 2

1-11-2016 – 30-04-2018

Grant Agreement 635750

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4	Universität Bern (UNIBE)	Switzerland
5	University of Évora (UE)	Portugal
6	Technical University of Madrid (UPM)	Spain
7	Institute for European Environmental Policy (IEEP)	UK and Belgium
8	Foundation for Sustainable Development of the Mediterranean (MEDES)	Italy
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12	Estonian University of Life Sciences, Institute of Agricultural and Environmental Sciences (IAES)	Estonia
13	University of Ljubljana (UL)	Slovenia
14	National Research and Development Institute for Soil Science, Agrochemistry and Environmental Protection (ICPA)	Romania
15	Agrarian School of Coimbra (ESAC)	Portugal
16	University of Miguel Hernández (UMH)	Spain
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18	Institute of Agricultural Resources and Regional Planning of Chinese Academy of Agricultural Sciences (IARRP)	China
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1. Explanation of the work carried out by the beneficiaries and Overview of the progress

1.1 Objectives

1 *Integrate existing soil quality related information with characterisations of crop and livestock farming systems in various pedo-climatic zones across Europe and China (Deliverables WP2, end-date month 20)*

This objective is concerned with the collection and classification of soil, climate and land use data to characterise the edaphic aspects of typical crop and livestock farming systems across Europe and China. The first step is to conceptualise the scale-dependency of different levels of pedo-climatic zones, taking into account the differences between- and inside main climate regions. This assessment is based on the evaluation of soil water and nutrient status and dynamics. Data need and availability of the conceptual model is assessed and an inventory of regional data availability status on different established. Geographical representation of cropping systems will be produced in parallel, using land use and land cover information. Analysis of the linkages between land use/cover and livestock systems will be performed. Definition, classification and spatial delineation of pedo-climatic regions as well as appraisal of their relation to crop and livestock farming systems will be delivered.

During the previous reporting period an inventory was made of available pedological and climatic data in order to construct pedo-climatic zones (Milestone 2.1). The spatial extent of Reference Soil Groups represent the major units of pedo-climatic zones. The delineation of pedo-climatic zones is based on regional soil differentiation rules, both in China and Europe. Pedo-climatic zones were further subdivided by introducing second-level soil qualifiers within the pedo-climatic zones which hold information on potentials of soil water and nutrient status and dynamics. Numerical approaches were applied to map the spatial extent of pedo-climatic zones in a comparable manner in China and Europe (Deliverable 2.1). Also, a review was made of different approaches to farming system classifications. A classification of farming systems was made (Deliverable 2.2) that groups practices based on the most important land use types including plant and animal breeding, under the highest categories of Arable land, Permanent Crops, Pastures and Livestock systems.

In the current reporting period, the analysis was extended to highlight the main features of farming by soil in Europe and China in Deliverable 2.3. Farming by soil in this context means the consideration of the soil type and soil properties when selecting crop types and cropping patterns. The analysis focused on land-based agriculture, i.e. large scale open-air arable farming. Cropping patterns in climate zones were studied with regards to the shares of crop types in different soils. Similarities and differences of the distribution of crop types on different soils within climatic zones was assessed in a comparative manner. We first assessed the dissimilarity between the cropping compositions of different pedoclimatic zones. Next, we assessed the differences of crop distribution in the climate zone by soil types and main crop types, by analysing the degree of association of crops to soil types. Finally, maps of the relative importance of the main cropping systems in each pedo-climatic zone were produced.

2 *Synthesize the evidence for agricultural management effects provided by long-term field trials across Europe and China on soil physical, chemical and biological properties, including interactions, and related ecosystem services such as agricultural productivity and yield stability (Deliverables WP3, end-date month 29)*

iSQAPER aims to mine the existing data on soil quality as assessed in European and Chinese field trials to identify the best subset of measurements that could be used to develop (aggregate) indicators of agricultural soil quality for desired ecosystem services. Data from published literature, as well as raw data from ongoing field trials and the identification of knowledge gaps in the field of quality indicator systems will be analysed and knowledge gaps emerging during screening of (data underlying) existing indicator systems and early development of SQAPP will be identified. Where needed, additional experimental work will be carried out at long-term field sites to fill the most important knowledge gaps on how soil type, climatic zone, topography and crop and land management interact to affect soil quality parameters. The WP will include a core set of >30 existing long-term field experiments selected to represent both cropland and pasture/grassland systems on a range of soil types in the dominant European and Chinese climatic zones.

In the second reporting period, we built further on the overview of existing field trials available to iSQAPER in Europe and China (Milestone 3.1) and a database of existing long-term experiment (LTE) data that was compiled in Task 3.2. Effects of four paired management practices: organic matter (OM) addition versus no organic matter input, no-tillage (NT) versus conventional tillage, crop rotation versus monoculture, and organic agriculture versus conventional agriculture) were compared on five key soil quality indicators, i.e., soil organic matter (SOM) content, pH, aggregate stability, earthworms (numbers) and crop yield. Relative effects were analysed through indicator response ratio (RR) under each paired practice. For this we considered data of 30 long-term experiments collected from 13 case study sites in Europe and China as collated in the framework of the EU-China funded iSQAPER project. These were complemented with data from 42 long-term experiments across China and 402 observations of long-term trials published in the literature. Out of these, we only considered experiments covering at least five years.

Several management practices had negative effects on soil quality indicators. For example, yield levels were lower under organic farming as compared to conventional farming and, to a lesser extent, under no-tillage compared to conventional tillage. However, the yield reduction could be marginal, if other principles of conservation agriculture such as proper residue management and crop rotation are applied. Under the chosen framework, earthworm numbers appear to be the most sensitive indicator for the four paired management practices and positively affected by all the promising practices in comparison to the corresponding standard practices. SOM content responds positively to all the promising practices in comparison to the references. Aggregate stability and yield are less sensitive to the practices, and soil pH appears to be the least sensitive indicator. The outcomes were delivered as a report (D3.2) and published as a peer-reviewed journal (Bai et al., Agriculture, Ecosystems and Environment).

The lack of a coherent dataset from all LTEs was identified as an important knowledge gap that was addressed in a sampling campaign performed in Task 3.3. A sampling campaign in 11 European LTEs was organized in 2016 and the data are under evaluation for a report (D3.3) as well as a manuscript to be submitted to a peer-reviewed journal. A similar sampling campaign was done in 2017 in Chinese LTEs and the analysis and evaluation is ongoing. The evaluation of this dataset will allow assessing how environmental conditions and land management affect soil quality indicators, and to identify the most cost-effective minimum dataset of soil quality indicators.

LTEs are an invaluable source of information and at the basis of understanding the mechanisms and magnitude of soil change. Given the ever increasing pressures on agricultural land, every effort possible should be undertaken to maintain, enhance, and connect existing LTEs, and where possible invest to extend their network. Opposite to our hypothesis, the potential for deducing meaningful trends for soil quality indicators from agricultural management practices was restricted by using currently available LTE data as the only source of information. The main reasons are the large study area with its huge range of pedo-climatic conditions, and the heterogeneous setup of LTEs making comparison of data difficult or impossible. Systematic mapping of evidence relating to the impacts of agricultural management on soil quality indicators is suggested as a way forward.

3 *Derive and identify innovative soil quality indicators that can be integrated into an easy-to-use interactive soil quality assessment tool, accounting for the effects of agricultural land management practices and related effects upon ecosystem services (Deliverables WPs 3 and 4, end-date month 24)*

Soil physical, chemical and biological measurements are proposed in a series of soil quality and soil health concepts all over the world. An overview of such soil quality concepts was produced in 2009 in Switzerland by Agroscope and FiBL. In iSQAPER, we update this compilation and evaluate the different soil quality indicators with respect to sensitivity to indicate soil threats, soil functions and land potential as well as reliability, simplicity and cost-effectiveness. The outcome of this review is a set of parameters which will be used to assess soil quality in various pedo-climatic conditions in Europe and China. The field of soil quality indicators is rapidly developing and there is a need to improve the capacity and methods for assessing soil-management interactions and their impact on soil functions. Newly developed state-of-the-art soil biological, chemical and physical methods will be evaluated using soils from the long-term field trials. The focus will be on enhancing biological soil quality assessment in the search for cost-effective indicators that respond more quickly and predictably to environmental and management stress as well as to soil remediation measures

A critical review of existing concepts of soil quality (Task 3.1) started by clarifying the important terminology and establishing linkages between soil functions, ecosystem services and soil threats, thus laying the conceptual basis for the objective. The review of soil quality concepts and indicators was delivered as a report (D3.1) and subsequently revised, submitted and accepted as a review in the peer-reviewed journal Soil Biology and Biochemistry (Bünemann et al. 2018). In both documents, we reviewed soil quality and related concepts, in terms of definition, assessment approaches, and indicator selection and interpretation. The most frequently used soil quality indicators under agricultural land use were found to be soil organic carbon, pH, available P and water storage. The review also revealed how soil quality assessment has changed through time in terms of objectives, tools and methods, and overall approach. Explicit evaluation of soil quality with respect to specific soil threats, soil functions and ecosystem services has rarely been implemented, and few approaches provide clear interpretation schemes of measured indicator values. This limits their adoption by land managers as well as policy. In the review, we list the crucial steps in the development of a soil quality assessment procedure that is scientifically sound and supports management and policy decisions that account for the multi-functionality of soil. This requires the involvement of the pertinent actors, stakeholders and end-users to a much larger degree than practiced to date.

Progress was also made with the identification and testing of novel soil quality indicators. Labile carbon fractions were shown to have higher concentrations in reduced tillage plots and in plots with high organic matter input compared to conventional tillage and low organic matter input, respectively. The fractions compared were: DOC, Hy, POXC, HWEC and POM. The fractions which were more affected by the tillage and the organic matter management were POXC and POM (both expressed in mg kg^{-1} and in % of TOC). In an overall analysis we found that the labile carbon stocks of all the labile carbon fractions were increased under reduced tillage and under high organic matter management, but POXC and POM were the most affected fractions. We found that POXC was the labile carbon fraction which was most strongly correlated with chemical (TOC, TON, CEC), physical (WSA, WHC, BD) and biological (MBC, MBN, soil respiration, qMic, qCO_2, earthworm biomass and numbers and decomposition measured with the tea bag index) soil quality indicators. POXC was also the labile carbon fraction more correlated to the other labile carbon fractions, indicating its heterogeneity. The general conclusion of this part of the project is that POXC is a sensitive indicator to the studied soil management factors, related to various soil quality indicators linked to functions, cheap and easy to assess and could therefore be used in soil quality assessments in addition or alternatively to other soil quality indicators.

Furthermore, soil suppressiveness was measured as % of growth reduction of cress plants upon the addition of the pathogen *Pythium ultimum* compared to plants growing in natural soil without pathogen addition. In general, we found that the soil suppressiveness phenomenon was due to biological properties of the soil, the 10 different experiments had different levels of natural disease present in the field and also had different levels of soil suppressiveness. The studied soil management had only a weak effect on growth reduction, with only two sites being significantly different in their level of growth reduction in the contrasting management applied. However, we found that growth reduction was correlated with soil chemical parameters related to soil nutrients (TOC, pH, Ca, CEC, available K), soil physical parameters (sand, penetration resistance and WHC), soil biological parameters related to soil microorganisms (microbial biomass and activity) and some labile carbon fractions (HWEC, Hy and POXC). Multiple regression analysis revealed that the most important parameters for explaining soil general suppressiveness across the 10 long term field experiments were microbial nitrogen (MBN) and hot water extractable carbon (HWEC). Soil management had little influence on disease suppressiveness, and each site had a specific capacity to protect plants against the disease. However, microbiological characteristics of the soil related to soil microbial biomass and activity were the most important variables which could explain growth reductions.

4 *Develop, with input from a variety of stakeholders, a multilingual Soil Quality Application (SQAPP) for in-field soil quality assessment and monitoring as an example of social innovation that allows interaction between multilevel actors (Deliverables WP4, first release SQAPP month 24, final version month 58)*

The development of a soil quality assessment tool is the central focus of the project. The tool will be developed in the format of an IT app – Soil Quality app (SQAPP) – running on mobile and/or notepad devices to facilitate in-field data collection. The app will be designed such that it can either be used stand-alone or allow connection with a server in the cloud where an extensive database will inform the SQAPP user immediately about the state of soil quality and recommended measures for improvement (these recommendations will follow from analysis in WP6). The app will accommodate operation at different levels of complexity, starting off with a minimum data set of easily observable/measurable indicators (WP3) which can be extended when more detailed data are available. At the same time, data submitted to the server can be used to inform aggregate soil quality monitoring. However, the user will be in control regarding data sharing. Some web-based functionality may only be available to users sharing data, e.g. regional reference values may depend on user contributions and as such could be regarded as premium content for those who do. WP4 internalises all activities directly geared towards development of the app, while strong linkages to other WPs will ensure iterative improvements to the app.

In the first reporting period progress was made on engaging with farmers, software developers and researchers to lay out the conceptual foundations of the SQAPP (as part of Task 4.1). Multiple sessions were organised to interact with different audiences and discuss or receive feedback on conceptual ideas. In the second reporting period, the specifications of the SQAPP design were formalised and a pilot app was built (Deliverable 4.1). A decision was made to develop a globally functional app, which required the delineation of pedo-climatic zones covering the entire world. A selection of soil property and soil threat indicators for which spatial data existed and which were deemed relevant in WP3 and WP6 was made; for all of these cumulative probability density functions were elaborated within each pedo-climatic zone. These data formed the basis for the development of a beta-version of SQAPP (Milestone 4.1). Intensive multi-actor multi-level testing of the SQAPP follows in WP5 and 6, after which an analysis is made of app performance to be integrated in a final SQAPP version.

5 *Test, refine, and roll out SQAPP across Europe and China as a new standard for holistic assessment of agricultural soil quality (Deliverables WPs 4, 5 and 6, end-date month 58)*

Towards the end of the second reporting period, a beta-version of SQAPP was released and made available on the Google Play and Apple Appstores for any interested user to test and provide feedback. Within the iSQAPER project a formal process of generating user feedback on the SQAPP is being initiated.

6 *Use a trans-disciplinary, multi-actor approach to validate and support SQAPP and to become truly relevant for agricultural practice under a wide range of circumstances (Deliverables WPs 5 and 6, end-date month 48)*

For all 14 case study sites in Europe and China the stakeholder inventory was conducted using a snowball sampling approach adapted to the project situation from a similar method applied in the EU-RECARE project (Leventon et al 2016). In this approach, a first set of stakeholders known to the case study partners fill in a questionnaire and identify several other stakeholders each. This “secondary” set of stakeholders is interviewed and, in turn, each interviewee identifies further stakeholders. This loop is repeated until the overlap between already interviewed stakeholders and new suggestions increases significantly, or until the case study partner considers the variety of stakeholders as sufficient. Milestone M5.1 is the compilation of the stakeholder inventory. This milestone shows per Case Study Site, 14 in total, the numbers and types of stakeholders approached by the research teams of iSQAPER. Their number varies from 2 to 53, in total 234 stakeholders for iSQAPER were identified. Many of the Chinese stakeholders are from agricultural institutes or villages that work with cooperatives representing more than 50 persons per stakeholder. That multiplies the number of stakeholders that are (in)directly related to iSQAPER.

A total of 148 plots/farms were identified, 114 in Europe and 34 in China, covering 8 Climatic regions and the most common soil types within each region. The most identified innovative AMP’s in Europe were: a) Manuring & Composting, Min-till and Crop rotation. In China the most identified AMP’s were: Manuring & Composting, Residue maintenance/Mulching and no-till. Using the highest soil threats in every Case Study Site area and the relevance of AMP towards the different soil threats, 24 *Testing sites* were preliminarily selected. *Testing sites* are spread in all Case Study site areas and account for 14 different innovative AMP’s (or combinations). After the withdrawal of partner CSS 13 (Zhifanggou), and introduction of changes per request to some CSS, corrections were needed. The values above are updated.

On the basis of WOCAT database (www.wocat.net) and extensive literature review, 18 promising agricultural management practices (AMPs) were selected and their impacts on soil quality were evaluated through a Visual Soil Assessment methodology at 14 study sites across Europe and China, covering the major pedo-climatic zones. Among the 138 sets of paired plots, 75.4 % show a positive impact of innovative AMPs on soil quality, 14.5 % do not show any difference in soil quality between soils under promising practices and soils in the control plots, and the remaining 10.1 % show inverse negative effect on soil quality. In Europe, the most promising AMPs that have been shown to positively impact soil quality are crop rotation / control or change of species composition, manure and composting, minimum tillage and to a certain extent no-till. For China, the most promising AMPs having positively impacted soil quality are residue maintenance/mulching, manure and composting, integrated pest and disease management, and green manure/integrated soil fertility, and irrigation management.

From the 11 variables selected to evaluate soil quality, the ones describing soil structure (porosity, structure and consistency, aggregate stability) revealed to be the most sensitive to soil quality. The variables selected by the farmers for the evaluation of soil quality are also related to soil structure and confirm the consistency of researchers' choice. The testing is ongoing in WP5 and WP6 in the following years in order to test innovative AMPs in a transdisciplinary approach to support and validate SQAPP.

7 *Develop scenarios of how widespread application of improved agricultural management practices can contribute to a lower soil environmental footprint at a continental scale (Europe and China), while maintaining or increasing crop productivity and yield stability (Deliverables WP7, end-date month 54)*

Upscaling intends to assess soil environmental footprint and therefore it is focused on three main ecosystem services linked to soil quality: food provisioning, water provisioning and regulation, and climate regulation. The analysis is based on three categories: farming systems, agricultural management practices and soil quality factors. The work in WP7 builds on elements and resources for the characterization of the soil threats, pedoclimatic zones, typical farming systems, and typical agricultural practices, that have been analysed and reported in WP 2, 3, 5, and 6. Many aspects and data have been mainly collected from different iSQAPER partners, official databases (such as Eurostat) and also from global datasets (JRC, MapSpam, EarthStat, ISRIC, FAO). We build from these publicly available datasets on soil, agriculture, physical context and socioeconomic context. These data have been compiled, processed and projected on a common geospatial framework that allows for cross-data analyses.

The categorization of farming systems, agricultural management practices and soil quality indicators is based on work carried out in iSQAPER and previous projects concerned with soil health. This work has been carefully reviewed and analysed in order to extract the most relevant features for upscaling. In each agricultural region there may be a very large number of indicators for upscaling. In our methodology, we provide a balance between the maximum number of indicators that can be distinguished and the minimal number of systems that should be considered in order to obtain a representative view of the effect of soil management practices on the environmental footprint. As a result, a proposal is made to consider seven categories of farming systems (cereals, rice, maize, soybean, vegetables, pasture and permanent crops), five categories of agricultural management practices (soil management, crop management, nutrient management, water management and organic agriculture) and three categories of soil quality indicators that can be linked to ecosystem services (crop yield, organic carbon and water holding capacity). All these categories are based on analyses carried out in WP3, 5 and 6 of the iSQAPER project. Based on these studies the categories have been properly defined and characterized.

8 *Carry out an integrated assessment of existing soil and agriculture related EU and national (including China) policies and derive recommendations for improvement, i.e. through the post-2020 CAP (Deliverables WP8, end-date month 60)*

A stocktaking survey of existing policies in the EU and China will establish in how far policy measures could be informed and enhanced by the results of earlier WPs and the scope for initiating innovative approaches in future. Problems identified in designing, implementing and monitoring policy measures at different scales will be documented and key cross-cutting issues identified. It can be difficult to specify those management practices required to meet soil quality objectives in a way which is both precise and relevant to variations in soil, cropping patterns, climate and weather conditions, etc. The project will generate both data and accessible, cost efficient tools (i.e. SQAPP) which farmers will be able to utilize in order to monitor and respond to changes in the critical parameters of the soil on their holdings. These insights and outputs can be applied to policy at different levels, from the broader European scale/level down to the individual farm. Lessons will be drawn from the different WPs to help design policies which introduce obligations on farmers, such as the GAEC component of cross-compliance, and those which involve voluntary agreements, such as agri-environment schemes. Soil monitoring tools have the potential to allow a more proactive role for farmers in meeting defined objectives and will assist the capacity of public administrations to evaluate the efficacy of different management practices. Policy measures then can be better calibrated to the most effective forms of management and progress made towards a predominantly results-based approach in agri-environment policy. The analysis will support wider policy conclusions relevant to measures in the current programming period and to the design of the next set of CAP reforms to be completed by 2020.

In the first reporting period, work started with scoping meetings to define a short list of concepts and priorities upon which to focus policy analysis. Building on this and to validate the core teams prioritisation a short questionnaire was completed by each partner/attendee at the plenary session in Hungary in June 2016 to allow the team to understand the perceptions of soil protection, policy and policy making across the iSQAPER case studies. Attention was also given to the international agenda and context and policy actions in place in China. Training sessions on the CAP and concept of Land Degradation Neutrality (LDN) were organised for project partners and a series of three policy briefs were prepared. The core effort completed so far (Deliverable 8.1) has focused on a systemic review of policies at EU level and national level (and in some cases regional level) in Europe that impact on the protection of soils on agricultural land.

Deliverable 8.1, finalised in the second reporting period departs from the notion that soil protection cannot be achieved through a single policy intervention. The analysis of EU level policies and national policies adopted by Member States has identified numerous policy goals and types of policy instrument that either protect soils directly or contribute indirectly to soil protection (i.e. through the pursuit of other goals or objectives). The analysis identified that soil is commonly being protected as a means to deliver an alternative goal; whether climate change mitigation, climate adaptation, biodiversity protection, water quality and availability or resilient and sustainable agricultural production. To deliver soil protection in this context it is important to recognise the positive changes needed to support improved soil condition and fully integrate these priorities within wider policy goals.

The SDGs offer an opportunity to make links between policy areas and highlight the relevance of soil protection to the achievement of sustainable development. At their core the SDGs are a set of interlinked objectives with soil protection and improved land management necessary for the delivery of multiple Goals. For example, the second SDG links hunger, food and nutrition security with sustainable agriculture; illustrating the connection between environmental sustainability and social inclusion in the SDGs. The SDGs provide targeted commitments and a new language that can be used by all actors to discuss progress towards sustainable development, including the protection of agricultural soils. The 2030 Agenda sets out ambitious targets for global transformation, yet in order to achieve change requires action in all signatory countries. To succeed, SDGs need to be integrated into national policy, central to policy implementation and monitoring frameworks.

At the EU level a list of 35 key policies of importance for soil protection was analysed to determine their relevance to the protection of agricultural soil specifically. Only 9 of these policies were identified as highly relevant to agricultural soils including: three measures related to the CAP (Cross Compliance, Greening and Rural Development Programmes; three measures related to the reduction of pollution (environmental liability, national emission ceiling and sewage sludge Directives); two related to the protection of water bodies (Water Framework Directive and the Nitrates Directive); and one linked to funding environmental and climate related projects (LIFE+). None of the policies identified as ‘highly relevant’ is specifically focused on soil protection.

An analysis of soil protection requirements linked to the current CAP policy framework was undertaken examining provisions for: Good Agricultural and Environment Condition set out as part of cross compliance; the greening of Direct Payments; and the more targeted support provided through Rural Development Programmes. The analysis shows that provisions exist within all three measures that offer potential to support the protection of agricultural soils.

The Regulations governing the funding, support and scope of the CAP are set at the EU level, with detailed decisions about how and which measures and instruments to implement made at the national and regional level; therefore, agricultural soils across EU Member States are subject to subtly different criteria and consequently potentially different levels of protection. When considering Member State implementation of CAP rules, it was concluded that Member States appear to be addressing soil erosion using a range of measures, offering opportunities for a similar range of positive interventions. The picture for the promotion and retention of soil organic matter is different; national and regional choices implementing support for soil organic matter protection and promotion appear to lead to less comprehensive coverage.

In addition to the implementation of EU laws and policy actions, Member States have also adopted a body of nationally initiated policy measures relevant to soil protection. 252 policies were identified as potentially relevant to soil protection on agricultural land and reviewed. The review confirms that there are a number of Member States that have comprehensive or dedicated policies for soil protection or management of agricultural soils and are promoting their protection as a key priority. The vast majority of Member States, however, rely on environmental policies either not dedicated to soils or not specifically focused on agricultural soils to address agricultural soil quality issues.

9 *Disseminate project results using a variety of formats and media to inform and engage targeted stakeholders, ranging from land users to high-level policy makers and the general public (Deliverables WP9, end-date month 60).*

This objective, addressed in a dedicated work package (WP9) focuses on disseminating project outputs and relative information which can enhance the impact of the project to professional and public individuals. This involves coordinating and facilitating contact and communication with the different groups of actors and target audiences who will be involved in iSQAPER, potential users of SQAPP and the wider public, and ensuring efficient and effective dissemination of knowledge generated in the project using a variety of media and methods as appropriate for the different actors and target audiences. To achieve this objective, an iSQAPER Dissemination and Communication Strategy will be formulated, methods of knowledge transfer and dissemination will be developed, an iSQAPER information system set up, the SQAPP will be promoted, and visual project impact created.

During this period, progress has focused on four of the five tasks. Significant attention was paid to improve the overall dissemination and communication efforts of the project. Consortium members are very familiar with writing material for the iSQAPERiS website and scientific journals. Therefore, during this period, we have concentrated on building skills to enable us to use social media more effectively. A training event on Using Social Media for Dissemination was delivered on Wednesday 13 September 2017, at the Third iSQAPER Plenary meeting in Beijing. The meeting was attended by some 70 members of the iSQAPER consortium and all work packages and study sites were represented. The training session had 3 tasks:

- revise the key messages that are emerging from each study site and work package,
- plan infographics for each message,
- start making short videos to illustrate each message.

As a consequence of the attention on multi-media products, to date some 20 infographics and 18 short videos covering a range of aspects concerning the project have been made. These and other dissemination outputs of the project are reported in the updated "Plan for the Exploitation and Dissemination of Results (PEDR)" The iSQAPERiS website (www.iSQAPER-is.eu) has been further developed to enhance the communication of the research results (Task 9.3) and several shootings for the film have been realised (Task 9.5).

1.2 Explanation of the work carried per WP

1.2.1 Work Package 1

Summary

WP1 has links to all WPs and partners, as it manages the whole project and coordinates data management strategies. There are in particular links with WP9 as communication, dissemination and visibility of the project are closely linked.

The **overall objective** of WP1 is two-fold: 1) to ensure proper activity management of the project; and 2) to streamline any administrative, financial, legal and IP (Intellectual Property) issues in order to enable RTD partners to focus on their research activities.

Specific **sub-objectives** are:

1. Activity management to facilitate smooth operation of the project objectives by supporting the coordinator, WP leaders and other partners, and compiling the periodic activity reports (Task 1.1);
2. To handle all the financial, administrative and legal matters of the consortium (Task 1.2);
3. Address gender equality issues in the project (Task 1.3);
1. To ensure good communication within the project, and to parties outside the consortium, including the management of data (Task 1.4);
4. To organize plenary project meetings and to facilitate the organization of Scientific Board meetings (Task 1.5).

Details for each task

Within the second periodic reporting phase (months 19-36), the following achievements have been made (progress included in italics):

Task 1.1: Activity management to facilitate smooth operation of the project objectives by supporting the coordinator, WP leaders and other partners, and compiling the periodic activity reports (Lead partner: WU)

Within task 1.1, the following activities have received the required attention and successful follow-up:

- Activity management aiming at i) maintenance of the project work plan and monitoring of its implementation (*done on a daily basis*), ii) identification of required corrective actions and contingency plans (*mainly focusing on monitoring the progress of tasks and making sure delays*

are accommodated without negatively affecting follow-on tasks, see also Section 5.1), iii) implementation of decisions of the project managerial bodies (*done accordingly*)
- Coordination of reporting procedures aimed at preparing periodic and final activity reports that comply with the EC rules (*done, resulting in the 2nd periodic progress report of the iSQAPER project*)
- Give overall direction to the project and provide follow-up on decisions of the plenary project meetings and the Scientific Board meetings (*done on a continuous basis to ensure proper execution of the project*)
- The Project Advisory Board will be recruited and consulted regularly (*done on an ad-hoc basis so far, with invitation to plenary project meetings and/or targeted WP leader intermediate meetings*)

Task 1.2: Financial and legal management (Lead partner: WU)

Activities within task 1.2 resulted in the following achievements:
- Financial administration with the aim of i) timely distribution of funding to the partners via a dedicated Euro account (*done*), ii) budget management, utilization and monitoring (*performed on a weekly basis*), and iii) preparation of periodic consortium consolidated financial statements (*in this reporting period done for the periodic reporting phase 19-36 months*)
- Coordination of reporting procedures is aimed at preparing periodic and final management reports that comply with the EC rules, including justification of costs and Form C of all beneficiaries (*in this reporting period done for periodic reporting phase 19-36 months*)

Task 1.3: Gender equality (Lead partner: CorePage)

Task 1.3 is meant to actively promote gender equality within the iSQAPER consortium, and will also pay due attention to gender related aspects in executing the project, especially in relation to activities in each of the Case Study Sites. Analyses will result in gendered Case Study Site mappings. Questionnaires and reports required by the European Commission concerning gender issues will be submitted. (*The activities deployed within the period 19-36 months have resulted in a dedicated gender equality report for the second reporting period, iSQAPER report no. 5*)

Task 1.4: Communication and data management (Lead partners: WU and MEDES)

Task 1.4 consists of the following actions:
- To establish and maintain a project website and co-define the functionality of the iSQAPER Information System (iSQAPERiS) in collaboration with WP9 (*project websites have been redesigned, filled, and maintained, see, for more information: www.iSQAPER-project.eu and www.iSQAPER-is.eu*)
- To prepare a project dissemination, communication and visibility plan in collaboration with WP9 (*achieved, and delivered as an update of the PEDR (Deliverable 9.2 v2))*
- To initiate and develop project working papers and project communication series for, respectively, internal and external communication of project results; also in collaboration with WP9 *(respective series have been launched and all project reports are allocated report numbers accordingly)*
- To produce a data management plan *(an update of the iSQAPER data management plan (Deliverable 1.2) was made and included in the PEDR report)*

Task 1.5: Organisation of meetings (Lead partner: WU and others)

In order to ensure appropriate progress of the iSQAPER project and outlining activities for future execution according to the Description of Action, the following issues deserve required attention:

- Smooth organization and facilitation of activities of the project will be achieved by plenary meetings planned well in advance, which ideally will be hosted by partner organisations with Case Study Sites in Europe and China representing different pedo-climatic zones. The goal of the meetings is to evaluate project progress, to outline work plans, to have scientific discussions, targeted training sessions for project partners, and to receive updates regarding the financial and IP status and interactions with the EC (*within period 19-36 months the third project plenary meeting was organised in Beijing, China. Several bilateral staff exchanges between different participating partner institutions also took place*)
- Organisation and facilitation of Scientific Board meetings, which will be either physical meetings or electronic meetings, whatever is most appropriate at the time. Partner 1 (WU) will facilitate the organization of Scientific Board meetings which will be planned ahead of time (*A range of other project related meetings have been organised during the second reporting period of the project, among which i) weekly project coordination team meetings at Wageningen University, ii) monthly electronic meetings with all Chinese participants, especially to ensure access to required project funds through MOST, iii) regular electronic meetings with all Case Study coordinators, iv) regular electronic meetings with the Work Package leaders, complemented with dedicated Work Package Leader meetings held in Madrid (February 2017) and Évora (February 2018), and v) ad-hoc meetings between different project institutions, staff members, administrative/financial units, and students*)

1.2.2 Work Package 2

Summary

This WP is dedicated to the collection and classification of soil, climate and land use data to characterise the edaphic aspects of typical crop and livestock farming systems across Europe and China. The first step is to conceptualise the scale-dependency of different levels of pedo-climatic zones, taking into account the differences between- and inside main climate regions. This assessment will be based on the evaluation of soil water and nutrient status and dynamics. Data need and availability of the conceptual model is to be assessed and an inventory of regional data availability status on different scales will be established. Geographical representation of cropping systems will be produced in parallel, using land use and land cover information. Analysis of the linkages between land use/cover and livestock systems will be performed. Definition, classification and spatial delineation of pedo-climatic regions as well as appraisal of their relation to crop and livestock farming systems will be delivered.

This WP contributes to WP3 by identifying distinct combinations of farming systems and pedo-climatic situations for detailed studies; to WP4 by demonstrating data availability for different regions/scales and providing geo-referenced data for the implementation of the Soil Quality app; and to WP7 by contributing data for scenario studies.

The main objectives of WP2 are:

1) To collect and classify soil, climate and land use data (Task 1);
2) To create harmonised spatial layers of soil, climate and land use/cover data (Task 2);
3) To establish pedo-climatic zones by integrated analyses of soil water and nutrient regimes and climatic factors (Task 3);

4) To classify farming systems across Europe and China (Task 4);
5) To analyse farming systems in the pedo-climatic zones (Task 5).

Detailed description of work carried out for each task

The tasks of WP2 has been completed, objectives have been realized. Tasks 1-4 were reported in the 1st periodic report, Task 5 is reported in the current report.

Task 2.5: Analysis of farming systems in the pedo-climatic zones (Lead partner: UP, partners: JRC, UPM, ISS, Case Study Sites)

Extent and spatial patterns of different farming systems in the pedo-climatic zones will be analysed. The analysis will cover comparative assessment of current farming systems on regional and continental scales including soil resource utilisation of different farming systems. Needs and gaps will be explored, with special attention to soil quality and nutrient management. Climate is recognized as one of the defining features of different farming systems; it follows that if the climate changes, farming system will have to shift, adapt, or be transformed into a different land use. The results of previous projects such as ECOFinders, RECARE, MyWater, CATCH-C, D-e-METER will also be utilised for this task.

Deliverable: „D2.3 Report on the spatial analysis of crop and livestock systems in relation to pedo-climatic conditions" was prepared to complete WP2. The deliverable highlights the main features of farming by soil in Europe and China. Farming by soil in this context means the consideration of the soil type and soil properties when selecting crop types and cropping patterns. The analysis focused on land-based agriculture, i.e. large scale open-air arable farming. Cropping patterns in climate zones were studied with regards to the shares of crop types in different soils. Similarities and differences of the distribution of crop types on different soils within climatic zones was assessed in a comparative manner. We first assessed the dissimilarity between the cropping compositions of different pedoclimatic zones. Next, we assessed the differences of crop distribution in the climate zone by soil types and main crop types, by analysing the degree of association of crops to soil types.

Results suggest that farmers in general consciously take pedoclimatic condition of farming into account when selecting their cropping patterns in Europe. In other words, farming by soil is a common practice in the different (climatic) regions of Europe. Pedoclimatic conditions are considered in their complexity by the farmers. For instance oilcrops are cultivated on relatively high share of Podzols in Mediterranean (temperate-sub oceanic) and low share of Podzols in southern sub-continantal zone, meaning that similar specific soil conditions are considered together with the prevailing climatic conditions. Other good examples of soil-based farming include rootcrop production on Histosols in the Atlantic climate zone, maize production on Gleysosls of the Southern sub-continental climate, cultivating cereals on Podzols of the Sub-Oceanic climate zone, which all can be regarded as a "farming by soil" practice, which is also recognized on this coarse scale of analysis.

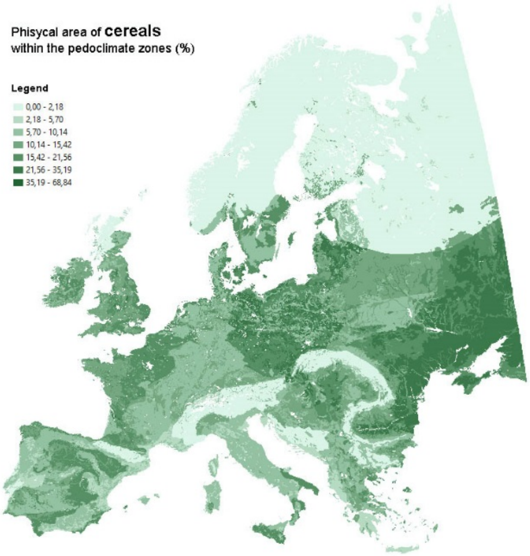
The fact that both zonal and azonal soils are among the soil types that might be cropped differently from the main cropping pattern of the given regions show that apart from climatic factors soil conditions have dominant role in selecting the most suitable crop.

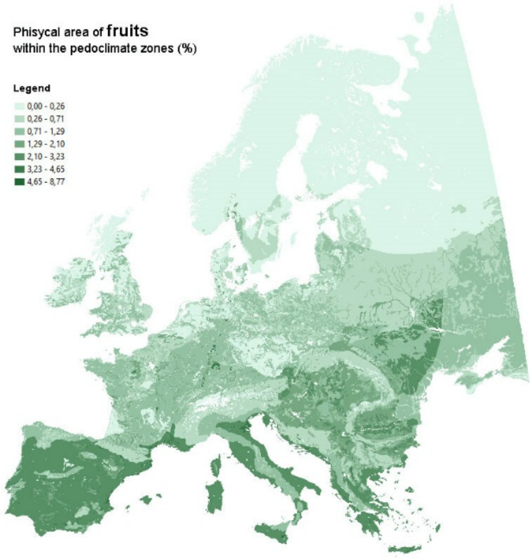
However, we have strong reasons to believe that soil suitability-based cropping is not practiced to its full potential over the continent at the moment. For example our finding suggests that production area of legumes are not always adapted till their full potentials for the local pedoclimatic conditions in some zones. We assume that the reason for this the consideration of legumes mostly "only" as an internal crop filling the cultivation gap between the preferred cash crops, rather than placing legumes in the rotation on their own right for balanced soil utilization. Probably including legumes to the rotations based on pedoclimatic conditions would enhance the overall agronomical output as well. However, cropping desirable from agronomic viewpoint is not necessarily meet the profitability targets of the farm enterprises.

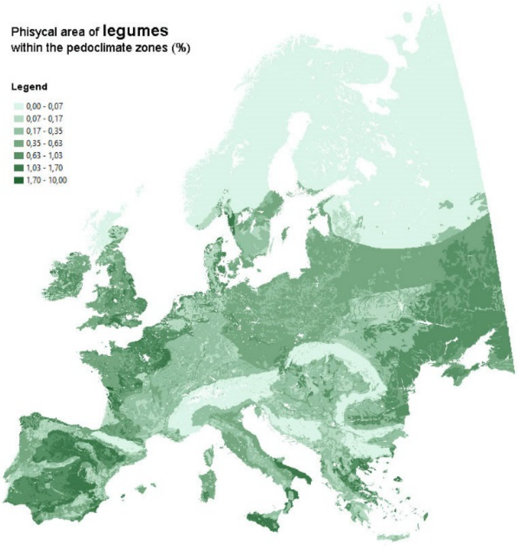
When comparing our findings with time series statistical data of crop cultivation (Eurostat 2017) we can assume that tendencies driven by policy incentives or climate change can restructure the crop composition of pedoclimatic zones rather rapidly too. Findings of farming in pedocimatic zones under the Atlantic climate underlines that economic drivers are decisive when farmers adopt their cropping (eg. oilcrops on Albeluvsiols), however soil suitability is considered too and may result in win-win situations for the economic return of crop production and management based on soil suitability (roorcrops on Histosols; cereals on Arenosols). In conclusion, we can assume that pedoclimatic conditions of cropping are respected in most of Europe. Farmers crop according to edaphic conditions whenever economic considerations do not override the ecological consideration of farming.

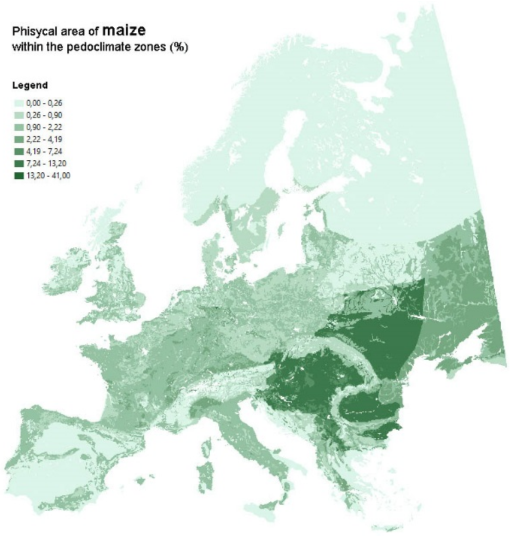
Obviously, the farming activity in China is generally conducted on reasonable soil types according to the long agricultural history. Our results revealed the difference of main soil types in each pedoclimatic zone regarding crop types. For various climatic zones, agricultural use of soil would give rise to different problems that should be paid extra attentions to. For example, in the tropical climate area, Ferralsols could be improved by highly technical interventions and the intensive use may lead to compaction problems due to their aggregate and pore morphology. Furthermore, Ferralsols soils are very friable and are easy to manage and present a low CEC and quick drainage. Cultivation on the Acrisols would exposes soils to significant erosion, in that Tropical climate zone usually has a large annual precipitation. Generally speaking, the cropping patterns of all the soil types are not significantly different with each other according to the Chi square statistics. There are two potential reasons for the insignificant difference: 1) some soil types with small areal shares present dominant difference versus other soil types; and 2) the ownership of most croplands in China was very scattered (only a few tenths of hectares) due to the large population and little farmland, and this heterogeneity increases the uncertainties of the input data applied in the analysis.

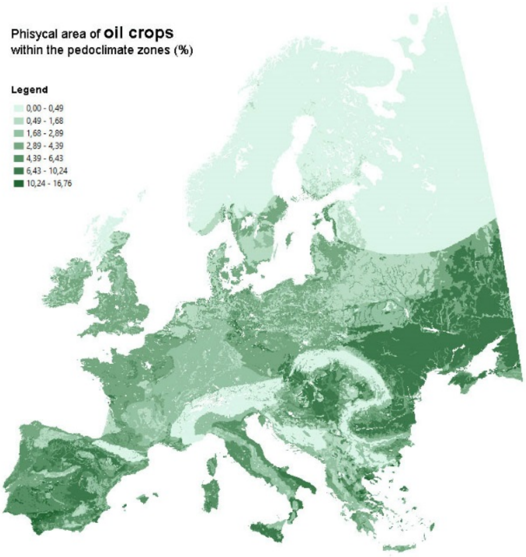
Furthermore, maps of the share of farming systems within pedo-climatic zones were prepared for Europe (Figure 1). These will be used as a basis for scenario analysis within WP7.

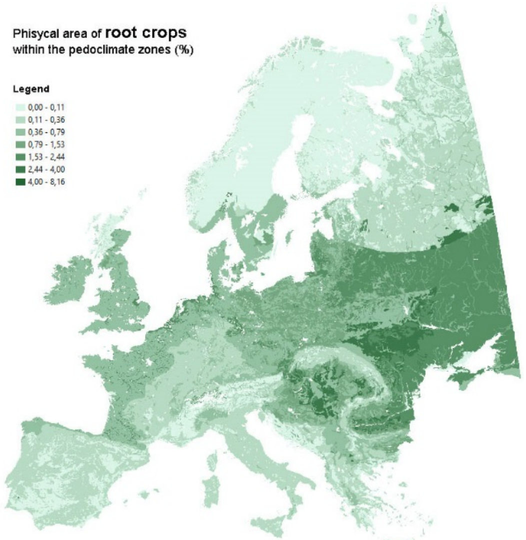

Phisycal area of cereals
within the pedoclimate zones (%)
Legend
0,00 - 2,18
2,18 - 5,70
5,70 - 10,14
10,14 - 15,42
15,42 - 21,56
21,56 - 35,19
35,19 - 68,84


Phisycal area of fruits
within the pedoclimate zones (%)
Legend
0,00 - 0,26
0,26 - 0,71
0,71 - 1,29
1,29 - 2,10
2,10 - 3,23
3,23 - 4,65
4,65 - 8,77


Phisycal area of legumes
within the pedoclimate zones (%)
Legend
0,00 - 0,07
0,07 - 0,17
0,17 - 0,35
0,35 - 0,63
0,63 - 1,03
1,03 - 1,70
1,70 - 10,00


Phisycal area of maize
within the pedoclimate zones (%)
Legend
0,00 - 0,26
0,26 - 0,90
0,90 - 2,22
2,22 - 4,19
4,19 - 7,24
7,24 - 13,20
13,20 - 41,00


Phisycal area of oil crops
within the pedoclimate zones (%)
Legend
0,00 - 0,49
0,49 - 1,68
1,68 - 2,89
2,89 - 4,39
4,39 - 6,43
6,43 - 10,24
10,24 - 16,76


Phisycal area of root crops
within the pedoclimate zones (%)
Legend
0,00 - 0,11
0,11 - 0,36
0,36 - 0,79
0,79 - 1,53
1,53 - 2,44
2,44 - 4,00
4,00 - 8,16

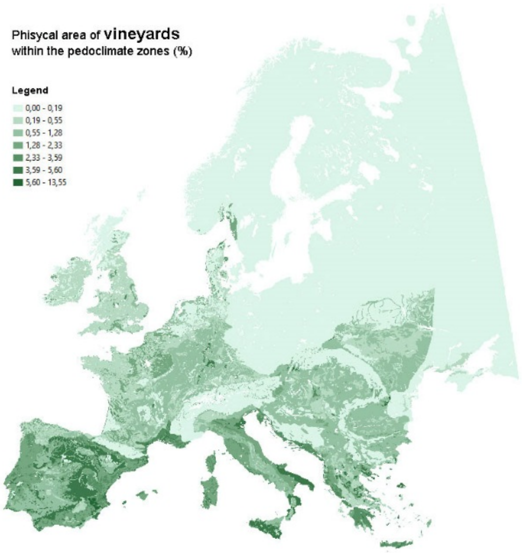


Figure 1. Share of different farming systems in pedo-climatic zones within Europe.

The data from WP2 have been compiled within a GIS platform. The platform was established as a Milestone in the first reporting period (Milestone M2.1 Inventory of available soil, land use and purpose specific climate data and regional representation of soil and land use data available on a GIS platform, and updated with new analyses in the current reporting period.

Data are available on a dedicated server at University of Pannonia:
FTP: isqaper.georgikon.hu
User name: isquser
Password: 20isq16
Contact: Tamas Hermann (tamas.hermann@georgikon.hu)

1.2.3 Work Package 3

Summary

In recent years a large body of work in the field of soil quality indicators has been produced by researchers in many areas of the world (EU-DESERTLINKS, EU-DESIRE, EU-ENVASSO, EU-ECOFinders, EU-Soilservice, various Visual Soil Assessments). National programmes have attempted to identify the most effective combination of measured soil properties that provide an effective assessment of soil quality. However, there is not yet a consensus on the best combination of measurements to use for assessing agricultural soil quality, from the perspective of the essential soil functions (soil structure formation; litter decomposition; carbon cycling; nutrient cycling; water cycling) that sustain soil ecosystem services (production; water infiltration, storage and supply; erosion control; nutrient retention and supply; filtering and buffering of nutrients and contaminants; maintaining the soil greenhouse gas balance; maintaining the soil organic matter balance; soil-borne pest and pathogen control; and serving as a habitat). Factors including sensitivity to indicate soil threats and soil functioning and management interactions, cost, reliability, and simplicity all need to be considered when selecting or developing a soil quality indicator system that is geared to land potential, i.e. to set goals for outcomes of soil functions to deliver ecosystem services.

In this work package we will provide a critical review of existing soil quality indicators systems all over the world, and mine the existing data on soil quality as assessed in European and Chinese field trials to identify the best subset of measurements that could be used to develop (aggregate) indicators of agricultural soil quality for desired ecosystem services. This will include a compilation of soil quality concepts worldwide, accessing data from published literature, as well as raw data from ongoing field trials and the identification of knowledge gaps in the field of quality indicator systems. Data will be analysed and results fed into WP4 for development of SQAPP. Knowledge gaps identified during screening of (data underlying) existing indicator systems and early development of SQAPP will be identified. Where needed, additional experimental work will be carried out at long-term field sites to fill the most important knowledge gaps on how soil type, climatic zone, topography and crop and land management interact to affect soil quality parameters. The WP will include a core set of >30 existing long-term field experiments selected to represent both cropland and pasture/grassland systems on a range of soil types in the dominant European and Chinese climatic zones. Experiments in this WP will also be used to screen newly developed indicators of soil quality.

The main objectives of WP3 are:

3.1. To critically review existing concepts of soil quality and soil health indicators *(Task 1)*;

3.2. To document existing field trials across various pedo-climatic zones in Europe and China so as to:

   a. compile a database of research results in the field of soil quality and soil health indicators
   b. analyse the data to identify the indicators that are the most cost-effective in terms of sensitivity to indicate soil threats, soil functions and land potential
   c. identify knowledge gaps in the field of soil quality indicator systems to be used in SQAPP *(Task 2)*;

3.3. To assess how soil type, climatic zone, topography and crop and land management interact to affect indicators of soil quality *(Task 3)*;

3.4. To screen and evaluate a range of newly developed indicators of soil quality in long-term trials *(Task 4)*.

Summary of progress towards objectives

Regarding task 1, a review of soil quality concepts and indicators has been delivered both as a report (D3.1) and as a peer-reviewed publication (Bünemann et al. 2018 in SBB). For task 2, a database of research results from long-term experiments (LTEs) in Europe and China was compiled and analysed. The outcomes were delivered as a report (D3.2) and submitted to a peer-reviewed journal (Bai et al., accepted in Agriculture, Ecosystems and Environment). For task 3, a sampling campaign in 11 European LTEs was organized in 2016 and the data are under evaluation for a report (D3.3) as well as a manuscript to be submitted to a peer-reviewed journal. A similar sampling campaign was done in 2017 in Chinese LTEs and the analysis and evaluation is ongoing. For task 4, samples from the European LTE sampling campaign have been analysed for various estimates of labile carbon, disease suppressiveness and nematode communities using molecular analysis, and phospholipid fatty acid analysis as well as MicroResp. The data are currently under evaluation for a report (D3.4) as well as several manuscripts to be submitted to peer-reviewed journals.

Details for each Task

Task 3.1: Critically review existing concepts of soil quality indicators **(Lead partner: FiBL, partners: WU, JRC, UE, IARRP, AUA)**

Soil physical, chemical and biological measurements are proposed in a series of soil quality and soil health concepts all over the world. An overview of such soil quality concepts was produced in 2009 in Switzerland by Agroscope and FiBL. We will update this compilation in the frame of the proposed project, and evaluate the different soil quality indicators with respect to sensitivity to indicate soil threats, soil functions and land potential as well as reliability, simplicity and cost-effectiveness. The outcome of this task will be a set of parameters which are used to assess soil quality in various pedo-climatic conditions in Europe and China. This set of parameters will be used in a meta-analysis under *Task 2*.

Activities and results

A review of soil quality concepts and indicators was delivered as a report (D3.1) and subsequently revised, submitted and accepted as a review in the peer-reviewed journal Soil Biology and Biochemistry (Bünemann et al. 2018). In both documents, we reviewed soil quality and related concepts, in terms of definition, assessment approaches, and indicator selection and interpretation. The most frequently used soil quality indicators under agricultural land use were found to be soil organic carbon, pH, available P and water storage (Figure 2).

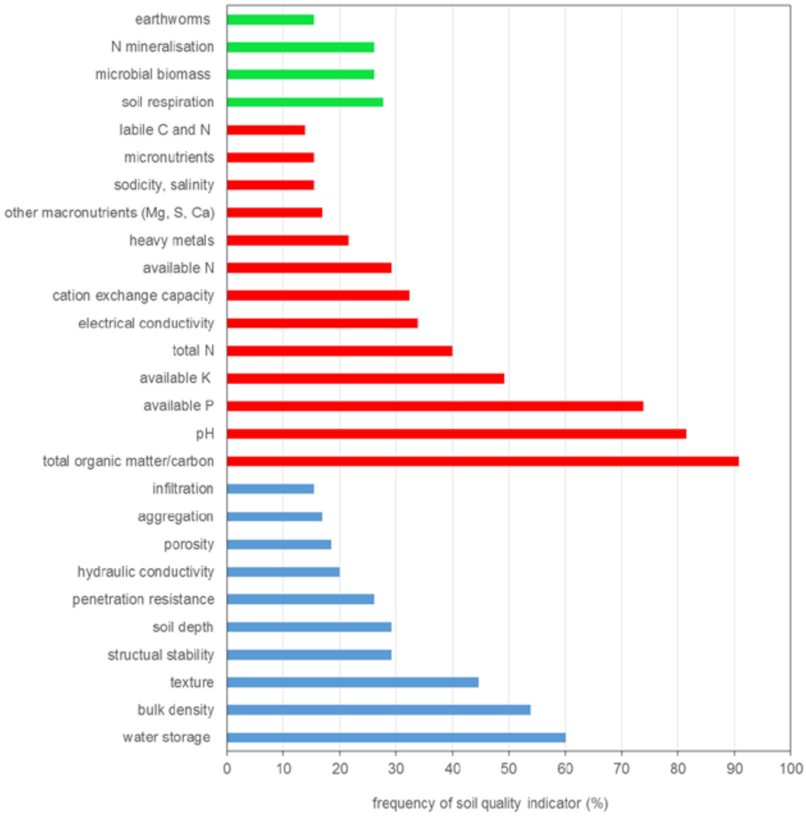


Figure 2: Most frequently used indicators in all reviewed soil quality assessment approaches (n=65). Soil biological, chemical and physical indicators shown in green, red and blue, respectively.

Our review revealed how soil quality assessment has changed through time in terms of objectives, tools and methods, and overall approach (Figure 3). Explicit evaluation of soil quality with respect to specific soil threats, soil functions and ecosystem services has rarely been implemented, and few approaches provide clear interpretation schemes of measured indicator values. This limits their adoption by land managers as well as policy.

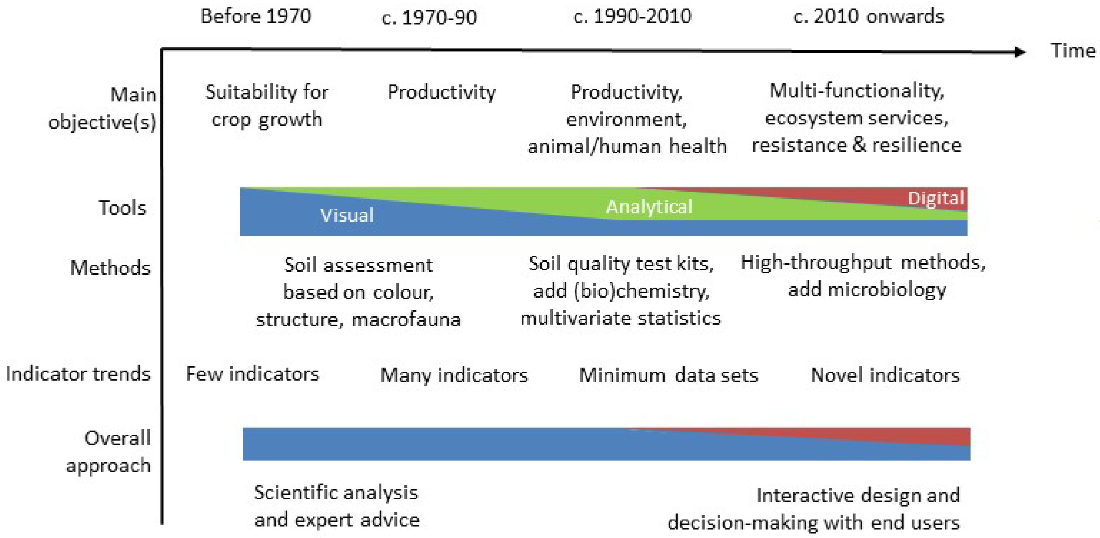


Figure 3: Main objectives, tools and approaches of soil quality assessment through history

In the review, we list the crucial steps in the development of a soil quality assessment procedure that is scientifically sound and supports management and policy decisions that account for the multi-functionality of soil. This requires the involvement of the pertinent actors, stakeholders and end-users to a much larger degree than practiced to date.

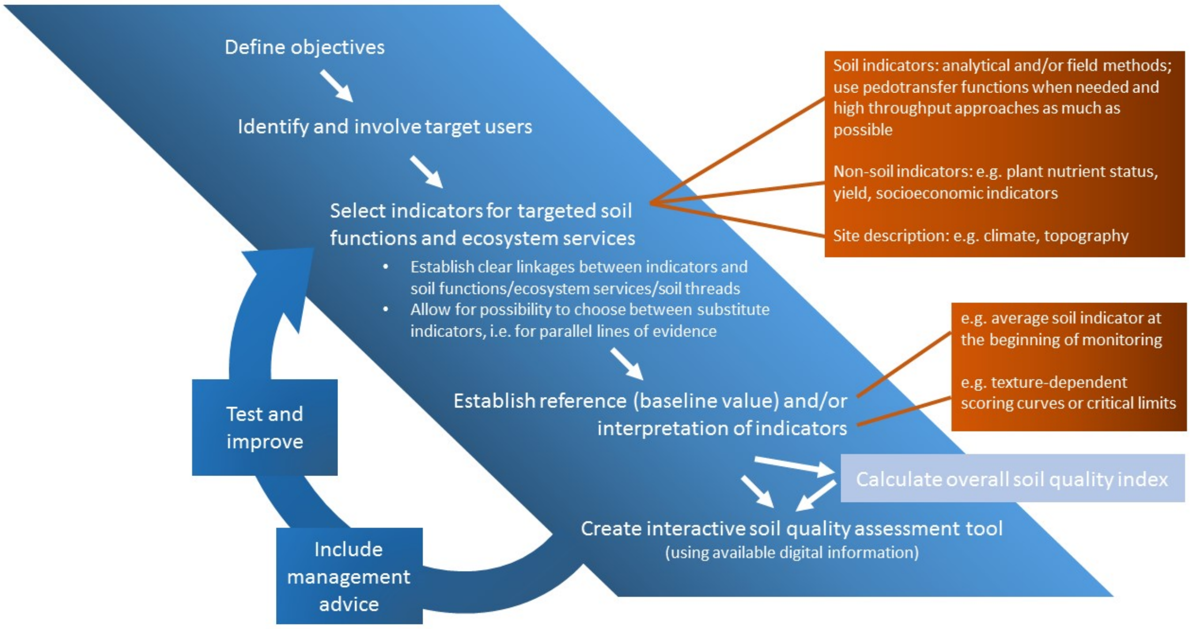


Figure 4: Main steps in the development of a soil quality assessment approach

Task 3.2: Documentation of existing field trials across various pedo-climatic zones in Europe and China (Lead partner: ISRIC, partners: FiBL, WU, DLO, IARRP, All partners with long-term field experiments)

This task will document the >30 long-term field trials contributed by the consortium members, complemented with other existing trial data. We will build on a field trial overview generated in an Era net project (Reduced tillage and green manures for sustainable organic cropping systems (TILMAN-ORG) on effects of conservation tillage on soil quality. Moreover we will include key study sites which are part of EXPEER (FP7 project: Experimentation in Ecosystem Research) and from a database of the EU project Catch-C (Compatibility of Agricultural Management Practices and Types of Farming in the EU to enhance Climate Change Mitigation and Soil Health). The trials will be characterised by site conditions (soil type, climate) and management practices (crop/animal production system, crop rotation, fertilisation, plant protection and tillage). Data of published and unpublished results on effects of management practices on soil quality indicators in view of key soil functions such as carbon sequestration, nutrient cycling, soil structure formation and pathogen/pest suppression will be fed into a database.

A literature review/meta-analysis will be conducted on effects of various management practices on key soil quality and soil health indicators using assembled data from the field trials, distinguishing between major European and Chinese climatic zones, soil type, topography and land use (arable, vegetable, grassland, permanent crops) as defined in WP2. The soil quality and health indicators will be evaluated with respect to their sensitivity to indicate soil threats and soil functions and interactions with management as well as reliability and simplicity of measurement. They will also be linked with yield data. Knowledge gaps will be identified, in particular in the field of soil biotic community assessment, soil root symbioses, and the capacity of soils to suppress plant pathogens and soil fatigue, as well as with respect to methods for assessing plant-available soil nutrients and soil structure and the soil's potential to sequester, retain or loose carbon and nutrients as greenhouse gases or other forms causing environmental stress.

Detailed description of work carried out for this task

- A database of research results from the long-term experiments (LTEs) in Europe and China was compiled;
- A database of long-term effects of agricultural practices on soil properties from extensive literature review was complied.
- The two databases were analysed, and outcomes were delivered as a report (D3.2) and submitted as a manuscript to the peer-reviewed journal *Agriculture, Ecosystems and Environment* with the title: "*Effects of agricultural management practices on soil quality: A review of long-term experiments for Europe and China*" (Bai *et al*., accepted):

In this paper we present effects of four paired agricultural management practices (organic matter addition (OM) versus no organic matter input, no-tillage (NT) versus conventional tillage, crop rotation versus monoculture, and organic agriculture versus conventional agriculture) on five key soil quality indicators, *i.e*., soil organic matter (SOM) content, pH, aggregate stability, earthworms (numbers) and crop yield. We considered organic matter addition, no-tillage, crop rotation and organic agriculture as "promising practices"; no organic matter input, conventional tillage, monoculture and conventional farming were taken as the respective references or "standard practice" (baseline). Relative effects were analysed through indicator response ratio (RR) under each paired practice. For this we considered data of 30 long-term experiments collected from 13 case study sites in Europe and China as collated in the iSQAPER project. These were complemented with data from 42 long-term experiments across China and 402 observations of long-term trials published in the literature. Out of these, we only considered experiments covering at least five years.

The results show that OM addition favourably affected all the indicators under consideration (Figure 5). The most favourable effect was reported on earthworm numbers, followed by yield, SOM content and soil aggregate stability. For pH, effects were variable; OM input favourably affected the pH of acidic soils, whereas no clear trend was observed under NT. NT generally led to increased aggregate stability and greater SOM content in upper soil horizons. However, the magnitude of the relative effects varied, e.g. with soil texture. No-tillage practices enhanced earthworm populations, but not where herbicides or pesticides were applied to combat weeds and pests. Overall, in this review, yield decreased slightly under NT. Crop rotation had a positive effect on SOM content and yield; rotation with ley very positively influenced earthworm numbers. Overall, crop rotation had little impact on soil pH and aggregate stability. A clear positive trend was observed for earthworm abundance under organic agriculture. Further, organic agriculture generally resulted in increased aggregate stability and greater SOM content. Overall, no clear trend was found for pH; a decrease in yield was observed under organic agriculture in this review.

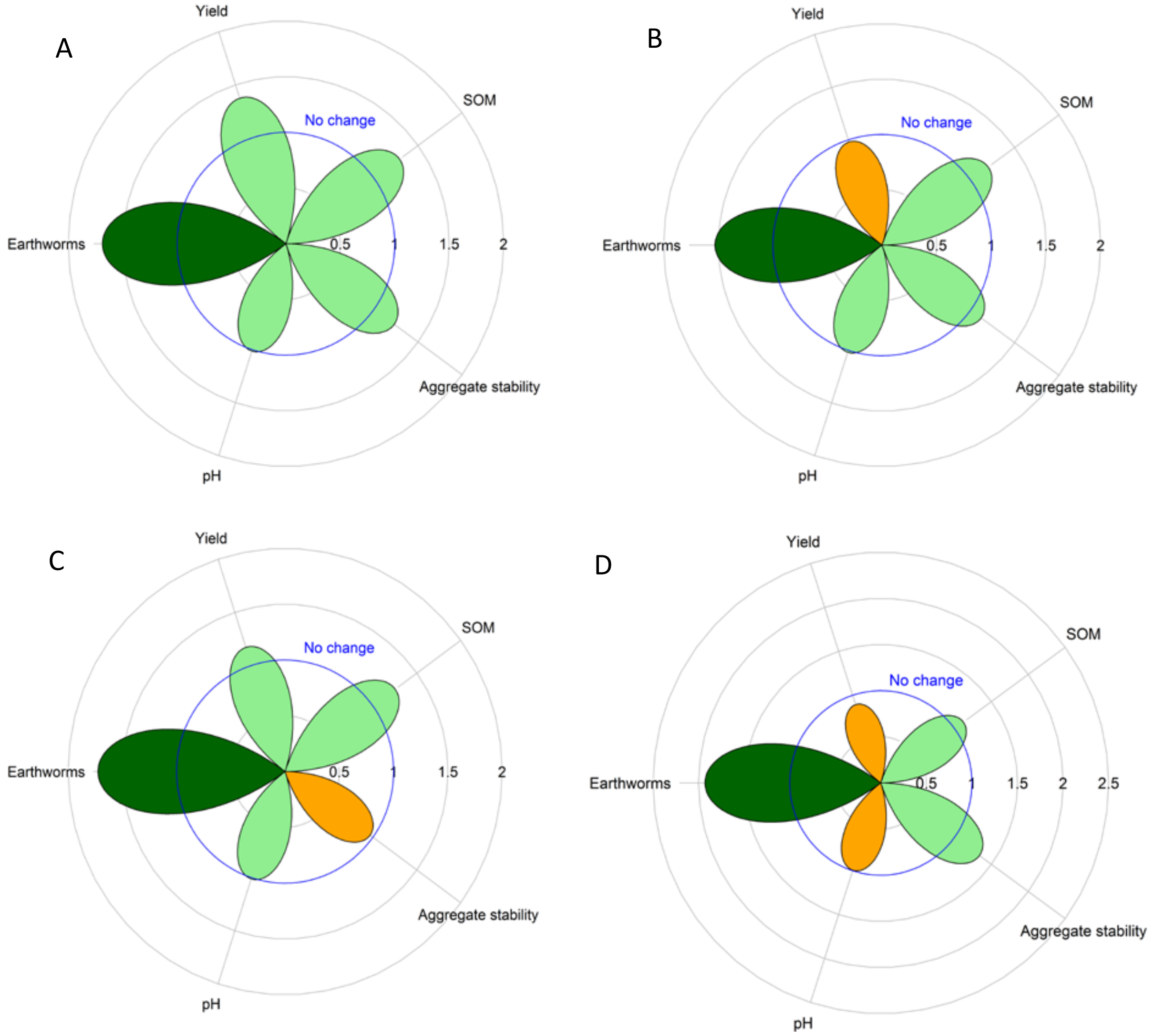


Figure 5: Long-term effects of agricultural management practices on soil properties: A, organic matter addition versus no organic matter input; B, no-tillage versus conventional tillage; C, crop rotation versus monoculture; and D, organic agriculture versus conventional agriculture. Relative effects are expressed as median of ratios and visualised with different colours: orange, median ≤ 1; light green, 1 < median < 1.5; and dark green, median > 1.5. Values >1 indicate positive effects.

Conclusions:

Our study confirmed that land management practices influence soil quality indicators in various ways. There are clear trends and relative changes in the five indicators as determined by the four-paired practices. However, the magnitude of the trends and direction of the indicator changes vary with the different management practices.

Several management practices had negative effects on soil quality indicators. For example, yield levels were lower under organic farming as compared to conventional farming and, to a lesser extent, under no-tillage compared to conventional tillage. However, the yield reduction could be marginal, if other principles of conservation agriculture such as proper residue management and crop rotation are applied. Conversely, there are also positive aspects of organic farming such as higher marketing price and reduced environmental damages. Therefore, to evaluate whether it is judicious to convert conventional farming to organic farming, socio-economic aspects will have to be considered in combination with soil quality impacts.

Under the chosen framework, earthworm numbers appear to be the most sensitive indicator for the four paired management practices and positively affected by all the promising practices in comparison to the corresponding standard practices. SOM content responds positively to all the promising practices in comparison to the references. Aggregate stability and yield are less sensitive to the practices, and soil pH appears to be the least sensitive indicator.

The agricultural practices chosen (e.g. organic matter input) represent categories rather than specific treatments (e.g. addition of farmyard manure, compost, green manure, crop residue, or slurry). Although details on the various different treatments under those categories were documented in the literature review database, a full meta-analysis was beyond the intention and scope of research performed for the iSQAPER project.

LTEs are an invaluable source of information and at the basis of understanding the mechanisms and magnitude of soil change. Given the ever increasing pressures on agricultural land, every effort possible should be undertaken to maintain, enhance, and connect existing LTEs, and where possible invest to extend their network.

Opposite to our hypothesis, the potential for deducing meaningful trends for soil quality indicators from agricultural management practices was restricted by using currently available LTE data as the only source of information. The main reasons are the large study area with its huge range of pedo-climatic conditions, and the heterogeneous setup of LTEs making comparison of data difficult or impossible. Efforts such as the systematic mapping of evidence relating to the impacts of agricultural management on SOC described by Haddaway et al. (2015) are promising and should be extended to collate data about other soil quality relevant indicators.

Finally, it should be noted that farmers often know very well which specific soil parameters are the most relevant for their particular situation. Therefore, the view of land managers should be taken into account when evaluating various sets of indicators for soil quality, necessitating a transdisciplinary and participatory approach.

- The above-mentioned results have been used in scoring effects of agricultural management practices on soil qualities or soil health indicators in the development of Soil Quality Assessment Tool (SQAPP) in the Work Package 4.

Task 3.3: Assess how soil type, climatic zone, topography and crop and land management interact to affect indicators of soil quality (Lead Partner: DLO, partners: FiBL, WU, UE, ISRIC, IARRP)

The field trials selected are expected to exhibit a range in soil quality status based on their differing histories and local pedo-climatic conditions. In this task an inventory of the current soil quality status in the selected field trials will be conducted using indicators selected in *Task 2*. This overview will provide important information about typical ranges for soil quality indicators in the different cropping systems and pedo-climatic zones. It will also provide an indication of how soil type, climatic zone, topography and crop and land management interact to affect indicators of soil quality. An additional output will be an evaluation of the indicators proposed in *Task 2* and recommendations about their applicability in different pedo-climatic zones and crop(/animal) production systems. Validated indicators will be used for the assessment of soil quality by SQAPP in all experiments and on-farm evaluations (WP5 and WP6).

Detailed description of work carried out for this task

Eleven Long Term Experiments (LTEs) across Europe were sampled in spring 2016. The LTEs covered a range of soil types, crop rotations and 3 climatic zones. The main treatments investigated in the LTEs were tillage and fertilisation. Tillage was simplified to conventional tillage (CT) or reduced tillage (RT). Fertilisation was divided into high organic matter input (HIGH) or low organic matter input (LOW). Samples were analysed on the parameters mentioned in the table below (Table 1).

Table 1. Measured parameters for the samples from all eleven LTEs with abbreviation and unit.

Parameter	Abbreviation	Unit
Water-stable aggregates	WSA	%
Particulate organice matter	POM1	Mg per gram soil
Carbonate content	$CaCO_3$	%
pH	-	-
Available phosphate	P-AL	mg per 100 g soil
Available potassium	K-AL	mg per 100 g soil
Total N		%
Total C		%
Total organic carbon	TOC	%
Texture: clay, silt, sand		%
Exchangeable cations (Ca++, Mg++, K+, Na+)		mmolc per 100 g soil
H+		mmolc per 100 gram soil
cation exchange capacity	CEC	mmolc per 100 g soil
Microbial carbon and nitrogen	Cmic, Nmic)	mg per kg soil
nitrogen mineralisation		µg net-N per kg soil per day.
water content	WC	%
Respiration rate: C from CO_2		µg per hour, per g soil.
Bulk density	Bulk	g per cm^3
Earthworms		numbers per m^2 ; weights in g per m^2
Tea-bag test		S : stabilisation factor , K : decomposition rate
Penetration resistance		MPa
Water holding capacity (water content at field capacity)	WHC	Calculated from clay%, total silt % and total organic carbon %(TOC)
Yield		t per ha

The parameters were statistically analysed using the following methods: Box and whisker diagrams, Response ratio, principal component analysis (PCA), REML mixed model. Whisker diagrams were used as a first visualisation of the data. An analysis of variance was performed on all parameters to test the effect of tillage and fertilisation. A Residual Maximum Likelihood (REML) analysis was performed on those parameters that showed highest results for the response ratio analyses. Finally also a PCA analysis was done.

Results

A selection of the results is shown below (limited by space constraints). Soon all results can be found in Deliverable 3.3. The parameters responding significantly to Tillage and/or Fertilizer in one or more LTEs are in Table 2 and 3, with the F-probabilities per LTE for Tillage and Fertilizer indicated with colours, for the three LTEs with both Tillage and Fertilizer the F-probablities for the contrast of CT LOW with RT LOW, CT HIGH and RT HIGH are indicated respectively with till, org and till+org.

Table 2. Overview of the F-probabilities and direction of the effects for parameters determined in the soil, in two layers, per management strategy for all individual LTEs. till = effect of (reduced) tillage, org = effect of (high) input of organic matter. Layers: 1 = 0-10 cm, 2 = 10-20 cm, - : 0-20 cm (on the LTEs CH3, HU1, PT1 where the topsoil was sampled in 1 layer).

LTE	mana		biological			bio-chem		chemical					physical			visual: spade diagnosis			ratio of two parameters		
	gement	layer	Cmic	Nmic	resp	POM1	TOC	P-AL	P-Ols	K-Al	Ntot	CEC	WSA%	Bulk	WHC	aggreg	%por	struct	Cmic/TOC	resp/Cmic	TOC/clay
CH1	till	1	+	+		+	+	+		+	+								+		+
CH1	till	2				-		-		-				+					+		
CH2	till	1				+			+	+										+	
CH2	till	2			-				-	-			+	+							
CH3	org	-	+	+	+	+	+			+	+		+								+
ES1	till	1			+	+	+	+	+	+	+	+	+	-	+						+
ES1	till	2	+	+		+			+		+		+	-		+	+				+
ES4	org	1	+	+	+	+				+	+	+	+	-	+		-			+	
ES4	org	2	+	+						+	+	+		-							
HU1	org	-	-							+						-			-	+	
HU4	till	1	+		+	+	+	+	+	+	+				+				+		+
HU4	till	2					+	+			+										+
NL1	till	1																			
NL1	till	2	-	-	-		-				-										-
NL1	org	1																			
NL1	org	2		-			-						-								-
NL1	till+org	1													+				-		+
NL1	till+org	2	-	-	-	-	-				-		-					+			-
NL2	till	1	+																+		
NL2	till	2	-																-		
NL2	org	1				+		+													
NL2	org	2	+	+		+	+	+	+		+										
NL2	till+org	1	+	+		+															
NL2	till+org	2				+		+													
PT1	org	-																			
SL1	till	1			+		+	+			+		+							+	
SL1	till	2					+	+		+	+	+	+	+							+
SL1	org	1					+	+		+	+	+							-		+
SL1	org	2					-			-		-		-						+	-
SL1	till+org	1					+	+	+	+	+	+	+		+	-					+
SL1	till+org	2								-			+	+	-	-					
All	Till	1	+	+	+	+	+	+	+	+	+		+		+			-			
		2			-								+	+			+				
	Org	1			+	+	+	+		+	+	+	+		+		-				
		2				+												+	+		
	Org	-			+	+	+	+		+	+						-		-	+	+
	Till+Org	1				+	+	+	+	+	+				+	-					
		2		-																	

Management:
till=tillage (reduced/conventional)
org=supply organic matter (yes/no)

layer:
1 = 0 - 10 cm
2 = 10 - 20 cm

Statistical significant:
not
P < 0.05
P < 0.01
P < 0.001

The **effect** of reduced tillage and/or supply of organic matter:
+ : enhanced
- : reduced

The biological parameters, Cmic and Nmic both showed many significant effects in several LTE's, but on average over the LTEs there were only significant effects of reduced tillage in layer 1 and for Nmic a reduction in layer 2 with the combination of reduced tillage and high addition of organic matter. Measurement of soil respiration demonstrated far fewer significant effects than Cmic or Nmic in the LTEs. However averaged over the LTEs, respiration was significantly affected by reduced tillage and addition of organic matter.

The bio-chemical parameters POM1 and TOC both demonstrated many significant effects in the LTEs and on average over the trials for both reduced tillage, high addition of organic matter and the combination of both. For the chemical parameters P-AL, K-AL and Ntot there were very much significant effects in the LTEs. On average over the LTEs these three parameters showed also significant effects for reduced tillage, high addition of organic matter and the combination of both. Especially with Ntot the effects of management (in layer 1) were very significant. Phosphate level measured as P-Olsen reflected management much less than P-AL. CEC showed only a few significant effects in the LTEs and only one significant effect (of high addition of organic matter) across all LTEs.

Of the physical parameters, WSA% and bulk density both showed several significant effects in the LTEs, but WSA% had more significant effects across the LTEs than bulk density. Especially reduced tillage had significant effects on WSA% in both soil layers (causing higher bulk density). Water holding capacity (WHC) was calculated from the percentages clay, total silt and total organic carbon and showed only a few significant effects in the LTEs, but on average across the LTEs there were significant effects of reduced tillage, (high) addition of organic matter and the combination of both, probably due to increases in organic carbon (see the parameter TOC).

Table 3. Overview on the F-probabilities and direction of the effects for the teabag test, earthworms and penetration resistance per management strategy determined in the soil for all individual LTEs.

		biological				physical			dry
LTE	mana-	tea-bag test		earthworms		penetration resistance			matter
	gement	S	K	number	weight	0-20 cm	20-40 cm	40-60 cm	yield
CH1	till				+				
CH2	till	*	*			+			
CH3	org								-
ES1	till	+				+			
ES4	org								
HU1	org								
HU4	till								
NL1	till								
NL1	org			+		+			
NL1	till+org								
NL2	till								
NL2	org	-							+
NL2	till+org								
PT1	org					*	*	*	*
SL1	till				+	+	+	+	
SL1	org								+
SL1	till+org			+	+	+	+	+	+
All	Till			+	+	+	+	+	
	Org			+					
	Till+Org			+	+	+	+	+	+

Management:
till=tillage (reduced/conventional)
org=supply organic matter

layer:
1 = 0 - 10 cm
2 = 10 - 20 cm

Statistical significant:
not
P < 0.05
P < 0.01
P < 0.001

The **effect** of reduced tillage and/or supply of organic matter:
+ : enhanced
- : reduced

*: not determined

PCA Analysis

There were strong differences between the eleven LTEs. This can be shown and summarized using multivariate techniques (Figure 6). First the best set of parameters from Table 1 was selected to discriminate between LTEs. In a Principal Component Analysis from this set of variates two new independent variates were formed after centring and normalizing (Figure 6). Dots, representing the experimental plots from the LTEs, in the same region in the plot are similar. Plots of the same LTE form clusters in the PCA biplot, so plots within the same LTE are more similar than plots from different LTEs. The plots of CH1 deviate from the plots of other LTEs. The projections of the plots of CH1 on Cmic, Nmic, CEC, WSA%, TOC and Ntot are high. So the contents of these parameters in CH1 soil are high. Remarkable are the deviating plots of ES1 and ES2 and the wide range along the first axis. For the further analyses the effect of the LTEs was cancelled out by adding a factor LTE as covariate to the PCA model.

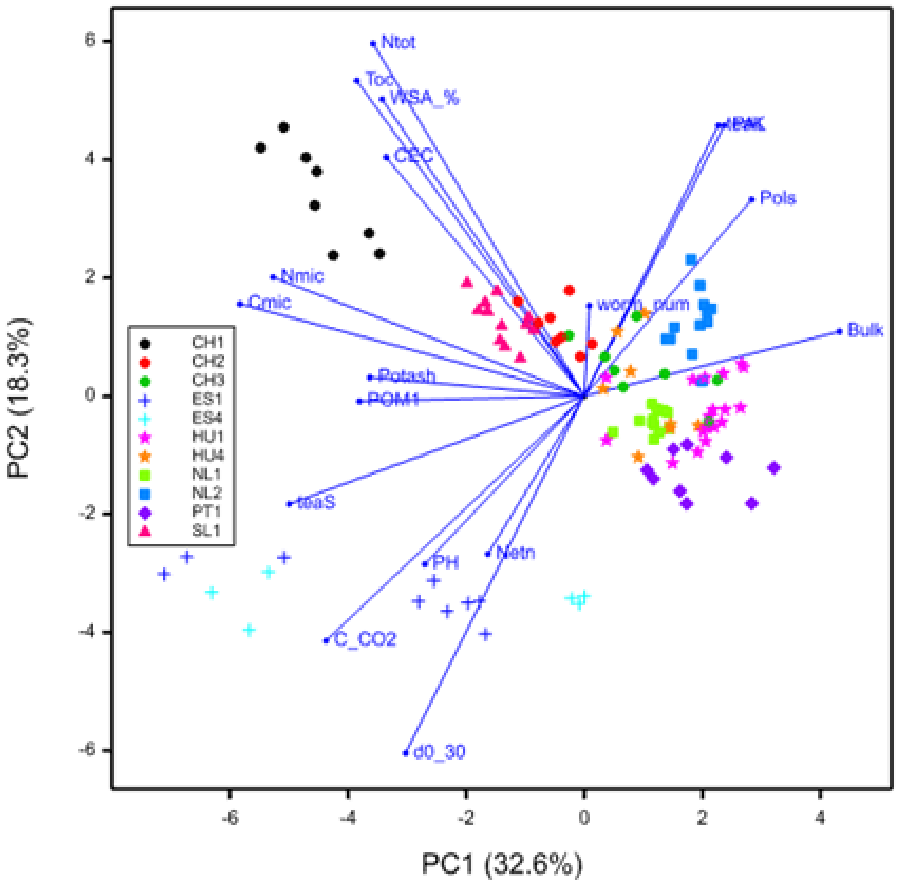


Figure 6. Principal component biplot of a series of parameters from Table 1. The plots from the different LTEs are marked with symbols.

In layer 0 – 10 cm (Figure 7), a separation can be seen between conventional tillage (CT) on the right side of the figure and reduced tillage (RT) on the left side. Within the reduced tillage treatment, high addition of organic matter seems to be more grouped on the left side than low addition of organic matter. The four treatments (CT high, CT low, RT high, RT low) are best distinguished from each other by K-AL (potassium) and POM1, closely followed by P-AL, Nmic, TOC and Ntot. The influence of the parameters Cmic, WSA%, bulk density and TOC/clay seems rather low in this layer. The direction (of the arrows) of the parameters indicates that reduced tillage increases levels of K-Al, P-Al, TOC, Ntot, POM1, Cmic, Nmic and WSA% and decreases bulk density. While the direction of Ntot is almost the same as that of TOC, Ntot seems of less value when TOC is already in the model (the correlation between Ntot and TOC is also high).

The same seems to be the case with Nmic and Cmic (the correlation between Cmic and Nmic is also very high). According to principle component analysis in layer 0 - 10 cm the most important parameters therefore seem to be K-AL, P-AL, POM1, TOC and Nmic.

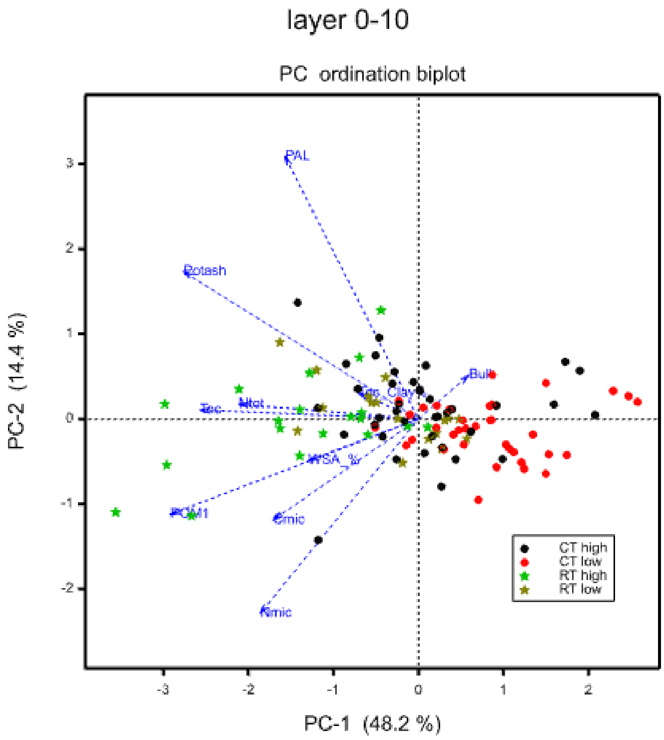


Figure 7. Principal component biplot based on data of all LTEs (with LTE as covariate) for the layer 0-10 cm.

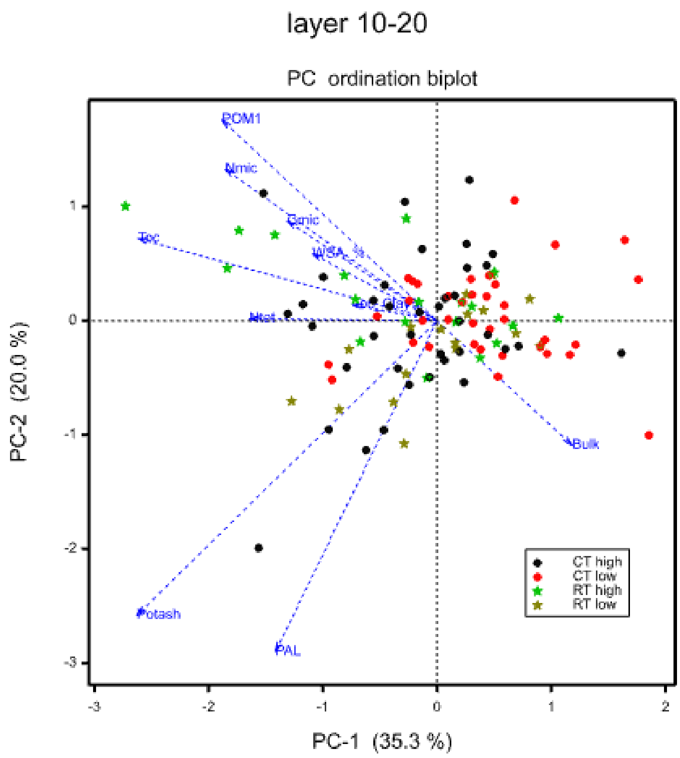


Figure 8. Principal component biplot based on data of all LTEs (with LTE as covariate) for the layer 10-20 cm.

In layer 10 – 20 cm (Figure 8) the separation between the treatments seems less clear than in layer 0 – 10 cm. Nevertheless conventional tillage in combination with low addition of organic matter seems to be grouped more on the right side of the figure and reduced tillage with high addition of organic matter more on the left side of this figure. The four treatments are best distinguished from each other by K-AL (potassium), P-AL, POM1, TOC and Nmic. In layer 10 – 20 cm the influence of bulk density seems higher than in layer 0 – 10 cm. Also in layer 10 – 20 cm the influence of Cmic seems low if Nmic is already in the model. The influence of Ntot, WSA% and TOC/clay seems relatively low in this layer. Therefore in layer 10 - 20 cm the most important parameters seems to be K-AL (potassium), P-AL, TOC, POM1, Nmic and probably also bulk density, while the latter in 0 – 20 cm is more important than in 0 - 10 cm.

Preliminary conclusions

Response ratio analyses of reduced tillage (compared to conventional tillage) and high versus low addition of organic matter showed that the following parameters were the most influenced by management: total nitrogen (Ntot), total organic carbon (TOC), particulate organic matter (POM), potassium (K-AL), phosphate (P-Al), water stable aggregates (WSA) and microbial carbon and nitrogen (Cmic and Nmic, respectively).

According to principle component analysis in both layers (0-10 and 10-20 cm) the most important parameters are K-AL, P-AL, POM1, TOC and Nmic while in layer 0 – 20 cm also bulk density seems to be important.

Outlook

Also in China, several LTEs were identified and collected samples are currently being analysed on the same parameters as the European LTEs. Results of these analyses will be included in the report (D.3.3).

Task 3.4: Screening and evaluation of newly developed indicators of soil quality in long-term trials (Lead partner: FiBL, partners: WU, UE, DLO, IARRP)

The field of soil quality indicators is rapidly developing and there is a need to improve the capacity and methods for assessing soil-management interactions and their impact on soil functions. Newly developed state-of-the-art soil biological, chemical and physical methods will be evaluated using soils from the long-term field trials.

Technologies for characterization of soil biodiversity and functions are rapidly developing particularly relating to microbial community structure analysis, bar-coding of soil fauna, e-DNA (i.e. environmental DNA derived from biological trace materials), functional genes of the N cycle and “soil fatigue”, as apparent from, e.g., the ongoing EU- EcoFINDERS project. Depending on results in TASK 1-3, a battery of newly developed methods to assess soil biotic community structure, using molecular and functional methods, will be used. At the molecular level, amplicons sequencing of fungal communities including mycorrhiza (ITS region) and of bacterial communities (16S region) by NGS (next generation sequencing) are candidate methods. In the glasshouse we will conduct new functional tests to assess soil fatigue, a phenomenon which is mostly related to an increasing incidence of soil-borne pathogens or to pests due to monoculture or short crop rotations.

In addition to standard soil physical and chemical indicators, which will be part and parcel of the proposed research, modern methods, such as NIRS (near infrared spectroscopy for topsoil organic matter and clay mineral assessment), HWC (hot-water extractable carbon for estimation of mineralizable nutrients) and resin methods for assessment of “available” soil nutrients will be evaluated. The focus will be, however, on enhancing biological soil quality assessment in the search for cost-effective indicators that respond more quickly and predictably to environmental and management stress as well as to soil remediation measures.

Because it is well known that arbuscular mycorrhizal fungi (AMF) play key roles for plant growth and nutrient supply to the plants, we will in addition evaluate methods to assess their presence and functioning.

Detailed description of work carried out for this task

Activities

According to the proposal written in the first six months of her PhD work, Giulia Bongiorno is working on the following tasks:

a. Characterization of labile, i.e. biologically active, soil organic carbon by determining:
   i. Concentration and quality of dissolved organic carbon (DOC)
   ii. Concentration and quality of hydrophilic carbon (Hy)
   iii. Permanganate oxidizable carbon (POXC)
   iv. Hot water extractable carbon (HWEC)
b. Soil general suppressiveness test with a model system of *Pythium ultimum* and cress.
c. Characterization of free-living nematode community structure and composition.
d. Community level physiological profiling (MicroResp®).
e. PLFA and enzymatic analysis on a selection of samples.
f. Characterization of fungal community (including mycorrhizal fungi) structure and diversity, and quantification of total bacteria and fungi with molecular methods.

The analyses are done on samples from 10 European long term experiments in five different pedo-climatic zones: Dfb and Dfc continental, Cfb and Csb temperate, Bsk arid (Figure 9).

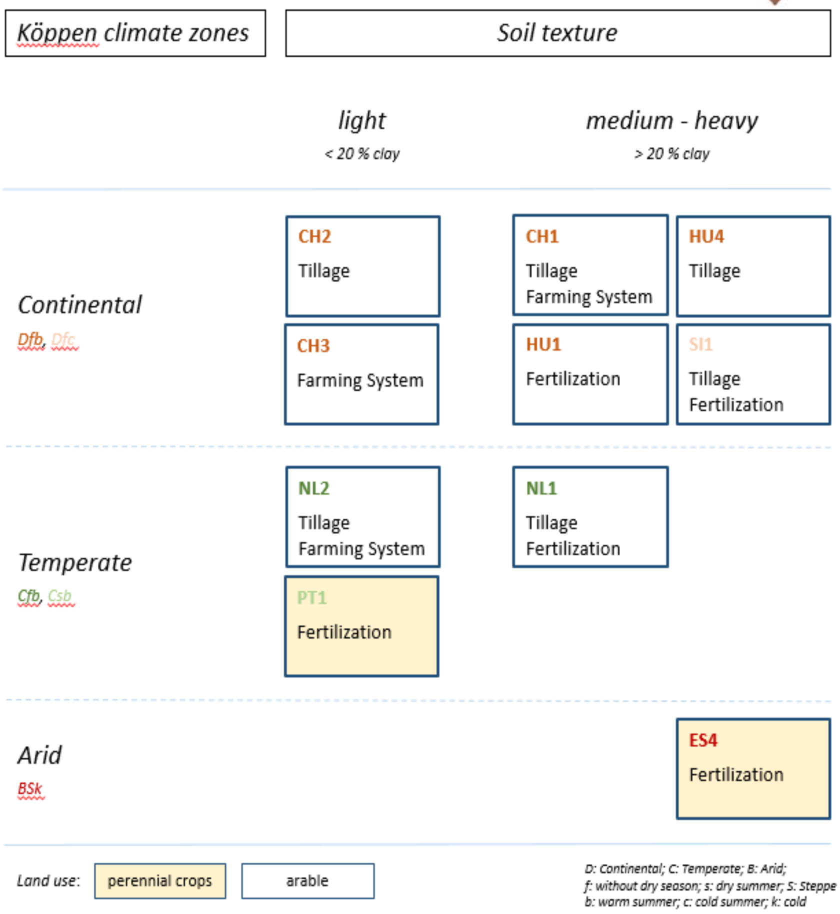


Figure 9: Long-term experiments sampled for task 3.4 grouped according to climate zone and soil texture, with indications on management factors and land use

In order to assess the suitability of the parameters measured as soil quality indicators, Giulia is testing i) their sensitivity to soil agricultural management, and ii) their correlation with the soil quality indicators linked to soil functions which were measured in the frame of WP 3.3. The main agricultural management factors are tillage (conventional tillage versus reduced tillage) and organic matter input (low organic matter input or no organic matter additions versus high organic matter input). In the trials with tillage as management factor, samples were taken from two depths: 0-10 cm and 10-20 cm. In the trials with organic matter input as the only management factor, samples were taken from the 0-20 cm layer.

Current state of activities and results

The following activities are being done:

a. Labile carbon fractions have been measured in all the samples and statistical analysis has been completed. Figure 10 shows the different sizes of the labile carbon fractions in the soil expressed in mg kg^{-1}.

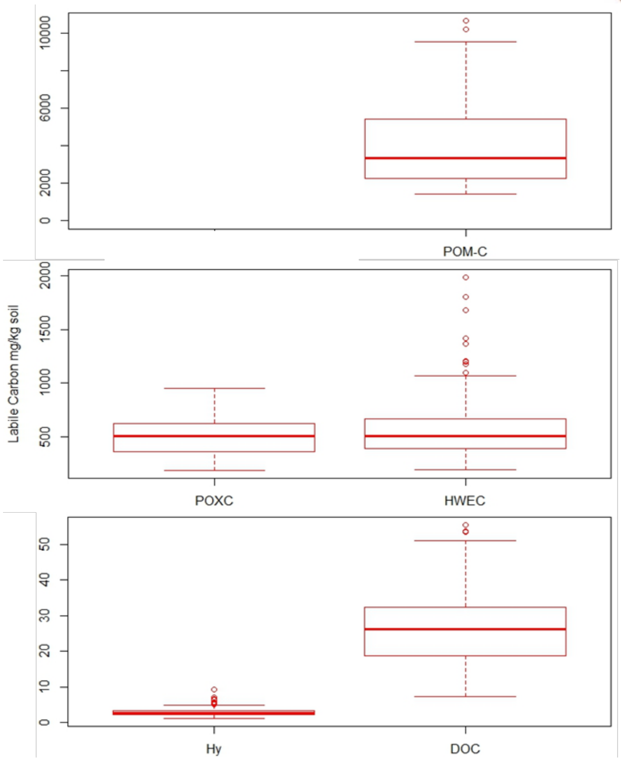


Figure10: Range of labile carbon fractions in 10 LTEs.

Currently, Giulia Bongiorno is writing the manuscript for this part of her project. The results of two overall mixed models show that in general the labile carbon fractions (mg kg^{-1}) had higher concentrations in the reduced tillage plots and in the plots with high organic matter input compared to conventional tillage and low organic matter input, respectively. The fractions compared were: DOC, Hy, POXC, HWEC and POM (the last measured in WP3.3). The fractions which were more affected by the tillage and the organic matter management were POXC and POM (both expressed in mg kg^{-1} and in % of TOC). In an overall analysis we found that the labile carbon stocks of all the labile carbon fractions were increased under reduced tillage and under high organic matter management, but POXC and POM were the most affected fractions (Table 4).

Table 4: Stocks of labile carbon fractions as affected by organic matter and tillage treatments

		Hy	DOC	POXC	HWEC	POM	TOC
0-20 layer				(Mg C ha^{-1})			
LOW-CT		0.009	0.071	1.42	1.78	19	84.5
LOW-RT		0.012	0.093	1.73	2.05	23.2	83.5
HIGH-CT		0.012	0.089	1.70	2.09	24.8	83.6
HIGH-RT		0.013	0.103	1.87	2.25	27.7	82.6
OM	F	13.44	12.7	32	14.28	42.2	0.28
	p	0.0009	0.001	<0.0001	0.0007	<0.0001	0.59
Tillage(T)	F	7.95	5.32	10.7	6.87	13.05	0.17
	p	0.008	0.027	0.002	0.01	0.001	0.67
T X OM	F	3.72	0.84	2.38	0.54	0.7	0.64
	p	0.06	0.36	0.13	0.46	0.40	0.43

We found that POXC was the labile carbon fraction which was most strongly correlated with chemical (TOC, TON, CEC), physical (WSA, WHC, BD) and biological (MBC, MBN, soil respiration, qMic, qCO_2, earthworm biomass and numbers and decomposition measured with the tea bag index) soil quality indicators. POXC was also the labile carbon fraction more correlated to the other labile carbon fractions, indicating its heterogeneity. The general conclusion of this part of the project is that POXC is a sensitive indicator to the studied soil management factors, related to various soil quality indicators linked to functions, cheap and easy to assess and could therefore be used in soil quality assessments in addition or alternatively to other soil quality indicators.

b. The soil general disease suppressiveness tests have been carried out in the 0-10 cm layers for the samples with tillage as the main factor, and in the 0-20 cm layer for the samples with organic matter input as the main factor. Giulia made a preliminary statistical analysis and she is currently writing a first version of the manuscript. Soil suppressiveness has been measured as % of growth reduction of cress plants upon the addition of the pathogen *Pythium ultimum* compared to plants growing in natural soil without pathogen addition. In general, we found that the soil suppressiveness phenomenon was due to biological properties of the soil, the 10 different experiments had different levels of natural disease present in the field and also had different levels of soil suppressiveness.

   The studied soil management had only a weak effect on growth reduction, with only two sites being significantly different in their level of growth reduction in the contrasting management applied. However, we found that growth reduction was correlated with soil chemical parameters related to soil nutrients (TOC, pH, Ca, CEC, available K), soil physical parameters (sand, penetration resistance and WHC), soil biological parameters related to soil microorganisms (microbial biomass and activity) and some labile carbon fractions (HWEC, Hy and POXC). Multiple regression analysis (Table 5) revealed that the most important parameters for explaining soil general suppressiveness across the 10 long term field experiments were microbial nitrogen (MBN) and hot water extractable carbon (HWEC).

Table 5: Multiple regression analysis on the soil parameters related to disease suppressiveness

Dependent variable	Starting model	Model type	AIC	Significant model parameters and related t-value
Growth reduction (%)	Sand, MBN, HWEC, POM, DOC, CEC, bulk density, pH, Mg, Available K, P Olsen, water stable aggregates, C/N, qCO_2, K, available P, Na, long term field experiment (LTE)	Generalized least squares model (allowing for different variance structure for the LTEs)	793	MBN (-3.22), HWEC (-2.4)

Since labile organic carbon resulted to be an interesting parameter from the results presented in the first part of the project described above, we decided to investigate the relationship between the labile carbon fractions and growth reduction (Figure 11). With structural equation model (SEM) we found that the positive influence of the labile carbon fractions, in particular HWEC and POXC, sand and CEC (nutrients) is through their positive influence on microbial biomass which influence microbial activity (measured as soil respiration) which influence negatively growth reduction (or soil suppressiveness).

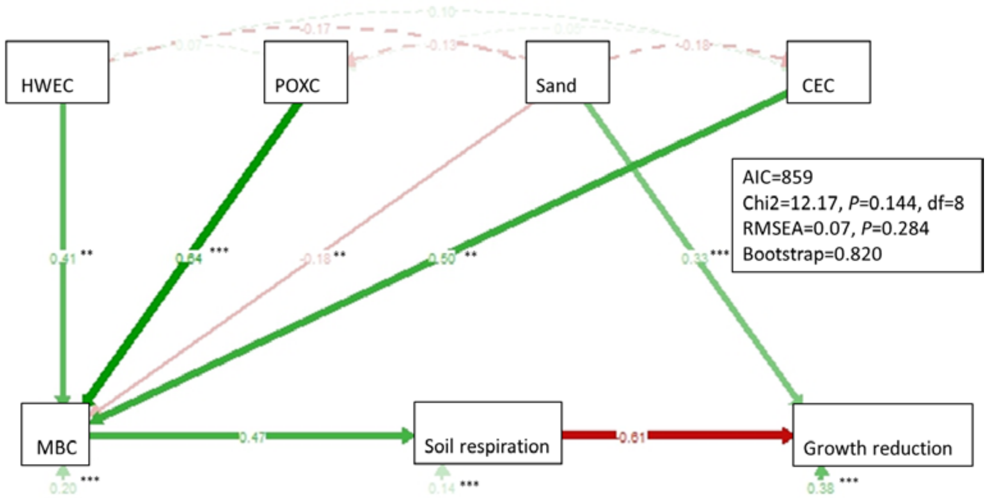


Figure 11: Structural equation model (SEM) to investigate relationships between labile carbon pools, soil parameters and disease suppressiveness as indicated by growth reduction

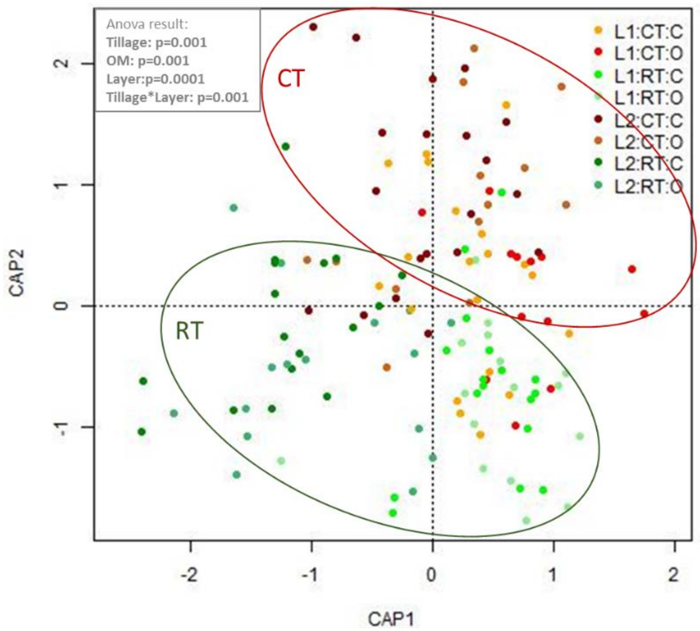


Figure 22: Analysis of nematode community structure

The general conclusion of this part of the project is that soil management had little influence on disease suppressiveness, and each site had a specific capacity to protect plants against the disease. However, microbiological characteristics of the soil related to soil microbial biomass and activity were the most important variables which could explain growth reductions. The same experiment could be carried out with other management practices and pathogens in order to generalize our conclusions.

c. Nematodes have been extracted from soil, total nematode abundance has been quantified with qPCR, and nematode community has been assessed with Illumina sequencing. At the moment Giulia Bongiorno is analysing the data. Total nematode abundance and diversity indexes (diversity, richness and evenness) are mainly affected by the different soil layers but not strongly by the management applied. Regarding the nematode community structure, preliminary analysis shows a difference in community due to the tillage (Figure 12). In the next months, Giulia will finish the analysis of this part of the project and will continue with the writing of the manuscript.

d. Community level physiological profiling (MicroResp®) have been done in all the samples and has to be analysed statistically.

e. PLFA and enzymatic analysis on a selection of samples (CH1, ES4, NL2, HU4 and CH3) have been measured and analysed by Julia Milozcky, a master student from Wageningen University working with Giulia Bongiorno in the fall of 2017.

f. The characterization of fungal community (including mycorrhizal fungi) structure and diversity, and quantification of total bacteria and fungi with molecular methods will start in June 2018.

1.2.4 Work Package 4

Summary

The development of a soil quality assessment tool is the central focus of the project. The tool will be developed in the format of an IT app – Soil Quality app (SQAPP) – running on mobile and/or notepad devices to facilitate in-field data collection. The app will be designed such that it can either be used stand-alone or allow connection with a server in the cloud where an extensive database will inform the SQAPP user immediately about the state of soil quality and recommended measures for improvement (these recommendations will follow from analysis in WP6). The app will accommodate operation at different levels of complexity, starting off with a minimum data set of easily observable/measurable indicators (WP3) which can be extended when more detailed data are available. At the same time, data submitted to the server can be used to inform aggregate soil quality monitoring. However, the user will be in control regarding data sharing. Some web-based functionality may only be available to users sharing data, e.g. regional reference values may depend on user contributions and as such could be regarded as premium content for those who do. This WP internalises all activities directly geared towards development of the app, while strong linkages to other WPs will ensure iterative improvements to the app.

Specific objectives are:

1. Lay out the specifications of SQAPP design and functionality at different levels of complexity (Task 1);
2. Develop a first release of SQAPP (Task 2);
3. Analyse first release performance and upgrading of SQAPP (Task 3);
4. Rolling out Beta-release and web-based data platform across Europe and China (Task 4);
5. Release of final SQAPP based on feedback of users of Beta-version and expert judgement (Task 5).

Detailed description of work carried out for each task

Task 4.1: Specifications of SQAPP design and functionality at different levels of complexity (Lead partner: WU, partners: UNIBE, MEDES, ISRIC, DLO, ICPAC, ESAC, IARRP, UP, ISS)

This task entails intensive collaboration between researchers, intended end-users and software developers to define, from the outset, what the most important functionalities are for the soil quality assessment app at different levels of complexity, so as to outline how the app and underlying database architecture should be structured. The idea is here to lay out a full palette of possible functionalities and options to accommodate any demand for development or later extension of the app as end-user needs or technological capabilities increase, allowing for use with a minimum set of easily observable indicators as well as more complex operation if more detailed data is available. This task will for a major part run simultaneously with Task 2 to ensure the functionalities can accommodate the requirements from the content-side. Activities to complete this task successfully will comprise a review of existing (partial) apps, evaluation of existing tools with both developers and end-users of those tools, defining technical specifications of hardware, and assessment of costs versus functionality.

To arrive at the pilot version of the soil quality assessment tool, intensive collaboration between researchers, intended end-users and software developers was established to define, from the outset, what the most important functionalities are for the soil quality assessment app at different levels of complexity, so as to outline how the app and underlying database architecture should be structured. The underpinning idea was to lay out a full palette of possible functionalities and options to accommodate any demand for development or later extension of the app as end-user needs or technological capabilities increase, allowing for use with a minimum set of easily observable indicators as well as more complex operation if more detailed data is available. These discussions were run simultaneously with the development of the first version of the app to ensure the functionalities can accommodate the requirements from the content-side. To define the desired functionality of the app, a review of existing apps was made, and wishes from different potential end-users inventoried. Furthermore, the technical specifications of hardware were considered, and an assessment of costs versus functionality was made.

The review of existing soil quality apps was structured in 7 categories based on the type of information each of the existing apps provides, and for what purpose (Table 6):

1. **Apps providing the user with access to soil data;** these apps mainly focus on giving the user easy access to existing soil data, whether at global or regional level. Communication in these apps is one-directional (information provision only), and the focus is on soil data itself, not on management advice.
2. **Apps building interactive soil datasets;** the mySoil app provides access to soil data, but also explicitly aims at validating such data by users to create better soil data ('citizen science').
3. **Apps informing the user about relative soil quality scores;** the SIFSS (Soil Information for Scottish Soils) app of the James Hutton Institute not only gives the user an indication on soil indicator scores, but also whether such scores are relatively high or low for particular soil types. The user can also enter their own soil indicator data. Moreover, (relative) scores can be shown for cultivated or semi-natural soils. There is no clear link to management advice, although it is stated that is important to maintain properties such as pH, carbon content, loss on ignition and calcium content, which all affect plant growth, at optimum levels.
4. **Apps providing management advice on a single soil quality aspect;** SOCit provides advice on how to increase soil carbon sequestration. Soil organic carbon content (SOC) is an important indicator of soil quality, but overall the scope of an app focussing solely on SOC is rather narrow when considering soil quality.
5. **Apps facilitating data collection for commercial (soil) management advice;** these apps facilitate the link to providing commercial soil management advice, either through managing the process of soil sampling and processing of laboratory analyses (Soil test pro) or through the use of a device (Soilcares Soil Scanner) that can take readings in-situ of which the results are analysed using an online database outputting tailored management advice. While there are more examples of the first type of app, they are not free to use and merely streamline soil information provision based on soil sampling. The Soil Scanner is an innovative soil information collection system, but has as a drawback that it needs upfront investment in the device and subscription to an annual licence fee to get advice.
6. **Apps guiding the user through self-assessment of soil quality;** the Capsella SoilApp and LandPKS are intended to guide users through a self-assessment of soil quality (on quite different grounds, a spade-test and a landscape assessment respectively). Both apps allow users to share and learn from other users submitting their assessments. While some information is partially prefilled, the apps are not providing users with an instant answer to their questions but provide guidance instead.
7. **Apps establishing cross-stakeholder collaboration for soil improvement;** finally, the CarbonToSoil app offers brokering capabilities in addition to soil information: the idea here is to bring together farmers that are willing to manage their soil more sustainably, and users willing to contribute payment to support that.

Overall, when looking at the existing soil apps, they mainly are intended to provide information about the soil. There is limited focus on providing management advice on improving soil quality, and if such focus exists, it is either narrowly focused on particular aspects of soil quality (SOC), or requires payment of a fee. Moreover, none of the reviewed apps explicitly considers soil threats and management advice on how to mitigate them. Thus, our ISQAPER aim to develop a mobile app, referred as Soil Quality Assessment Application (SQAPP) by integrating existing soil quality data consisting of a range of physical, chemical and biological soil quality indicators and associated soil threats is found to go beyond functionalities currently offered by existing soil apps. Moreover, based on the information of soil indicators and soil threats, the SQAPP will provide recommendations on how to improve soil indicators and combat soil threats.

Table 6. Categorisation of existing soil apps.

Apps providing the user with access to soil data SOIL INFO soilmapp Soilscapes	**Apps building interactive soil datasets** my Soil	**Apps informing the user about relative soil quality scores**
Apps providing management advice on a single soil quality aspect QMS QUALITY MEAT SCOTLAND	**Apps facilitating data collection for commercial (soil) management advice** SoilTestPro	**Apps guiding the user through self-assessment of soil quality** LandPKS
Apps establishing cross-stakeholder collaboration for soil improvement		

An inventory of information needs of stakeholders concerning soil quality and selection of innovative practices was made based on Milestone 5.1. A summary of the findings is given in Table 7. We distinguish four broad categories of information needs:

1. **Soil information;** Many stakeholders, ranging from individual farmers to high-level policy makers, expressed a need to have better information about soils. Many of the interviewed stakeholders displayed a keen interest in comparative soil quality data, i.e. the need to know more about the management-varying part of soil quality. There was also widespread interest in broader information about how soils are currently managed, how soil quality can be assessed, what the environmental impacts of agriculture are, and how biological soil quality can be suitably assessed.
2. **Management advice;** the second category related to a widely felt need to get advice on how to improve soil quality. A long list of topics was brought up: measures to improve soils, measures to mitigate soil threats, advice on how to enhance environmental and economic outcomes of farming, and advice on how to most effectively use rainfall in drought-prone environments. Such advice was not only requested by farmers, but also identified by other stakeholders such as extension agents, researchers, environmental NGOs and policy makers as important.
3. **Awareness raising and education;** although this need is of a higher abstraction level, it was reiterated by many interviewees that in order to change unsustainable soil management practices, awareness and education about the functioning of soils and what constitutes good soil management is critical. This awareness raising is a cross-cutting theme across the stakeholder landscape, from individual land users deciding about their land management systems and practices to policy makers making the rules and regulations about soil management.

Table 7. Categorised multi-stakeholder information needs

Soil information • Comparative soil quality data • Information on land management • Information about soil quality indicators • Information about the environmental impacts of agriculture • Biological soil quality indicators	**Management advice** • Information about soil improvement practices • Information about measures to mitigate soil threats • Information about opportunities for sustainable intensification • Fertilization advice • Increasing economic return • Effective use of rainfall
Awareness raising and education • Knowledge development about soils and environmental protection	**Procedural** • Opportunities for information exchange • Quick assessment of soil indicators/soil threats • Faster knowledge transfer • Quick advice on soil management • Methods for soil quality assessment

Source: based on multi-stakeholder inventories in the iSQAPER Case Study sites (Milestone 5.1).

4. **Procedural;** a final need expressed by multiple stakeholders was more procedural in nature: how to exchange information about soils and innovative agricultural management practices? How to get a quick assessment of soil quality and soil threats? These needs confirmed the notion that developing a soil quality app would have added value in facilitating widespread procedural issues.

Based on the performance of soil quality indicators in existing indicator systems (WP3) and experience with such systems in specific combinations of farming systems and pedo-climatic zones (WP2) the most promising indicators to be included in SQAPP were identified. Farming systems and pedo-climatic zones were considered to define the agricultural management practices possible in a given context.

Task 4.2: Developing of first release of SQAPP (Lead partner: WU, partners: JRC, ISRIC, UP, ISS)
Based on the performance of soil quality indicators in existing indicator systems (WP3) and experience with such systems in specific combinations of farming systems and pedo-climatic zones (WP2) we will identify the most promising indicators to be included in SQAPP. Farming systems and pedo-climatic zones are likely to have a large impact on the usefulness of specific indicators, such that a modular approach is envisaged. The pilot app (D4.1) will consist of a minimum data set to be applied universally, with modular add-on functionalities based on location (linked to pedoclimatic conditions and land use). With the data collected in WP2 and WP3, a first release of the app will be produced that will subsequently be tested in the field with stakeholders (WP5). When compiling and connecting the various indicators, information gaps will be identified that will be fed back to WP3 for further exploration.

The SQAPP was designed with the idea that it should provide the user with the opportunity to access fragmented data on soil quality and soil threats in an easy-to-use way. Moreover, the user should not only receive indicator values, but be guided in interpreting these values by providing more contextual information: is a certain indicator value high or low in a given context? Such contextual information is provided through analysing indicators within combinations of climate zones and soil types, and by distinguishing between arable land and grazing land. Finally, the user should receive, based on an assessment of the most critical issues, management recommendations on how soil quality can be improved and soil threats be overcome.

A second consideration in designing SQAPP was the idea to use soil quality and soil threat indicators for which spatial data exist. This way, it is possible to provide the user with data for any indicator for which data exist for a given location, in combination with the comparative contextual information. The comparative aspect of the soil indicator data is then realized by calculating cumulative probability density functions for each pedo-climatic zone. All indicator values are given as ‘best guestimate’ for the location. The user can proceed with generating management recommendations based on these standard values, or replace some or all indicator values with own data to get more accurate recommendations. This design helps to make the SQAPP directly helpful by visualizing available soil information in a systematic and easy-to-access way.

Thirdly, the SQAPP recommends agricultural management practices to improve soil quality and/or mitigate soil threats based on an integrated assessment of the aspects most urgently needing attention. This integrated way of considering soil quality indicators is new in comparison to existing soil apps and indicator systems. This integration avoids consideration of poor single indicator scores in isolation, which could have trade-offs with other soil quality indicators that are also suboptimal.

Fourthly, although the iSQAPER project focuses on Europe and China, it quickly became clear that the amount of work required to develop SQAPP would be more appropriately justified by building an app with global coverage. This inclination to go global was reinforced by some hurdles experienced along the way to harmonise European and Chinese data (see below). As a consequence, the pilot app was designed with global functionality in mind.

The overall procedure to develop SQAPP is given in Figure 13. These steps include:

1. Selecting soil quality indicators; based on the review of soil quality indicators in WP3 (Caspari & Bai, 2015; Bünemann *et al.,* 2018; Bai et al., 2018), a selection of the most commonly used was made. For these indicators, we examined availability in terms of global datasets. All relevant indicators for which maps existed were retained as input data layers (see Section 5). Similarly, maps of soil threats were reviewed. Here, were available global datasets were used; in Europe some further soil threats were included based on soil threat maps with European coverage.
2. Defining pedo-climatic zones; as one of the principles underpinning SQAPP is a relative assessment of soil indicators, appropriate zones with similar conditions need to be defined. Within WP2, pedo-climatic zones were developed for both Europe and China (Deliverable 2.1). As the basic climate zones distinguished in these classifications were not comparable and because there were some conversion issues to reclassify Chinese soil types to WRB (World Reference Base) soil types, the resulting pedo-climatic zones in Europe and China were not directly comparable, and moreover, did not cover other areas of the world. This became an issue for calculating relative soil indicator scores at global level. To resolve this issue, a new pedo-climatic zonation was produced within WP4 for the purpose of calculating consistent data layers for the app.
3. Ranging soil quality indicators; once indicators are selected and pedo-climatic zones are defined, it is possible to calculate cumulative probability density functions for each indicator in each pedo-climatic zone. These cumulative probability density functions become the basis for the relative assessment of soil quality. Moreover, within each pedo-climatic zone, attention also needs to be paid to the land use/cover, as land use is known to greatly influence the indicator scores of several soil indicators. To account for this issue, separate calculations are made for the minimum and maximum scores of each indicator in each pedo-climatic zone, specific for arable and grazing land respectively.
4. Scoring indicators; the relative scores of soil property values are considered based on their position on the cumulative probability density curves. That means (considering whether indicators are of the ‘more is better’ or ‘more is worse’ type), that the bottom 33% of the

frequency distribution are considered as low, and the top 33% as high, with medium the outcome for intermediate values. For soil threats, absolute, expert-based values were considered based on the work conducted in WP6 (Milestone 6.2).

5. Assessing indicators; this step concerns the calculation of the potential for soil improvement (percent score) across all soil property indicators, and the calculation of the average soil threat level (on a bar slider between low and high). The top-3 poor performing soil property indicators and top-3 soil threats are considered as the most urgent aspects to be addressed.
6. Recommended practices; the final step in the SQAPP is to recommend agricultural management practices based on the overall soil quality score and most urgent soil quality aspects to be addressed. Underlying the recommendations is the development of a large matrix table of the agricultural management practices and a) applicability factors – defining where each of the AMPs is applicable; and b) effectiveness – where the impact on soil property and soil threat indicators of each AMP are scored. The 10 AMPs reaching the highest overall score for the combination of soil properties and soil threats to be addressed in a given location are presented to the app user.

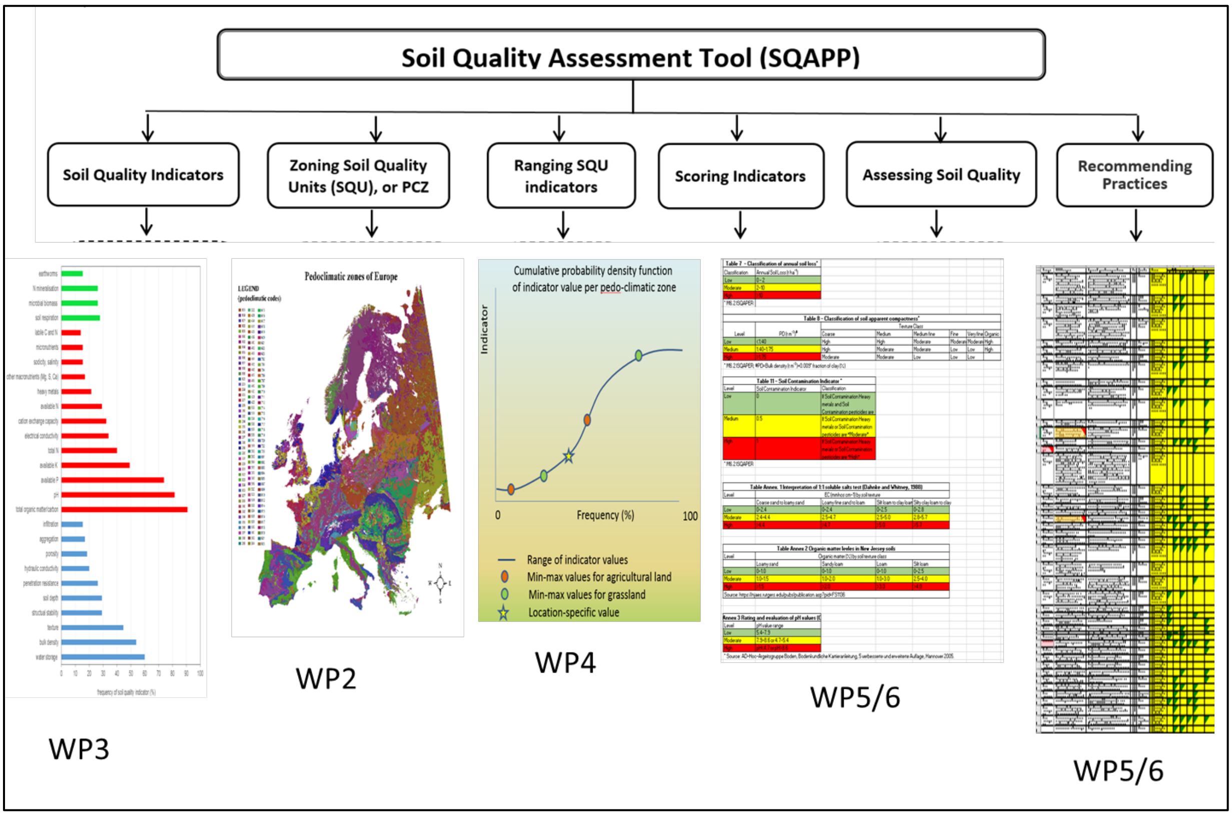


Figure 13. Overview of the procedures followed to develop the pilot version of SQAPP, including links to different work packages

Task 4.3: Analysis of first release performance and upgrading of SQAPP (Lead partner: WU, partners: FiBL, UNIBE, MEDES, ISRIC, DLO, ICPA, ESAC, UMH, IARRP, UP, ISS)

In this task results and feedback from the application of the first release of the app in WP5 will be analysed to assess the performance of, and user experience with the app. Information from different land users in case study areas will be used to improve the pilot app; the field application of the app is likely to confront it with a range (combinations) of conditions which needs to be analysed for a) indicator ranges for which the app has been designed; b) correlations between multiple indicator scores; and c) consistency of soil quality assessment and recommendations across farming systems and pedoclimatic zones. This activity will also be aided by availability of analysis from long-term field trials (WP3). In addition, under this task we will be able to define local benchmarks for different combinations of farming systems and pedoclimatic zones, such that soil quality indicator scores are contextualised for the range of local conditions and best possible scores can be set as reference levels. This analysis, which will be adapted to relevant scale depending on data availability, will be integrated into the development of a Beta-release of the app for broad testing (Task 4).

As we took a different route to testing the app – focusing on internal feedback first to tackle the major issues with the pilot version of the app before asking stakeholder feedback (to avoid negative user opinion risking a decline in stakeholder interest in the app while it is still in a premature stage), Deliverable 5.1 on stakeholder feedback on the app is delayed. We are now soliciting user feedback on the beta-version of the app rather than the pilot version as originally planned. Analysis of the experiences will hence be considered in modifying the final version of the SQAPP.

Task 4.4: Rolling out Beta-release and web-based data platform across Europe and China (Lead partner: WU, partners: JRC, ISRIC, ISS)

Given the experience with the first release of SQAPP (Task 2) and upgrading and further contextualising of the app in Task 3, in this task we will roll out a Beta-release and web-based platform of the app across Europe and China. This will allow widespread testing of the app beyond the partners in the immediate consortium, offering the potential to truly test the app across a pan-European and pan-Chinese range of conditions. This version of SQAPP will also be employed in on-farm experiments to test the usefulness of the tool to monitor soil quality improvement (WP6). Apart from developing the app and promoting it (in WP9), this task will also design a web-based data platform to systematically process experiences and feedback from users willing to share data and feedback centrally. The rolling out of the Beta release and web-based data platform will be an important Milestone of the project and will allow extensive testing of the system to feed into the development of the final version of the app (Task 5).

A beta-version of SQAPP was released following the design laid out in Deliverable 4.1. A range of soil property and soil threat indicators for which global and continental data exist were selected and their distributions calculated over pedo-climatic zones. Pedoclimatic zones were defined based on the overlay of climate zones (Peel et al., 2007) and the SoilGrids soil classes predicted based on the World Reference Base (WRB) and USDA classification systems with covariates of ca. 280 raster layers in total (Hengl et al., 2017) resulting in 118 soil classes. This leads to 29 x 118 = 3422 potential combinations, of which 2098 indeed have overlap and were defined as pedo-climatic zones. Calculating the cumulative probability density functions and minimum and maximum soil indicator values for each property for each pedo-climatic zones is very computationally intensive and takes several months of calculations on a high performance server (each global data-layer at 250 m resolution has a size of over 11 Gb).

The following data sets were used for building the pilot version of the SQAPP:

- Soilgrids (www.soilgrids.org), at 250 m resolution, has been used for the following soil parameters with global coverage: absolute depth to bedrock, bulk density, texture, available soil water capacity, soil organic carbon content, cation exchange capacity, soil pH and its derived soil acidification. For further information on SoilGrids see the paper by Hengl et al. (2017).
- European Soil Data Centre (ESDAC) (https://esdac.jrc.ec.europa.eu/ - Panagos et al., 2012) has been used for the following soil threat data with European or global coverage: soil erosion by water (Panagos et al., 2015), soil erosion by wind (Borrelli et al., 2017), susceptibility to soil compaction (Houšková and Van Liedekerke, 2008), soil contamination (Rodriguez Lado et al., 2008). Global Soil Biodiversity Atlas Maps have been used for the following soil biological data: global estimates of soil microbial abundance and soil macrofauna (Serna-Chavez et al., 2013), and soil macrofauna data (courtesy of Dr Jerôme Mathieu of University Pierre and Marie Curie, Paris VI, manuscript in preparation).
- Global Soil Dataset for Earth System Modelling (http://globalchange.bnu.edu.cn/research/soilw) has been used for: electrical conductivity, exchangeable potassium, phosphorus using Olsen method, and total nitrogen (Shangguang et al., 2014).

In SQAPP agricultural management practices are recommended in response to the underperforming soil properties and most important soil threats. To define the practices two steps were taken: 1) establishing a classification of agricultural management practices; 2) establishing an expert-opinion based matrix table of the applicability and effectiveness of AMPs. The final recommendation is made based on simple additive scoring. A total of 84 AMPs has been distinguished. The applicability limitations and effects of these AMPs on soil properties and soil threats are established in a matrix. The selection of AMPs on the basis of this matrix to generate recommendations is exemplified in Figure 14.

Identified problems:	Lists of options (~80 AMPs)		
	AMP1	AMP2	AMPx
Physical properties			
Plant-available water storage capacity (mm)	0	0	1
Soil organic carbon content (%)	1	-1	1
Soil threats			
Soil erosion by water *- Soil loss (t/ha/year)*	0	1	1
Soil compaction *- Natural susceptibility (low, medium, high)*	1	-1	0
	Total: 2	Total: -1	Total: 3
Rank:	**2**	**3**	**1**

Figure 14. Example of the ranking of different AMPs for a given set of identified problems.

The beta-version of SQAPP was released on Google Play and Apple Appstore. Figure 15 includes some screenshots from the SQAPP.

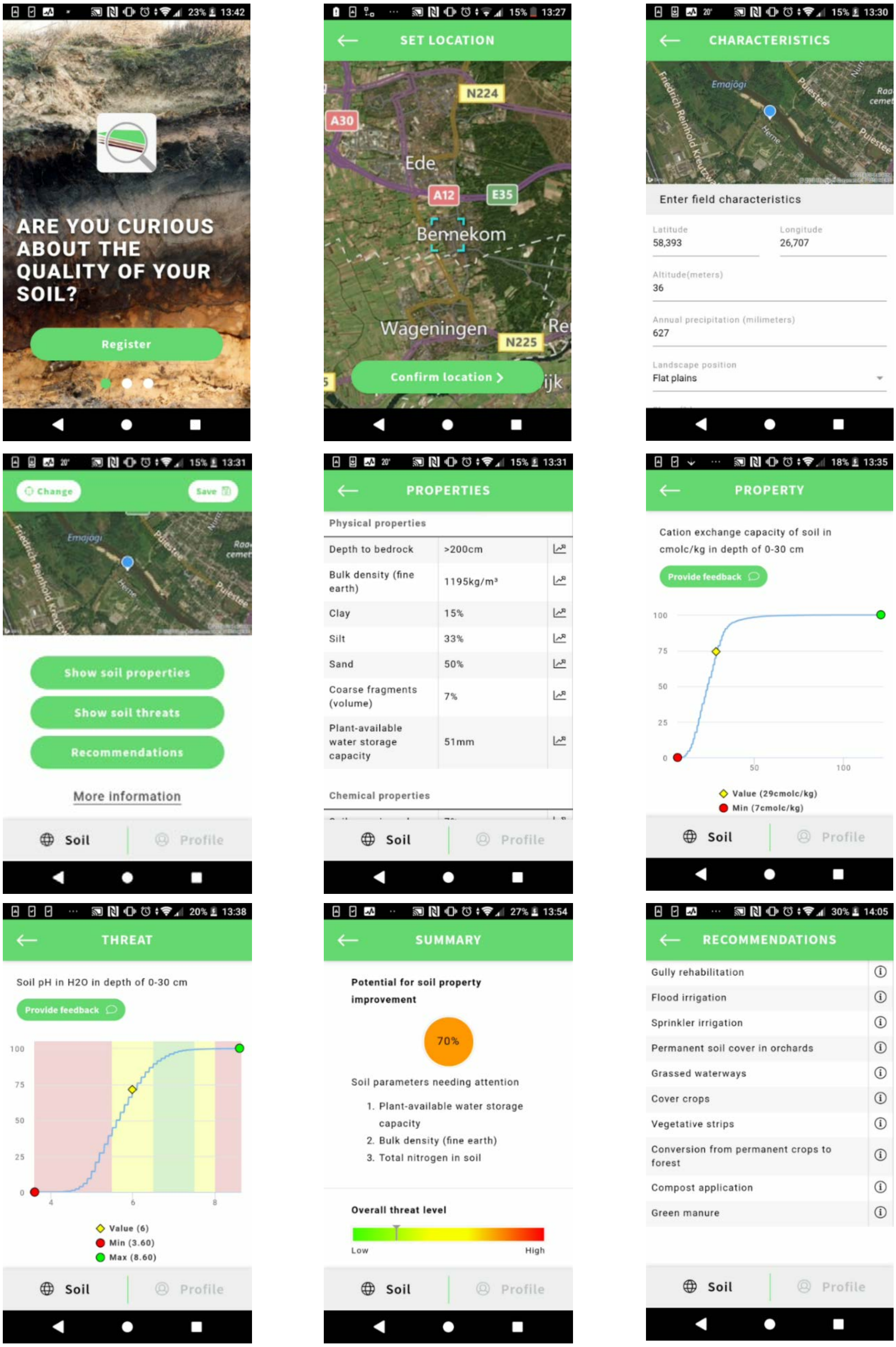


Figure 15. Screenshots of the beta version of SQAPP.

1.2.5 Work Package 5

Summary
WP5 will link applied agricultural management practices to the soil quality status in the Case Study Sites and select innovative practices together with stakeholders. Associating changes in soil quality with agricultural management practices is a challenge due to slow responsiveness of soil characteristics, and can therefore only be approximated by comparing different management practices applied under identical pedo-climatic conditions. The generation of a soil quality inventory at the Case Study Site level will provide the framework to test the alpha-release version of the SQAPP. The testing will be done in collaboration with multiple actors, such as farmers, agricultural advisors, local staff of government and research institutions and soil specialists. With the help of these actors, currently applied and promising agricultural management practices will then be identified, documented and assessed holistically (i.e. regarding their economic, ecological and socio-cultural impact). This assessment will in turn provide the criteria to select innovative practices, or the basis to develop new ideas for management improvements respectively. The WP follows a trans-disciplinary as well as interdisciplinary approach in order to include the broadest expertise and perception of soil quality and agricultural management practices as possible, and to make sure the SQAPP will be truly relevant for application in practice. The activities in this WP are to: i) apply and test the soil quality assessment tool with a variety of actors; ii) make an inventory of soil quality status and applied soil management practices in case study areas; and iii) select innovative agricultural management practices improving soil quality. Deliverables will include i) a report on stakeholder feedback to the soil quality assessment tool (TRL5); ii) a soil quality inventory of Case Study Sites; and iii) a database of currently applied and promising agricultural management practices (TRL5).

The main objective of WP5 is to link applied agricultural management practices to the soil quality status in the Case Study Sites, and select innovative practices together with stakeholders. Due to the mostly slow responsiveness of soil characteristics to management changes, improvements in soil quality are often only observable over a longer period of time (i.e. several years). However, an initial inventory of current state of soil quality at the Case Study Sites at an early stage of the project will enable measuring selected impacts of changed management (in WP6) towards the end of the project. At the same time, the generation of such a soil quality inventory at the Case Study Sites level will provide the framework to test the alpha-version of the SQAPP developed in WP4. The testing will be done in collaboration with multiple actors, such as farmers, agricultural advisors, local staff of government and research institutions, soil specialists, and others. With the help of these actors, currently applied and promising agricultural management practices will then be identified, documented and assessed holistically (i.e. regarding their economic, ecological and socio-cultural impact). This assessment will in turn provide the criteria to select innovative practices, or the basis to develop new ideas for management improvements respectively. These will then be tested in WP6.

WP5 follows a trans-disciplinary as well as interdisciplinary approach in order to include the broadest expertise and perception on soil quality and agricultural management practices as possible, and to make sure the SQAPP will be truly relevant for application in practice.

Specific objectives are:

1. To apply and test the soil quality assessment tool with a variety of actors (Task 1);
2. To make an inventory of soil quality status and applied agricultural management practices at the Case Study Sites (Task 2);
3. To select innovative agricultural management practices improving soil quality (Task 3);

Milestones and deliverables so far achieved:

- M5.1 Actors to be included in Case Study Sites identified [Month 10] *In collaboration with Heleen Claringbould (CorePage).*
- M5.2 Selection of innovative agricultural management practices to be evaluated in WP6 [Month 24].
- D5.1 Soil quality inventory of Case Study Sites [Month 38] was achieved and constitutes the most important of the results presented in this periodic report.

Details for each Task

***Task 5.1: Multi-stakeholder testing of the soil quality assessment tool* (Lead partner: UNIBE, partners: WU, UPM, MEDES, CorePage, Case Study Site partners)**

In order to test the SQAPP developed in WP4, the tool will be applied by multiple stakeholders on farmers' fields within the Case Study Sites. Relevant stakeholders will be specified for each Case Study Sites at the beginning of the project. The testing will be done in a systematic way, using standardized protocols to identify data quality as well as benefits and disadvantages of different aspects and features of the tool. WP5 will also facilitate the capturing of ideas for tool enhancement from a variety of potential users and other stakeholders, such as within multi-stakeholder workshops at the case study sites (see Task 3). The testing of the SQAPP will be an iterative and repeated process throughout the tool development phase.

***Task 5.2: Soil quality and agricultural management practices inventory at case study sites* (Lead partner: UNIBE, partners: JRC, UE, ISS, Case Study Site partners)**

While testing SQAPP at the case study sites, an inventory of the current status of soil quality can be compiled. This inventory will be done across a representative number of fields across the main pedo-climatic zones apparent in the Case Study Site. Additionally, comparing the soil quality status with farmers' interviews about their historical changes in management will help to identify those management practices which have improved soil quality. Whether the latter is indeed the case will thus be assessed based on stakeholder observation and perception of changes. Comparison of soil quality status under different agricultural management practices within the same pedo-climatic zone will help to derive those practices which have a relevant impact on soil quality.

Promising land management practises thus result from identifying those practices, which are applied on healthy soil or have improved the soil quality status markedly. Using the standardized WOCAT framework for documentation and evaluation of Sustainable Land Management (SLM) technologies (see www.wocat.net/en/methods/slm-technologies-approaches.html), 3-5 of these practices per study site will be recorded. The framework enables to describe the details of the land management practices, including costs of implementation and maintenance, and provides a comprehensive list of economic, ecological and socio-cultural benefits and disadvantages, including off-site impacts.

Task 5.3: Selection of innovative agricultural management practices **(Lead partner: UNIBE, partners: UE, UPM, Case Study Site partners)**

The global WOCAT database of SLM technologies provides the platform to share experience of agricultural management practices across the case study sites, as well as globally. The selection of innovative agricultural management practices will be guided by the documented existing practices across the project study sites and from other comparable sites within the WOCAT database. A search interface for the WOCAT database will integrate with the soil quality assessment tool and will facilitate the search. Potential innovations do not only refer to new practices, but equally to variations of existing, well proven practices. In order to identify new or 'improvable' practices, a structured process of joint selection and negotiation within a multi-stakeholder participative workshop will be conducted at each case study site. The workshop will be designed to provide the creative environment that enables to develop new ideas for management improvements and allows innovations to flourish. The soil quality improvement potential of selected practices will subsequently be tested in WP6.

A summary of carried works is given in **Table 8**. With regard to timing of deliverables and milestones, the first milestone (M5.1, Identification of actors to be included in Case Study Sites) was delivered according to the expected time (Month 10).

Table 8. *Description of the tasks to carry out during the project-time life and their corresponding deliverable time; accomplished work is given in the shaded rows*

		Description	Month
Deliverables	D5.1*	Report on stakeholder feedback to soil quality assessment tool	32
	D5.2	Soil quality inventory of Case Study Sites	38
	D5.3	Database of currently applied and promising agricultural management practices	48
Milestones	M5.1	Actors to be included in Case Study Sites identified	10
	M5.2	Selection of innovative agricultural management practices to be evaluated in WP6	24
	M5.3*	Stakeholder feedback ready for SQAPP improvement	28

**Work not yet done since the first version of the SQAPP was not developed in time (see 5. deviation from annex 1)*

Milestone M5.1 *Actors to be included in Case Study Sites identified*

The milestone M5.1 was carried out in close collaboration with CorePage (Heleen Claringbould).

Milestone M5.2 *Selection of innovative agricultural management practices (AMPs) to be evaluated in WP6 (Month 24)*

This Milestone is an essential prerequisite for Task 1 of WP6 consisting in the selection of sites for testing, evaluating and demonstrating of selected 'soil improving' measures. On the basis of the literature review, the AMPs existing at the case study sites, and comparable sites within the WOCAT database, we have established 19 innovative AMPs aiming to include the broadest expertise and perception of soil quality and agricultural management practices as possible. The implementation of the innovative AMPs was based on the criteria of improving soil quality for comparable pedo-climatic zones considered in the project and covering all study sites across Europe and China.

Deliverable D5.2 *Soil quality inventory of Case Study Sites (Month 38, in progress)*

Although that **Task 2** is planned for Month 38, a questionnaire for the evaluation of the impact of the innovative AMPs on soil quality of the selected Study Sites and a related manual were carried out and sent to the Study Site Leaders already on month 17. The manual gives a clear and precise description on how to assess the indicators of soil quality based on Visual Soil Assessment Methodology (VSA). The questionnaire was successfully applied by all Study Site Leaders and we have received the first results that we used for this deliverable . This exercise served as a test for further improvements and an improved version of the questionnaire that includes plant indicators was sent to the Study Site Leaders in April 2018 to be used for the assessment of soil quality in 2018 (**Table 9**). First results are presented below.

Table9. *Baseline information and indicators included in the new version of the questionnaire for soil quality assessment planned for 2018*

Baseline information	Surface ponding
	Susceptibility to wind and water Erosion
Soil indicators	Soil structure
	Soil porosity
	Soil stability
	Topsoil compaction
	Subsoil compaction
	Number and colour of soil mottles
	Earthworm count
	Degree of clod development
	Soil colour
	pH
	Labile organic carbon
Plan indicators	Crop yield
	Size & development of the root system
	Root diseases
	Weed infestation
	Soil fauna
	Environmental Exposure to Pesticides (EEP)

Clearly significant results and (preliminary) conclusions

Results show that among 138 sets of paired plots, 104 pairs (75.4 %) show a positive impact of promising agricultural management practices on soil quality, 20 pairs (14.5 %) do not show any difference in soil quality between soils under promising practices and soils in the control plots, and the remaining 14 plots (10.1 %) show an inverse effect. When considering Europe, 82 sets of paired plots (73.2%) (22 or 84.6%, for China) show a positive impact, 19 pairs (17%) (1 or 3.8% for China) do not show any difference in soil quality, and the remaining 11 pairs (9.8%) (3 or 11.5% for China) show an inverse impact (**Table 10**).

Table 10. *Summary of the impact of the implementation of the selected AMPs on soil quality in Europe and China*

Impact	Total plots (138)		Plots in Europe (112)		Plots in China (26)	
	Absolute value	(%)	Absolute value	(%)	Absolute value	(%)
Positive	104	75.4	82	73.2	22	84.6
No effect	20	14.5	19	17.0	1	3.8
Inverse	14	10.1	11	9.8	3	11.5

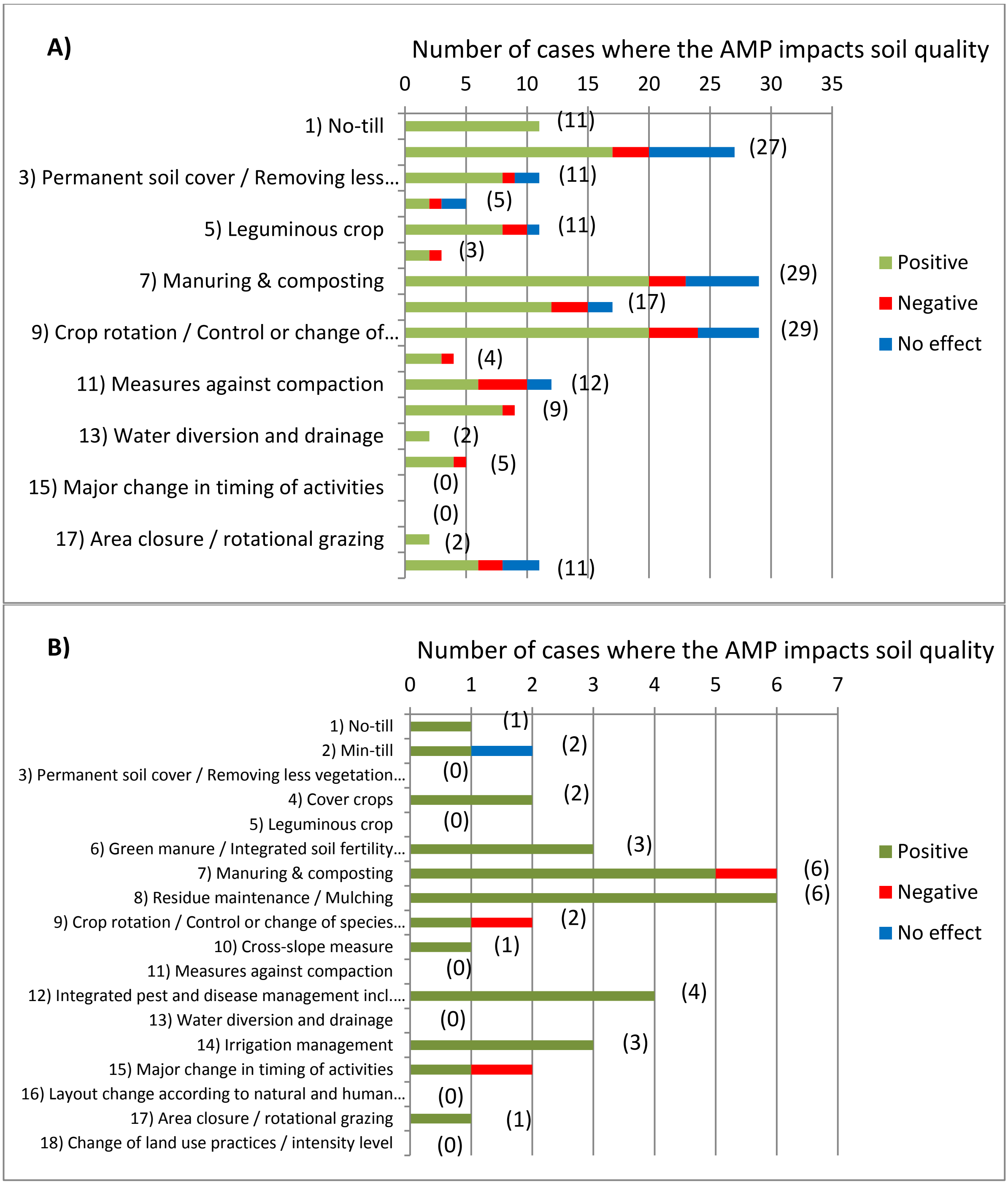


Figure 16. *Impact of the agricultural management practices (AMPs) on soil quality A) in Europe, and B) in China; total numbers of AMPs considered is given in brackets*

In Europe, the most promising AMPs that have been shown to positively impact soil quality are "crop rotation /control or change of species composition", "manure and composting", "minimum tillage" and "no-till" (Fig. 16A). For China, the most promising AMPs having positively impacted soil quality are "residue maintenance / mulching", "manure and composting", "integrated pest and disease management" and "green manure / integrated soil fertility" and irrigation management" (Fig. 16B).

When considering only the soil types that are at least 10 times represented over all study sites (Antrosol, Fluvisols, Cambisols, Regosols, Calcisols, Luvisols, and Podzols), AMPs with positive impacts on soil quality are implemented mostly in Podzols (100%), Calcisols (91%) Regosols (84.6%), Antrosols (71.4%), Luvisols (70.6%), Cambisols (62.5%), and finally Fluvisols (58%) (**Table 11**).

Table 11. *Impacts of agricultural management practices (AMPs) on soil quality in the most investigated soil types*

Soil types	Positive impacts (%)	No effects & Negative impact (%)	Total number of soil types considered (-)
Antroposol	71.4	28.6	14
Fluvisol	58	42	19
Cambisol	62.5	37.5	32
Regosol	84.6	15.4	13
Calcisol	91	9	11
Luvisol	70.6	29.4	17
Podzol	100	0	10

Within these soils, AMPs with negative and no effect on soil quality are implemented mostly in Cambisols (37.5 %), Fluvisols (42 %) and Luvisols (29.4 %). The non-detectable effect of the promising practices on soil quality are due to type of tillage management, soil type and fertility that mask the effect of management practices on soil. Furthermore, the timing of the assessment may be an important parameter. VSA methodology should be performed in the middle of growing period of a certain crop or crop type. Certain soils, such as Fluvisols, are so fertile that only small differences in harvest time, tillage or crop type can cause changes in scores. Some types of management (min tillage) can explain the low number of earthworms present throughout soil profile due to the fact that organic matter is not ploughed deeper into the soil.

Results show that the most sensitive variables to soil quality are these describing soil structure, such as soil structure and consistency, soil porosity, aggregate stability reflected by the slaking test, and soil colour, followed by soil compaction indicated by the presence of a cultivation pan (Fig. 17). Taking into account some criteria regarding the assessment (e.g., friendly use, sensitivity to different soil types) and the feedbacks of the study site teams, the indicators selected for the evaluation of the impact of the AMPs on soil quality appear to be appropriate for soils of all study sites except for very fertile soils (Fig. 17).

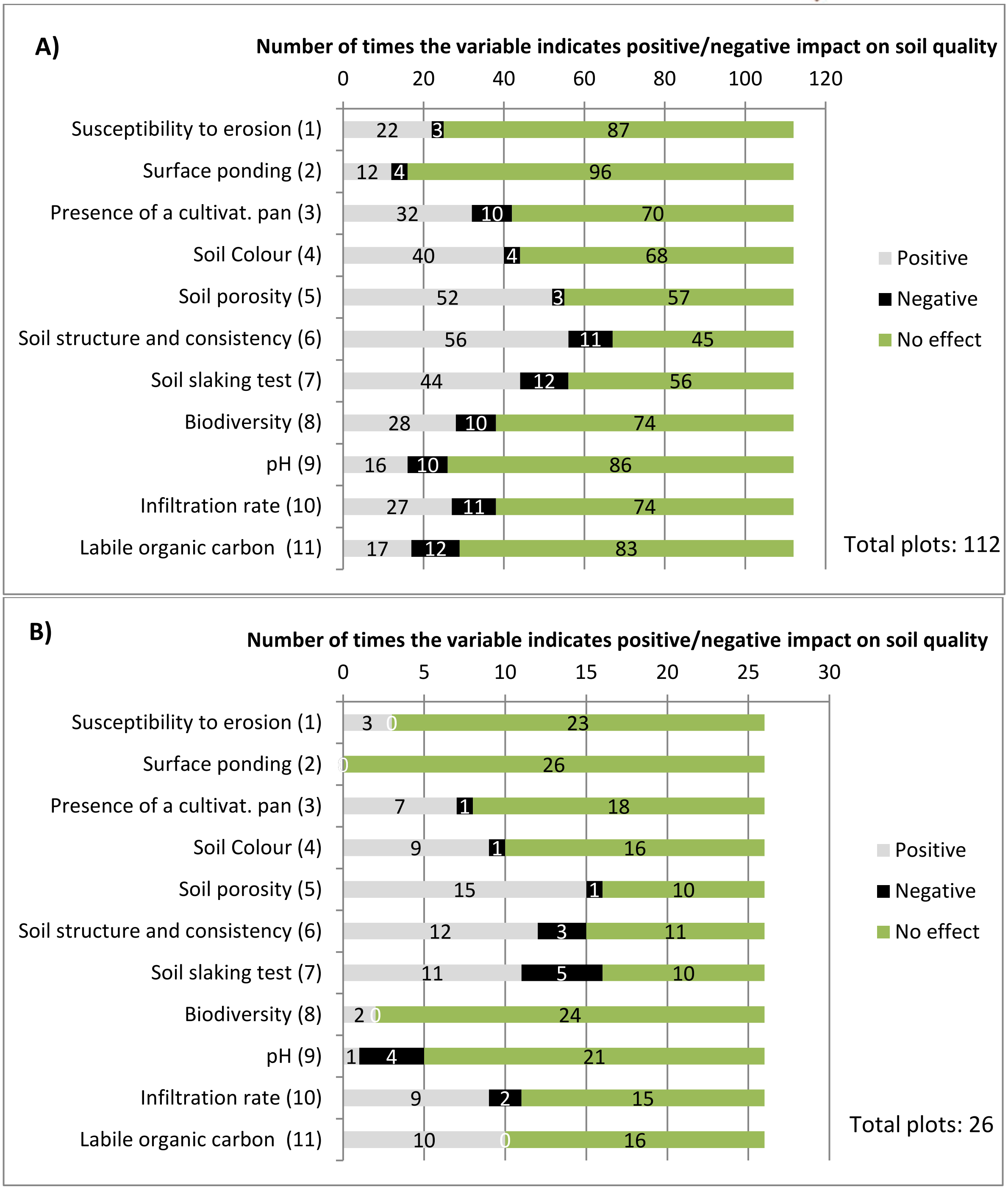


Figure 17. *Number of times the variable indicates positive/negative impact on soil quality in A) Europe (n=112), and in B) China (n=26); positive means an improvement of soil quality, negative means an inverse effect*

In Europe, the variables selected by the farmers to evaluate soil quality are generally in accordance with researchers' selection, but with fewer interests on soil colour, biodiversity and infiltration rate (Fig. 18). Similar opinion was also observed in China, except for biodiversity which was not selected by the farmers. Figure 19 shows that the three main variables selected by the farmers for the evaluation of soil quality are related to soil structure, namely soil porosity (5), soil structure and consistency (6), and soil slaking test (7), respectively).

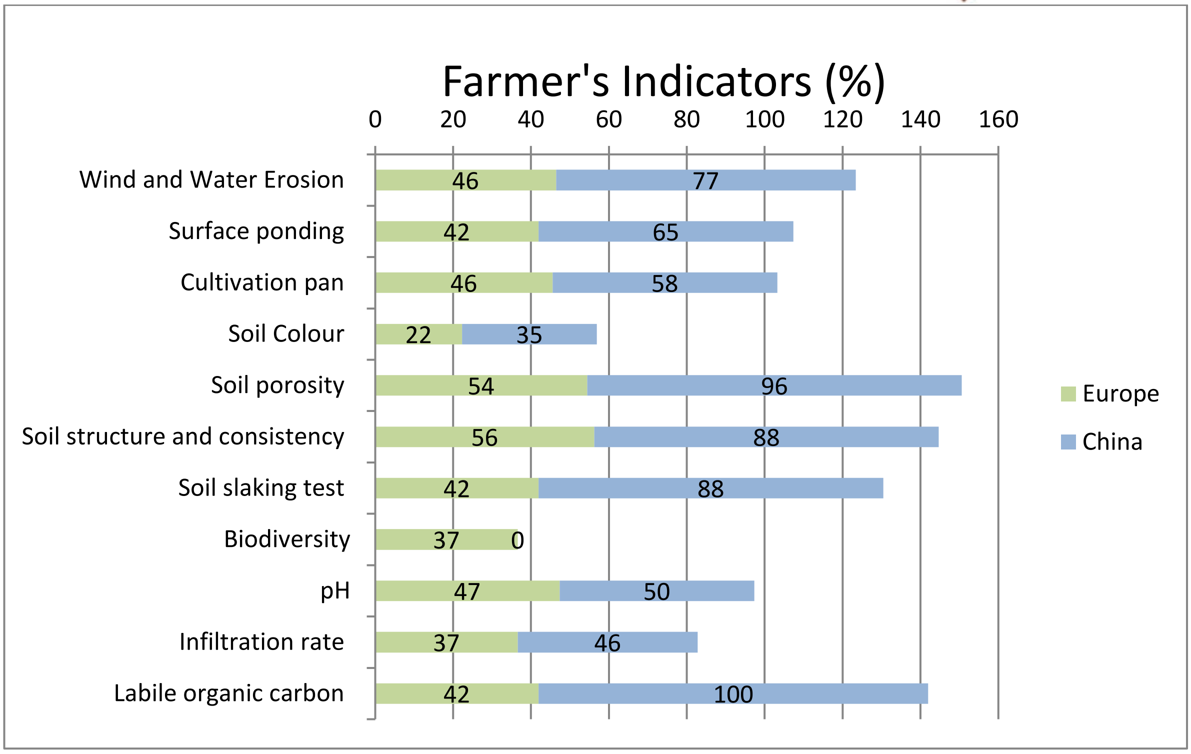


Figure 18. *Indicators proposed by the farmers to evaluate soil quality in % for Europe and China*

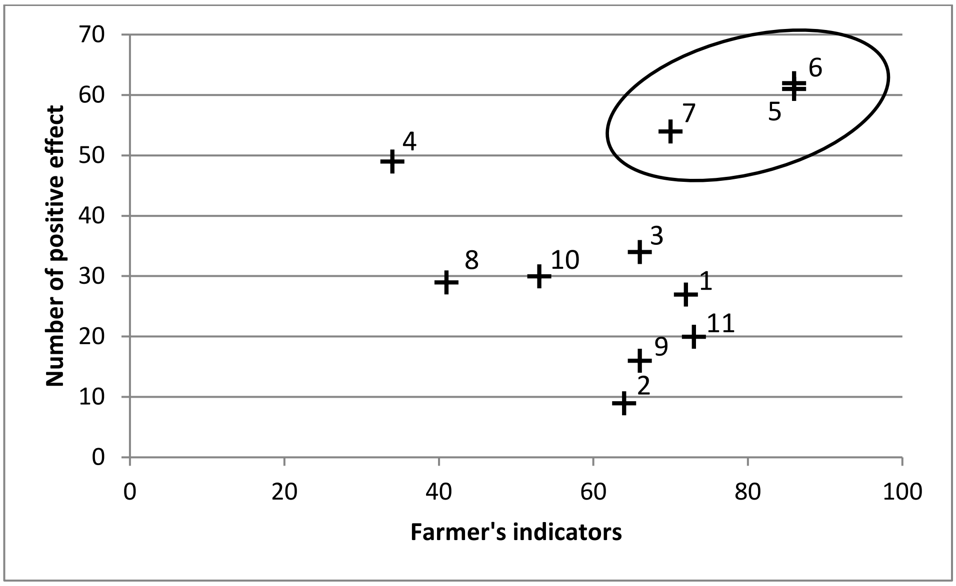


Figure 19. *Number of times the indicators were selected vs. number of times the indicators were sensitive in indicating changes in soil quality*

Documentation with WOCAT database shows the on-site impacts of the selected AMPs on the economic, socio-cultural and ecological dimensions including climate (Fig. 20). The following important outcomes can be drawn.

Over all case studies it appears clearly that socio-cultural impacts, such as “SLM knowledge” and “food security” have been increases trough the implementation of new practices. In general the new documented technologies also have positive ecological impacts with some exceptions in “soil loss”, “water quality” and “soil compaction”. Most negative impacts are observed or expected in “workload”, “expenses”, and “crop production”, which are all socio-economic impacts and mainly related to AMP Nr. 12 *Integrated pest and disease management incl. organic agriculture* (Figure 20).

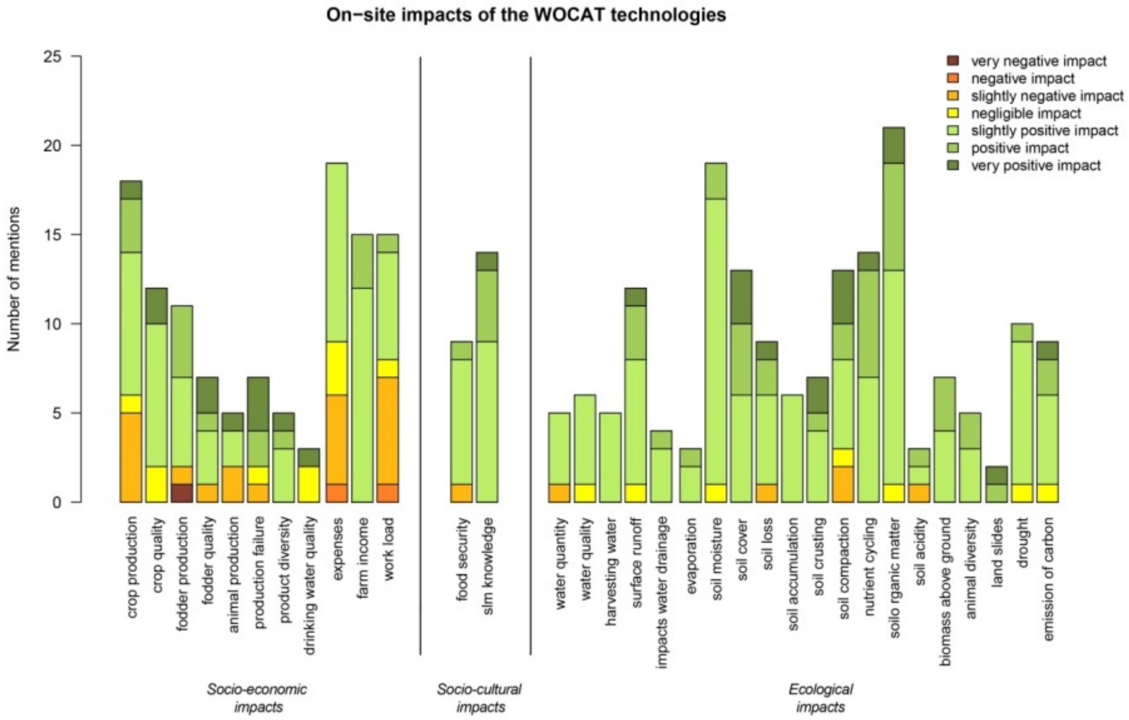


Figure 20. *On-site impacts of the WOCAT technologies*

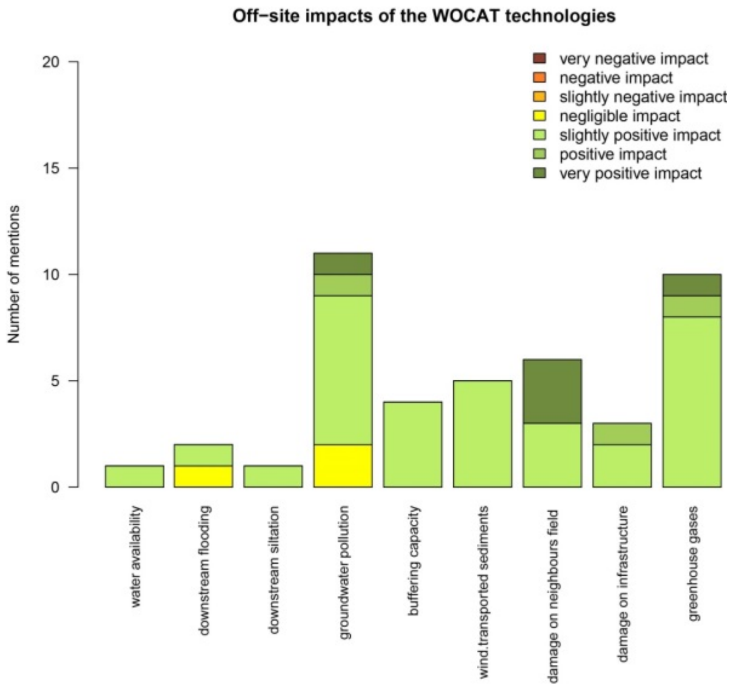


Figure 21*: Off-site impacts of the WOCAT technologies*

On the other hand, impacts can also be off-site and affect adjacent areas further downstream with "groundwater pollution" or "damages on infrastructure and fields" (Fig. 21). But the newly implemented AMPs have all a negligible or positive off-site impacts. Especially through reducing "groundwater pollution" and "damages on infrastructure and fields" through reduced surface runoff and soil erosion.

Conclusions and perspectives

On the basis of WOCAT database (www.wocat.net) and extensive literature review, 18 promising agricultural management practices (AMPs) were selected and their impacts on soil quality were evaluated through a Visual Soil Assessment methodology at 14 study sites across Europe and China, covering the major pedo-climatic zones.

Among the 138 sets of paired plots, 75.4 % show a positive impact of innovative AMPs on soil quality, 14.5 % do not show any difference in soil quality between soils under promising practices and soils in the control plots, and the remaining 10.1 % show inverse negative effect on soil quality. In Europe, the most promising AMPs that have been shown to positively impact soil quality are crop rotation / control or change of species composition, manure and composting, minimum tillage and to a certain extent no-till. For China, the most promising AMPs having positively impacted soil quality are residue maintenance/mulching, manure and composting, integrated pest and disease management, and green manure/integrated soil fertility, and irrigation management.

From the 11 variables selected to evaluate soil quality, the ones describing soil structure (porosity, structure and consistency, aggregate stability) revealed to be the most sensitive to soil quality. The variables selected by the farmers for the evaluation of soil quality are also related to soil structure and confirm the consistency of researchers' choice.

The analysis based on WOCAT documentation supported the first assessment of soil quality using the visual soil assessment and gave useful information on the off- and on-site impacts on a large range of indicators related to socio-cultural, economic, and ecological dimensions. In general the implantation of the new technologies have positive ecological impacts with some exceptions in "soil loss", "water quality" and "soil compaction". Most negative impacts are observed in "workload", "expenses", and "crop production", which related to the socio-economic impacts and mainly related to Integrated pest and disease management incl. organic agriculture.

Our findings will serve as basis for recommendations given in the SQAPP. The AMPs having positively affecting soil quality will be completed by knowledge gained from long-term experiments to establish a list of innovative AMPs to be included in the list of the recommendations to address a specific soil threat. This task is planned within the framework of the deliverable D5.3 for Month 48 (Database of currently applied and promising agricultural management practices).

Our findings will be validated on selected sites again the results obtained with quantitative measurements leaded by WP6 during season 2018.

1.2.6 Work Package 6

Summary

WP6 will assess the impact of innovative management practices on soil quality and crop performance and provide the necessary iterative feedback for the further improvement of SQAPP. This WP will select representative sites where promising measures can be tested for their performance with regard to soil quality and overall sustainability of crop and livestock production. A demonstration component within this WP will provide valuable support for both up-scaling activities and for dissemination and communication. Activities will include: i) selecting sites for testing, evaluating and demonstrating selected promising 'soil improving' agricultural measures; ii) identifying parameter/indicator sets for testing and evaluating the impact on soil quality and crop production parameters; iii) assessing parameters/indicators (including through applying SQAPP) for testing and evaluation of innovative agricultural management practices; and iv) organizing demonstration events at selected field sites. The main deliverables of this WP will be an internal report on performance of promising agricultural management practices to populate recommendations of SQAPP (TRL5), and a report on the performance of key and site-specific parameters and indicators for all monitored sites (TRL6).

The specific objectives of WP6 to be pursued in different tasks will be to:

1. Select sites for testing, evaluating and demonstrating of selected promising 'soil improving' measures (Task 1);

2. Identify parameter/indicator set for testing and evaluating the impact on soil quality and crop production parameters (Task 2);

3. Assess parameters/indicators (including through applying SQAPP) for testing and evaluation of innovative management practices (Task 3);

4. Organize demonstration events at selected field sites (Task 4).

Summary of progress

Task 6.1 has started in Month 8 and finished in month 18 as predicted (**deemed finished**). *Milestone 1 – Selection of sites for testing and evaluation*.

Task 6.2 has started in Month 14 and finished in month 22 as predicted (**deemed finished**). The identification of the parameters/indicators to assess soil quality and crop response with main activities being bibliographic review and communication/discussion sessions with partners from WP3 and WP5. This work was based on the guidelines set previously by D3.1" Concepts and indicators of soil quality – a review" from WP3. *Milestone 6.2 - Identification of parameter/indicator set for testing and evaluating the impact on soil quality and crop production parameters*.

Task 6.3 has started in Month 25 and is predicted to finish in month 48 (**in progress**). The set of Testing Sites, per CSS, was consolidated, resulting in 24 pair AMP-Control in 13 CSS; CSS Zhifanggou failed to produce comparable AMP-Control pairs. A questionnaire (excel file SQ1_SQ2_WP5_WP6_2018) to be filled by the CSS team coordinators was prepared, comprising the information needed on soil parameters (physical, chemical and biological), farming system, land use, agriculture measures, and topographic information. A Guide was prepared to support the filling of the questionnaire, the field measurements and observations, and laboratory work (Soil Quality Assessment. General Guidelines for the Field, Desk and Laboratory Work of WP6-Task 6.3). The required field and laboratory work is now being carried on at the CSS partners, according to their own time frames (appropriate soil conditions to conduct the measures/ observations).

Deliverable 6.1 Internal report on performance of promising land management practices to populate recommendations of SQAPP [Month 48].

D6.2 Report on the performance of key and site-specific parameters and indicators for all monitored sites [Month 58].

Details for each Task

Task 6.1 - Selection of sites for testing, evaluating and demonstrating of selected 'soil improving' measures

This initial task of WP6 will build on the pedo-climatic zonation and respective spatial characterization of crop and livestock systems (WP2). It will further interact with WP5 regarding the definition of the most promising innovative practices capable of enhancing soil quality and functions and contributing to sustained crop production. Based on the definition of farming systems and pedo-climatic zones, in combination with the potential soil improving measures the sites for testing, evaluation and demonstration will be established. Local stakeholders and research institutions will be involved in the identification of already existing experimental sites or adequate paired field sites that allow comparing innovative with conventional practices and assessing the already achieved impact of management changes on soil quality and crop production.

A total of 148 plots/farms were identified, 114 in Europe and 34 in China, covering 8 Climatic regions and the most common soil types within each region. The most identified innovative AMP's in Europe were: a) Manuring & Composting, Min-till and Crop rotation. In China the most identified AMP's were: Manuring & Composting, Residue maintenance/Mulching and no-till. Using the highest soil threats in every Case Study Site area and the relevance of AMP towards the different soil threats, 24 *Testing sites* were preliminarily selected. *Testing sites* are spread in all Case Study site areas and account for 14 different innovative AMP's (or combinations). After the withdrawal of partner CSS 13 (Zhifanggou), and introduction of changes per request to some CSS, corrections were needed. The values above are updated.

Activities and results

This task is deemed finished. For details, please see report on *Milestone 1 – Selection of sites for testing and evaluation*.

Task 6.2: Identification of parameter/indicator set for testing and evaluating the impact on soil quality and crop production parameters

Based on the work carried out within Task 1 of WP3, already during but mainly after the selection of the sites for testing and evaluation the most adequate parameters/indicators will be identified to assess both the response of soil quality and crop performance to innovative management practices. At all sites, independent of pedo-climatic conditions and farming system, the same set of key parameters will be observed. In addition, dependent on pedo-climatic conditions and cropping or livestock system, condition or site-specific parameters or indicators may be identified to assess adequately soil functions and/or crop performance. In order to obtain results on the impact of management practices on soil quality within the period of the project, parameters to be observed have to be sufficiently responsive to change but should not be so easily changeable as to give little indication of long-term alterations, or monitoring should focus on existing implementation sites.

A set of 8 soil threats (Erosion, Compaction, Salinization, SOM Decline, Soil Biodiversity Loss, Soil Contamination, Acidification, Nutrient Depletion/Surplus), with direct impact on soil quality across the pedo-climatic conditions that can be found in Europe and China, was identified. For each soil threat, indicators that best describe each soil threat were chosen taking into account data availability, reference values, existence of robust models/ pedo-transfer functions, adequacy and easiness of soil parameters measurement needed. In order to evaluate the Soil Quality at a given moment, a Soil Quality Index was developed. An extended list of parameters for a correct evaluation of soil quality, including site-specific parameters, was built for use in task 3. This extended list encompasses: location inputs (georeferenced location, topography features, and expected contaminants (from natural origins or others)); soil properties relevant for indicators estimates (physical, chemical and biological); land use (farming system types, crops/ occupation, pesticide usage, and others); landscape features (stonewalls, grass margins).

Activities and results

Milestone 6.2 - *Identification of parameter/indicator set for testing and evaluating the impact on soil quality and crop production parameters* – objective is to identify (and develop) the parameters/indicators to assess soil quality and crop response regarding the use of promising agricultural management practices. This work was developed by WP6 and based on the guidelines set previously by D3.1" Concepts and indicators of soil quality – a review" from WP3.

In the following readings, there is a description on the methodology adopted to successfully select the soil parameters to evaluate Soil Quality. Briefly, we have selected soil parameters by first developing a Soil Quality Index that is based on the soil status concerning different Soil Threats.

Each Soil Threat was then diagnosed using a method/measurement that requires specific soil parameters.

The soil quality index is based in the guidelines set in previous work by WP3 (see D1 "Concepts and indicators of soil quality – a review"). The first step is to evaluate the soil quality status concerning the main soil threats currently impacting on soil across a variety of pedo-climatic conditions. The evaluation of soil quality is then assessed by quantifying the level of damage caused by different threats. By evaluating soil quality through the vulnerability to each soil threat it is easier to consider management options to farmers to counteract specifically the problems detected.

The implementation of such quality index includes the establishment of indicators for each soil threat and a methodology to assess them using soil chemical, physical and biological parameters. Finally, a classification system is established for every soil threat in order to evaluate the soil status (Figure 22).

The first step in this development is the establishment of the soil threats that should be considered. The list of soil threats discussed over iSQAPER workshop organized by WP3 leader at FiBL in Switzerland Frick (October 2015) was used in a first approach. The number of soil threats considered in the index was reduced to the most relevant ones in agricultural soils. Also, an indicator was established– described as a model/methodology/parameter – to correctly assess each threat and the input parameters necessary for its calculation and evaluation.

Soil indicators

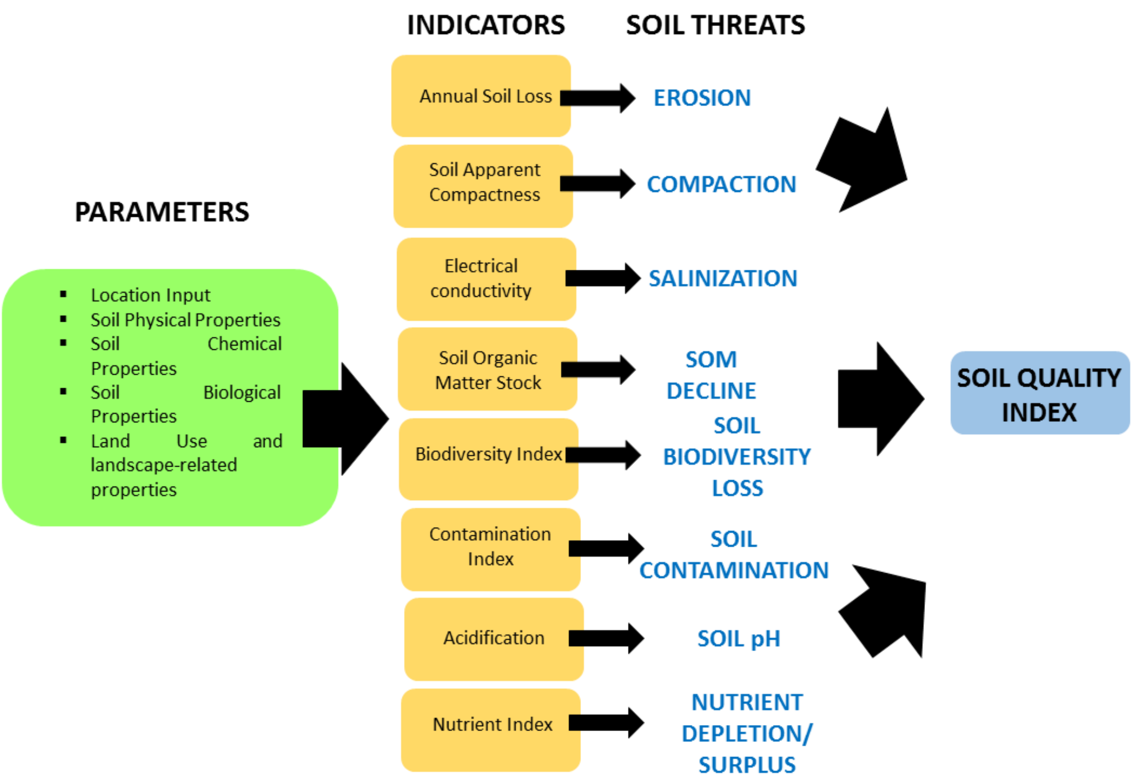


Figure 22 – Soil threats indicators used in Milestone 6.2 and the development of the Soil Quality Index

Erosion

Erosion is estimated using ***Annual Soil Loss*** as an indicator. Annual Soil Loss is calculated by the overall known RUSLE equation (Panagos et al., 2015e), which calculates mean annual soil loss rates by sheet and rill erosion according to the following equation:

$$E = R \times K \times C \times LS \times P$$

Where:
E: annual average soil loss (t ha^{-1} yr^{-1});
R: rainfall erosivity factor (MJ mm ha^{-1} h^{-1} yr^{-1});
K: soil erodibility factor (t ha h ha^{-1} MJ^{-1} mm^{-1}),
C: cover-management factor (dimensionless),
LS: slope length and slope steepness factor (dimensionless);
P: support practices factor (dimensionless)

For further details on the calculation of each factor, available data, etc. please see the report of Milestone 6.2 - *Identification of parameter/indicator set for testing and evaluating the impact on soil quality and crop production parameters*.

Compaction

Soil compaction is evaluated using the ***apparent compactness*** of the soil as an indicator (Jones et al., 2003). This indicator evaluates is based on soil's bulk density and clay content:

$$PD = DB + 0.009C$$

Where PD (t m^{-3}) is the ***apparent compactness of the soil***, DB is the bulk density (t m^{-3}) and C is the clay content (% wt).

Salinization

The indicator used to estimate the level of salinization of the soil is the electrical conductivity (EC) of the water, measured in situ and expressed as decisiemens per meter – dS m^{-1} (Hanson et al., 2006).

SOM decline

The evaluation of the soil organic matter (SOM) decline in the soils is evaluated using the concentration of organic carbon and the soil bulk density, to calculate the **SOC stock** as the indicator.

$$SOC_{stock} = SOC_{conc} \times \rho \times l$$

Where SOM_{stock} is the stock of organic matter (g m^{-2}) and SOM_{conc} is the concentration of organic matter measured (g kg^{-1}) in the top *l* meters. We are assuming the organic matter calculation in the first 30 cm.

Soil Biodiversity Loss

Soil biodiversity Loss can be estimated by calculating the availability of a) quantification of Soil Microorganisms and b) diversity of soil Macrofauna. The Indicator to assess the biodiversity is a combination of these two measurements and can be calculated as follows:

- Measure the Biomass microbial carbon - By estimating the carbon content in the microorganism pool (g kg^{-1}), convert it to g m^{-2} using the local soil bulk density and extrapolating for 1 meter of soil depth (Serna-Chavez et al., 2013).
- Measure the number of co-occurring soil macro fauna groups - by identifying in a 25x25 soil sample the number of different macro fauna groups co-existing (earthworms, ants, termites, spiders, millipedes, centipedes, isopods, fly larvae, cockroaches and mantids, moth and butterfly larvae, grasshoppers and crickets, gastropods, beetles) (Orgiazzi et al., 2016).

Finally, the Biomass microbial carbon should be converted into a "0-1 Indicator" considering 0 as minimum and 250 g m^{-2} as maximum and the Soil macro-fauna number of co-existing groups should be converted into a "0-1 Indicator" considering 0 as minimum and 14 as maximum number. The "soil biodiversity Indicator" is the harmonized sum of the previous two indexes.

Contamination

Contamination is a soil threat mainly related to the presence of heavy metals and pesticides that are toxic for plants and humans and that hamper the presence of micro and macro fauna, transforming soil into a closed system. For soil contamination the main heavy metals considered are: As, Cd, Cr, Cu, Ni, Pb, Zn and Hg (Lado et al., 2008).

Both pesticides and heavy metals will only be assessed, if there is background information supporting the hypothesis of contamination. This information was asked for in the questionnaire that was sent to all testing sites and will take into account the history of application of potential contaminants and the individual location of each site (i.e. type and amount of application of pesticides, sewage sludge, urban waste or composts, proximity to polluting industries, etc.) If pesticide and other potential contaminant inputs are below certain threshold levels or if the site is not located in a place where heavy metal contamination from industries can be expected, then no sampling and analysis for contaminants will be requested.

Since the best indicator for contamination is the content of each component, these parameters should only be determined in cases where farmers consider that contamination might be a problem in the plot/farm. Otherwise, the analysis of contaminants should be ignored.

Acidification

Acidification is the soil enrichment of hydrogen ions. Several problems are associated with the acidification of soils, since many biogeochemical processes are enhanced at low pH, such as the mobility of aluminium that becomes toxic for the plants. The level of acidification will be assessed in this study by measuring the soil pH of a sample collected at 30 cm in CaCl2.

Nutrient depletion/surplus

Nutrients such as Nitrogen (N), Phosphorus (P) and Potassium (K) are essential for crop growth. If soils faces nutrient depletion, the growth of crops might be compromised and soil functions will not be fully operational.

Nutrient depletion will be assessed in this study by measuring total N and total P as well as extractable P and extractable K in soil samples. The results will be assessed against existing soil nutrient maps and combined into a single Index that shows if the soil is generally depleted in nutrients or not.

Soil threats classification

To evaluate the outcomes of each indicator it was necessary to establish reference values for each indicator regarding the different soil threats. The classification system includes the comparison of each calculated indicator with a reference/potential value and the classification dependent on the difference between the soil threat indicator assessed and that reference value for the same situation.

Erosion

Using the scale provided in the work of Panagos et al., (2015e) for European soil erosion, shown in Figure 23, we have established three categories to classify Annual Soil Loss (Table 12).

Table 12 – Classification of annual soil loss

Annual Soil Loss (t ha^{-1})	Classification
0 - 2	Low
2 - 10	Moderate
>10	High

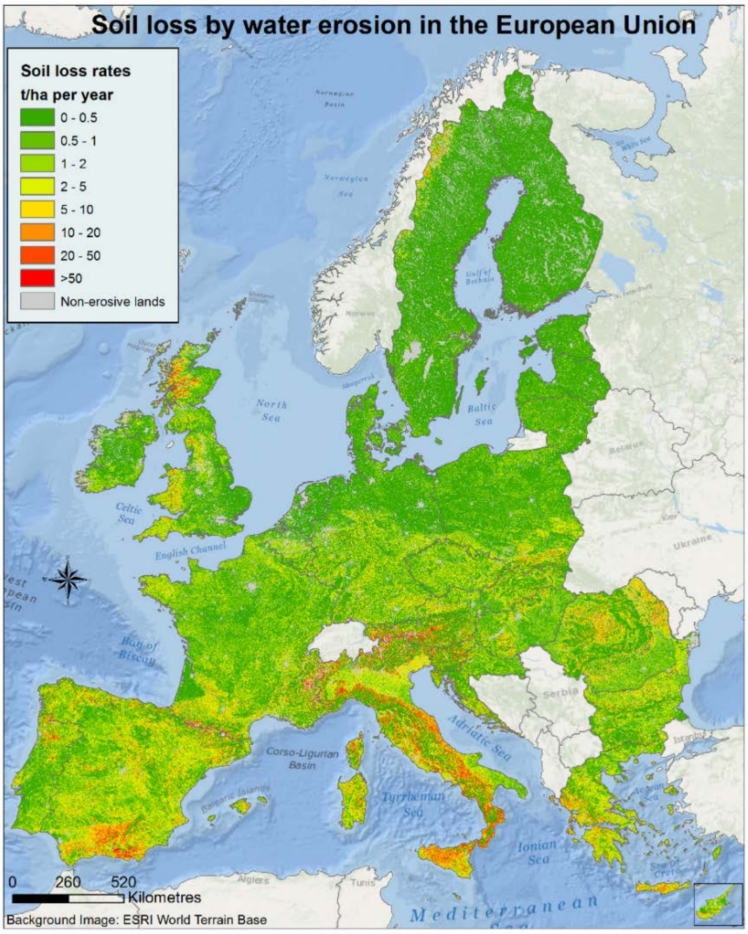


Figure 23 – Soil Erosion by water in Europe

SOM decline

In order to classify the Soil organic carbon decline of a specific soil, it was necessary to use the Map of SOC stocks in agricultural soils from (Lugato et al., 2014; Orgiazzi et al., 2016). This map (Figure 24) provides an estimation of SOC stocks (t C ha^{-1}) in 2010. By comparing the actual stock with the one existing in 2010, it is possible to observe if the carbon stocks are increasing or decreasing.

The classification is "Low" when the actual SOC compared to 2010 increased and it is "Moderate" when the stock although descendent, decreases at a rate that is lower than 1% each year. Moreover, if the soil carbon stock is lower than this rate is considered as "High" (Table 13).

Table 13 – Classification of soil SOM decline

SOM decline (t C ha^{-1})	Classification
$C_{atual} > C_{2010}$	Low
C_{atual} > 1% x Years x C_{2010}	Moderate
C_{atual} < 1% x Years x C_{2010}	High

C_{atual} is the carbon stock for the current year and for a specific location; C_{2010} is the carbon stock in 2010 and for the same specific location; Years is the difference from current year and 2010

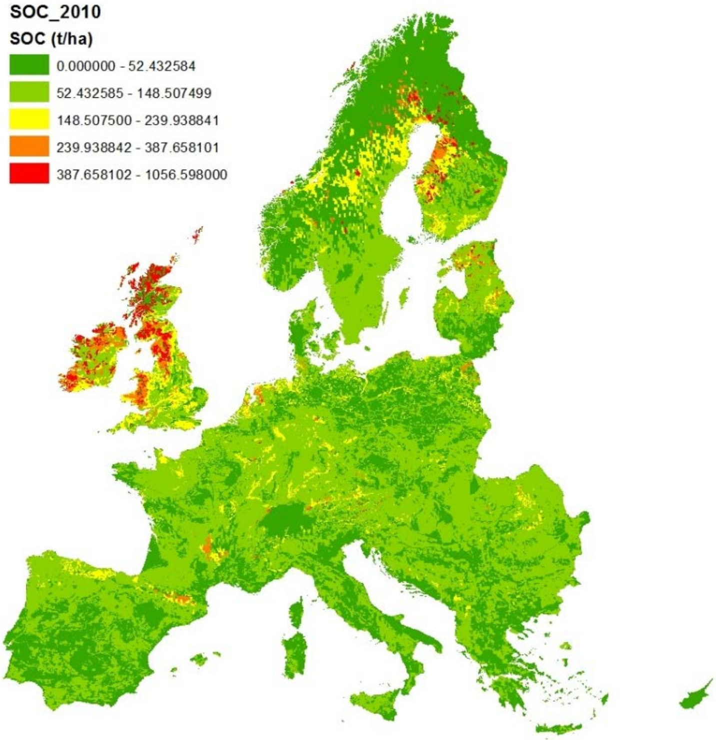


Figure 24 – SOC in agricultural soils in 2010

Compaction

The classification system established for soil compaction level, estimated through soil apparent compactness is shown in Table 14, as proposed by Jones et al., (2003). The classification levels are different depending on the soil texture.

Table 14 – Classification of soil apparent compactness

Texture Class	PD (t m^{-3})		
	Low (<1.40)	**Medium (1.40-1.75)**	**High (>1.75)**
Coarse	High	High	Moderate
Medium	High	Moderate	Moderate
Medium fine	Moderate	Moderate	Low
Fine	Moderate	Low	Low
Very fine	Moderate	Low	Low
Organic	High	High	

Salinization

The classification system used to evaluate the salinity of a soil, based on the electrical conductivity of the water, is based on the individual crop thresholds for salinity. This means that instead of evaluating the soil status concerning the level of salinization, we will in fact evaluate the soil salinization concerning the most salt-sensitive crop grown on it. In order to do that, we have used the crop thresholds of Hanson et al., (2006), to establish the level beyond which a soil growing that specific crop is considered as saline. This approach takes into consideration the intention of the farmer in producing specific crops in their fields.

Also, to establish an intermediate category, and to reflect an electrical conductivity that, although lower than the 'absolute' threshold, is still high and might become a problem for crop growth, we have considered the interval between 100% and 75% of the threshold as an intermediate class. For a comprehensive list of crops, salinity threshold, and classification used to calculate the soil quality index, see the report of Milestone 6.2 - *Identification of parameter/indicator set for testing and evaluating the impact on soil quality and crop production parameters*.

Soil Biodiversity Loss

The classification of the Biodiversity Indicator is based on the map of *Potential Biodiversity Index* from Orgiazzi et al., (2016) (Figure 25). This map shows the potential Index as calculated previously, but it uses models instead of local measurements, to take into account the variations from different pedo-climatic regions. In this way, it becomes possible to compare the Soil Biodiversity Index measured in situ with the potential value for the same location. The classification system is different, therefore for each specific location, but 3 classes are always established from 25% and 75% of the Potential Soil Biodiversity Index for a certain location.

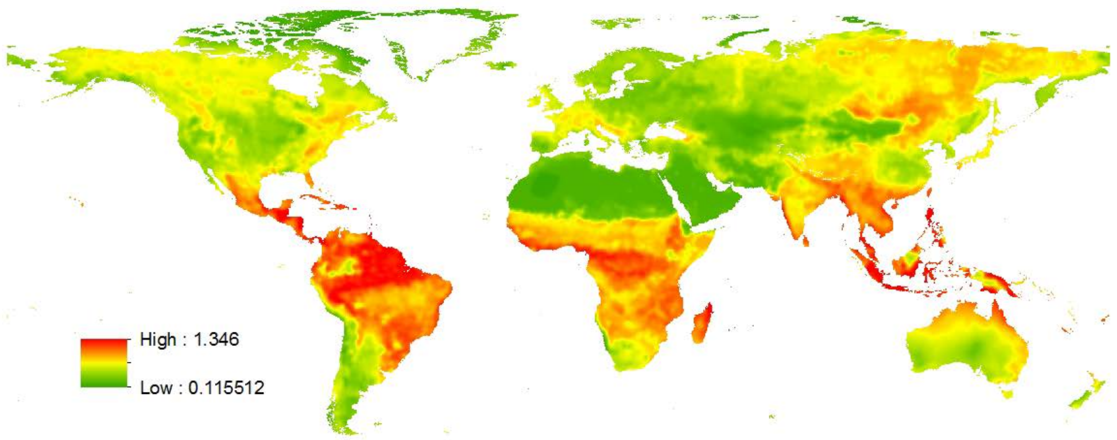


Figure 25 – Potential Soil Biodiversity Index

Soil Contamination

Soil contamination includes two main groups: contamination of the soil with heavy metals and contamination of the soil with pesticides. Each contamination should be assessed individually, since they are independent, but their final value will be included in one only indicator of Soil Contamination. We will always adopt a conservative approach, which means that if the soil is contaminated with pesticides or heavy metals, then the soil quality Indicator for Soil Contamination should reflect that (Table 15).

Table 15 – Soil Contamination Indicator

Soil Contamination Indicator	Classification
0 (Low)	If Soil Contamination Heavy metals **and** Soil Contamination pesticides are "Low"
0.5 (Moderate)	If Soil Contamination Heavy metals **or** Soil Contamination pesticides are "Moderate"
1 (High)	If Soil Contamination Heavy metals **or** Soil Contamination pesticides are "High"

It is often very difficult to establish threshold values for soil contamination, since toxicity and bioavailability of heavy metals is not solely dependent on the total content in soils but also on many other environmental variables. Also, the determination of natural background values is controversial because they can decrease the responsibility of human activities for the overall pollution on soils and it is often difficult to determine the background values that would correspond to a pristine situation since the geochemistry of most of our ecosystems is greatly influenced by a long history of anthropic activities (Lado et al., 2008). However, to evaluate the Soil Indicator concerning Soil contamination in this work, it was necessary to establish a classification system that somehow could show to the end-users if there was any contamination in the soil or not.

To establish a reference classification for the heavy metal contamination, we have considered the limits from (Nicholson & Chambers, 2008). For each of the heavy metals previously established to be under control in soil contamination threat, the maximum values allowed (for each soil pH) are expressed in Table 16:

Table 16– Maximum limits established by Nicholson & Chambers (2008) for each of the considered heavy metals

Heavy Metal (mg/kg)	Soil pH			
	5.0 - 5.5	5.5 - 6.0	6.0-7.0	>7.0
Zn	200	200	200	200
Cu	80	100	135	110
Ni	50	60	75	110
Cd	3	3	3	3
Pb	300	300	300	300
Hg	1	1	1	1
Cr	400	400	400	400
As	50	50	50	50

In order to obtain three categories to establish the soil contamination level of a soil concerning heavy metal pollution, we have considered the intermediate category as 75% of the limit value for each heavy metal (at each soil pH). In this way the Intermediate category already alerts for the eminent dangerous of soil contamination by heavy metals. Below the interval consider for this category, the contamination level is considered to be *Low* (Table 17).

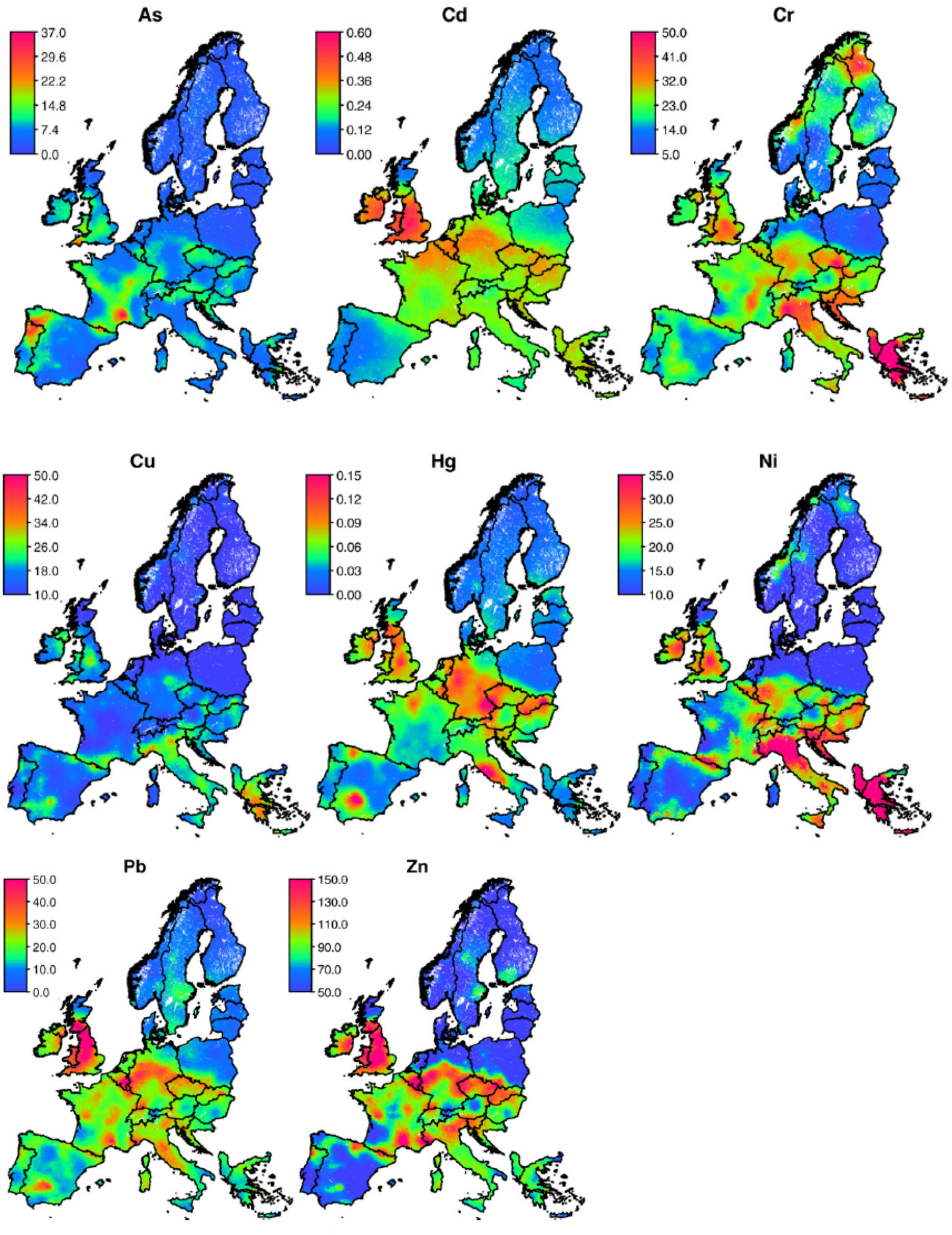


Figure 26 – Soil Contamination in Europe

Table 17 – Classification for soil contamination (heavy metals)

Heavy Metal	Low				Moderate				High			
	Soil pH											
	5.0 - 5.5	5.5 - 6.0	6.0 - 7.0	>7.0	5.0 - 5.5	5.5 - 6.0	6.0- 7.0	>7.0	5.0 - 5.5	5.5 - 6.0	6.0- 7.0	>7.0
Zn	<150	<150	<150	<150	150-200	150-200	150-200	150-200	>200	>200	>200	>200
Cu	<60	<75	<101.3	<82.5	60-80	75-100	101.3-135	82.5-110	>80	>100	>135	>110
Ni	<37.5	<45	<56.25	<82.5	37.5-50	45-60	56.25-75	82.5-110	>50	>60	>75	>110
Cd	<2.25	<2.25	<2.25	<2.25	2.25-3	2.25-3	2.25-3	2.25-3	>3	>3	>3	>3
Pb	<225	<225	<225	<225	225-300	225-300	225-300	225-300	>300	>300	>300	>300
Hg	<0.75	<0.75	<0.75	<0.75	0.75-1	0.75-1	0.75-1	0.75-1	>1	>1	>1	>1
Cr	<300	<300	<300	<300	300-400	300-400	300-400	300-400	>400	>400	>400	>400
As	<37.5	<37.5	<37.5	<37.5	37.5-50	37.5-50	37.5-50	37.5-50	>50	>50	>50	>50

The Contamination Indicator for Heavy Metals, is established as 0, 0.5 or 1, depending on the status regarding each pollutant (Table 18). We adopted a conservative approach and therefore consider soil contamination by heavy metals status as "Bad" if only one of the contaminants exceeds the limits. Available maps of heavy metal contamination levels in Europe are shown in Figure 26.

Table 18 – Soil Contamination Indicator for heavy metals

Contamination Index Heavy Metals	Classification
0 (Low)	If ALL pollutant score "Low" classification
0.5 (Moderate)	IF ANY pollutant scores "Moderate" classification
1 (High)	If ANY pollutant scores "High" classification

When considering the soil contamination with pesticides, several factors should be taken into account, for an accurate evaluation of their interference and impact on the soil quality. Pesticides may be added in more or less quantity (application rate), but different persistent times in soils (half life time), different adsorption capacity to other soil compounds (adsorption coefficient) and their potential to move toward groundwater will also determine if the pesticide is dangerous for soil (and human) health.

As so, the pesticide application rate on itself cannot be establish as a good soil contamination per pesticides indicator, on its own. Here we suggest that the Pesticide soil contamination indicator is a combination of two sub-Indicators (Figure 27):

- Indicator on Pesticide Persistency and Movement in soil (PPMsoil);
- Indicator on Soil Environmental Exposure to Pesticides (EEPsoil);

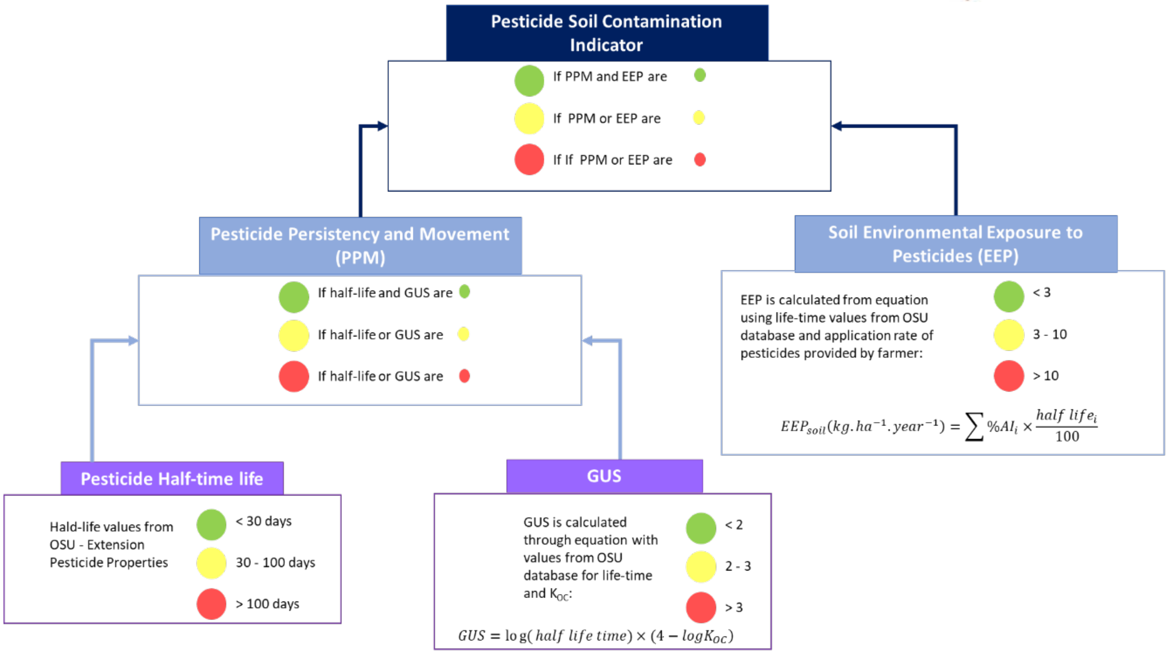


Figure 27 – Pesticide Soil Contamination Indicator

Each of this indicators will be ranked as "High", "Moderate" and "Low", and we will adopt a conservative approach, when mixing them. This means that the Pesticide Soil contamination Indicator will only be generally classified as "Low" when both EEP and PPM have individually "Low" classifications as well (Table 19).

Table 19 – Soil Contamination Indicator for pesticides

Contamination Index for Pesticides	Classification
0 (Low)	If PPM **and** EEP are "Low"
0.5 (Moderate)	If PPM **or** EEP are "Moderate"
1 (High)	If PPM **or** EEP are "High"

Indicator on Pesticide Persistency and Movement in soil (PPMsoil)

This indicator will aggregate information concerning the a) pesticide values on half life time, and b) potential to move toward groundwater. For each one of these, a classification system will also be assessed. Once more the conservative approach is used to calculate the soil aggregated PPMsoil.

- **Pesticide Half-time life**

Based on values from *OSU - Extension Pesticide Properties Database*, the classification system was established as follow:

Low – Half life time <30 days

Moderate – 30 < Half life time < 100 days

High - Half life time>100 days

- **Potential to move toward groundwater**

Based on the following equation, GUS (Groundwater Ubiquity Score) is calculated using both the half life time and the adsorption coefficient:

$$GUS = \log(half\ life\ time) \times (4 - logK_{OC})$$

Then, for the classification of GUS is also used the recommendation from *OSU - Extension Pesticide Properties Database*:

Low – GUS <2

Moderate – 2 < GUS < 3

High – GUS >3

Indicator on Soil Environmental Exposure to Pesticides (EEPsoil)

This indicator aggregates information concerning the pesticide persistence (half life time) in soil together with the actual input of a specific pesticide (the application rate). If more than one pesticides are applied in soil, their specific half-life times should be considered. To evaluate the environmental exposure of pesticides we will use the equation described in (Wijnands, 1997):

$$EEP_{soil}(kg.ha^{-1}.year^{-1}) = \sum \%AI_i \times \frac{half\ life_i}{100}$$

To establish a reference classification system to EEP, we will also base ourselves in the work developed by (Wijnands, 1997):

Low – EEP <3

Moderate – 3 < GUS < 10

High – GUS > 10

Acidification

Using the pH ($CaCl_2$) measured in 2009, available from the ESDAC data (Figure 28), it will be possible to compare with local measurements and establish if the soil maintains the pH or after some time it is becoming more acidic than it was before. If the actual pH is higher than before, then no acidification is taking place. However if the relative difference between the two measurements (when the actual pH is lower than in 2009) is higher than 10% then a moderated acidification is occurring. If that difference is higher than 10% then the situation is more serious (Table 20).

$$\frac{pH_{2009} - pH_{actual}}{pH_{2009}} > 10\%$$

Table 20 – Classification of Acidification

Soil pH ($CaCl_2$)	Classification
$pH_{atual} > pH_{2009}$	Low
$0.8 < pH_{atual}/pH_{2009} < 0.9$	Moderate
$pH_{atual}/pH_{2009} < 0.8$	High

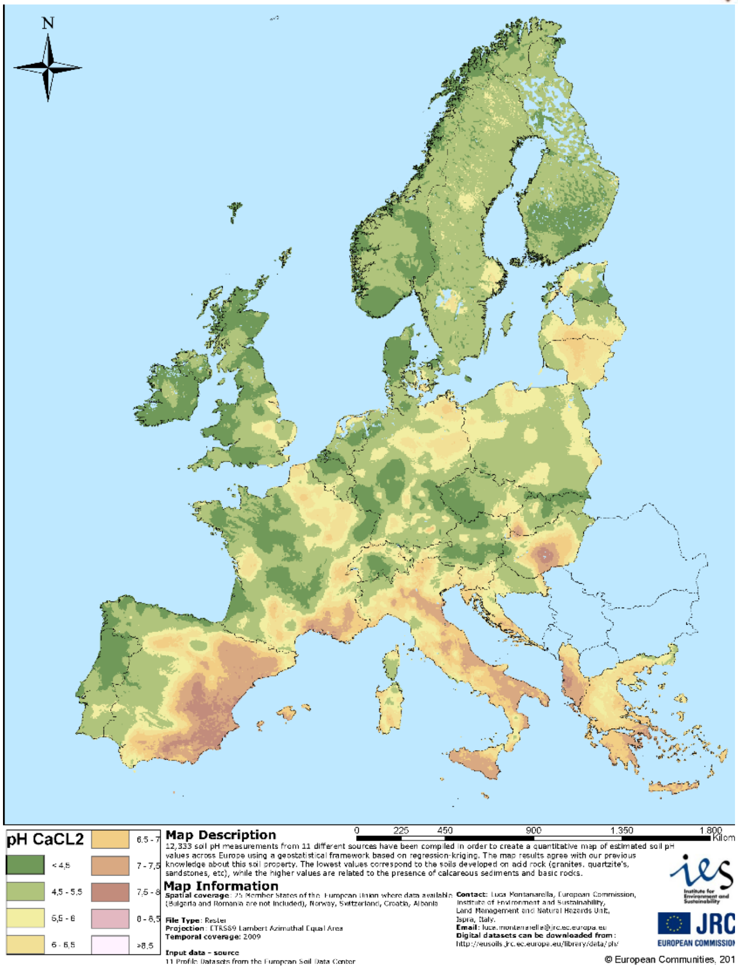


Figure 28 – Soil pH ($CaCl_2$)

Nutrient depletion/ surplus

The results will be assessed against existing soil nutrient maps and combined into a single Index that shows if the soil is generally depleted in nutrients or not. (**work still in progress).**

Soil Quality Index Evaluation

The calculation and merge of the individual soil quality indicators concerning the different soil threats into one single Soil Quality Index, is a subjective process that should reflect the objective of the evaluation and respond to the major concerns of the end-users.

As so, we have considered two types of soil quality indexes so far: 1) *Index AVG* – the average index, which considers the same weight for each soil quality indicator; 2) *Index STE* – soil threats significance reported by the end-users. In the second approach, the awareness of end-users regarding which soil threats are more significant in their specific plot/farm will determine the sensibility of the Soil Quality Index towards different threats.

$$AVG = \frac{\sum_{i=1}^{n} SoilIndicator_i}{n}$$

Where *SoilIndicator* is the value calculated for each soil threat indicator and *n* is the total number of soil threat indicators.

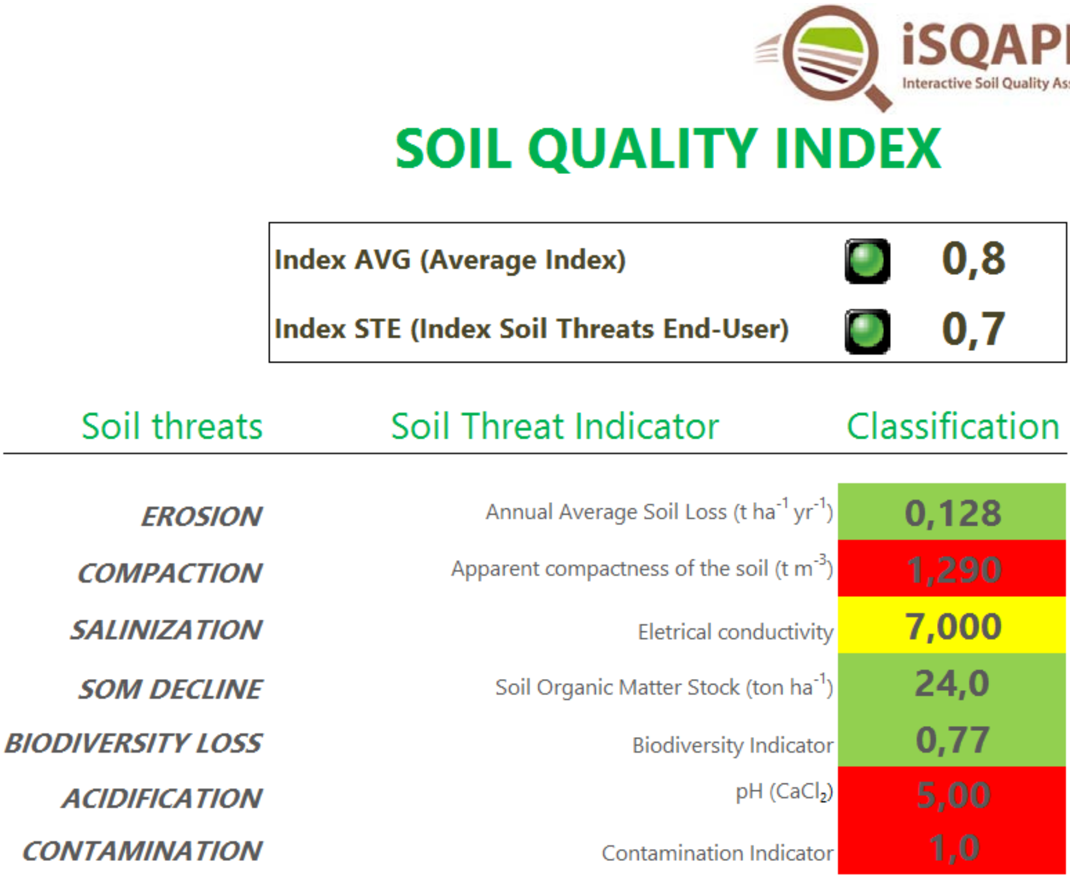


Figure 29 – Soil Quality Index calculation (example)

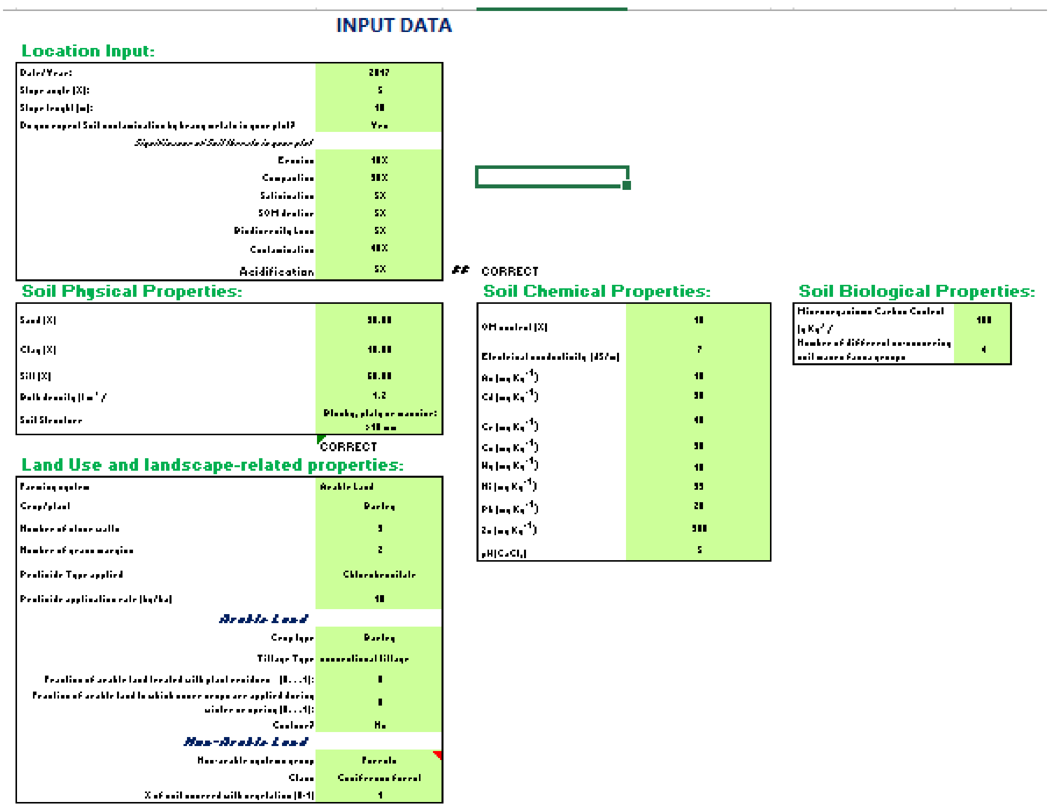


Figure 30 – Input data for Soil Quality Index calculation (example)

$$STE = \sum_{i=1}^{n} SoilIndicator_i \times significance_i$$

Where *SoilIndicator* is the value calculated for each soil threat indicator, *significance* is the percentage of significance attributed by the end-user to the specific threats and *n* is the total number of soil threat indicators.

The soil quality Index described here was implemented in a simple Visual Basic algorithm using excel sheets. The program is able to calculate the several soil threat indicators, evaluated them and finally calculate the soil quality index (Figure 29), from a set of information, provided by the end-users (Figure 30).

Task 6.3: Assess parameters/indicators (including SQAPP) for testing and evaluation of innovative management practices

Based on the definition of the key and site-specific parameters and indicators (Task 2), their assessment at the selected Case Study Sites (Task 1) in collaboration with local stakeholders and research institutions will be the core activity of this WP. The idea here is to distinguish between soil quality parameters that are responsive to changes in management in the short term and those that take several years to respond. The first ones will be assessed at the beginning of the task and again towards the end, whereas long-term change parameters will be assessed once comparing soils under contrasting management systems from long-term replicated field experiments and from paired field sites. Once available, the beta-release version of SQAPP (WP4) will be additionally employed to test the usefulness of the tool to monitor soil quality improvement. Environmental resilience will be assessed based on the study indicators assessing natural capital (soil, water, climate, and vegetation).

Based on the work developed in task 6.2, a questionnaire (excel file SQ1_SQ2_WP5_WP6_2018, sheets SQ_WP6_AMP and SQ_WP6_Control) to be filled by the CSS team coordinators, for each pair AMP-Control selected (task 6.1), was prepared, comprising the information needed on soil parameters (physical, chemical and biological), farming system, land use, landscape features, agricultural measures, topographic and geographic information. A Guide was prepared to support the filling of the questionnaire, the field measurements and observations, and laboratory work (Soil Quality Assessment. General Guidelines for the Field, Desk and Laboratory Work of WP6-Task 6.3).

Activities and results

Based on the work carried out in task 6.2, a set of soil parameters measurements are proposed to assess the soil's vulnerability to and impact already suffered from different soil threats, at the 24 AMP-Control selected sites (task 6.1).

A questionnaire was built and integrated in excel file SQ1_SQ2_WP5_WP6_2018, for the AMP and the control plots, that also comprises the questionnaire for visual soil assessment (WP5). Table 21, depicts the fields that compose the questionnaire. For further details on the questionnaire structure, please see the excel file. To support the field and laboratory work, and to assure that the same observation and measurements methods are used, hence data allows comparisons, a comprehensive Guide was prepared (for further details, please see file *Soil Quality Assessment. General Guidelines for the Field, Desk and Laboratory Work of WP6-Task 6.3*). These measurements are currently being made by the CSS partners.

Table 21- Required information for soil quality assessment

Main Group	Group	Fields
General farm, plot and management information	General farm Information	• Plot location (CSS) • Plot number (in iSQAPER) • Researcher responsible for the collection/analysis • Contact email • Phone contact
	General plot information, land use and agricultural measures	• Plot centre coordinates • Plot area [ha] • Slope angle [%] • Slope length [m] • Do you expect heavy metal contamination in your plot? • If yes, what is the source? • If yes: Which heavy metal contamination (As, Cd, Cr, Cu, Hg, Ni, Pb, Zn) do you expect? • Do you expect pesticide contamination in your plot? • Is there an input of manure / slurry / sludge in your soils? • If yes: is there any analysis of heavy metal content? • If there's an input of manure/ slurry/ sludge: Please provide details concerning the type applied and the amount [kg ha-1]. • Is salinity or any other soil crust/hardpan inducing source a problem in your plots? • If yes, please mention the source of soil salinity, and whether or not it induces a soil crust, and hardpans you may encounter in the profile. • Do you use plastic mulch in your soils? • If yes: Please describe the plastic mulch management. • Number of stone walls in the plot. • Number of grass margins / stripes in the plot. • Is there any contour farming measure? • If yes: please describe the contour farming measure. • What is the importance of soil threats in your plot? (8 threats to be evaluated) • What is the farming system? **Arable Land:** • Please indicate the main three crops / plants in your rotation.

		• Please indicate more details of the actual or the normal crop rotation in your plot relevant for 2018. • Tillage type. • If your tillage practice is not in the list, please name it. • Tillage frequency per year. • Tillage depth [cm]. • Secondary soil tillage type. • Secondary soil tillage frequency per year. • Fate of plant residues for the cropping season of 2018. Type of plant residues. • Amount left [t ha-1]. • Percentage of soil covered [%]. • Cover crops during winter? • Cover crop (specie). If it's a mixture (species). • Sowing date (dd-mm-yyyy) • End date (date of the final intervention (cut, burried, etc)) • Percentage of soil covered [%] • Approx. biomass left [t DM/ha] **Non-arable system:** • Details of the farming system: Plants species; management practices. • Percentage of soil covered by crop canopy. • Percentage of soil covered by other vegetation.
Soil examinations, soil properties	Soil physical properties	• Is there anything particular about the soil at your testing site? If Yes: please mention them. • Estimation of the stone content. Granules and pebbles (2-64 mm). Cobbles (64-256 mm). Boulders (>256 mm). Form of the stones. Content in [Vol.-%] >2mm. • Soil texture. Sand [%] (2 - 0.1 mm). Fine Sand [%] (0.1 - 0.05 mm). Silt [%] (0.05-0.002 mm). Clay [%] (< 0.002 mm). • Bulk density [t m-3]. • Soil Structure.
	Soil biological properties	• Microorganisms Carbon Content [g kg-1]. • Number of different co-occurring soil macro fauna groups.
	Soil chemical properties	• OM content [%]. • pH (CaCl2). • Electrical conductivity [dS m-1]. • Total N (mg kg-1 of soil). • Total P (mg kg-1 of soil). • Extractable P (mg kg-1 of soil). • Extractable K (mg kg-1 of soil). • Heavy Metals (mg kg-1 of soil): As, Cd, Cr, Cu, Hg, Ni, Pb, Zn.

The selected 24 pairs AMP-Control are shown in table 22.

Table 22- Selected 24 pairs AMP-Control, CSS, climatic region and georeferenced coordinates.

CSS	CLIMATIC REGION	PLOT Nº	GEOREFERENCED	coordinates	FARMING SYSTEM	FARMING SYSTEM DETAIL	SOIL TYPE	AMP Nº
The Netherlands	Atlantic	1.1	51,53948° N	5,848589° E	Irrigated land with arable and vegetable crops	Potato-pea/grassclover-leek-springbarley-carrot-silage maize (both in AMP and control)	Podzol/ Anthrosols	2
		Control	51,539474° N	5,848187° E				
		1.3	51,543047° N	5,849341° E	Irrigated land with arable and vegetable crops	Potato-pea/grassclover-leek-springbarley-carrot-silage maize (both in AMP and control)	Podzol/ Anthrosols	12
		Control	51,539442° N	5,846824° E				
France	Atlantic	2-1 AMP b	48,001360° N	1,449080° E	Arable land	Maize/cereal rotation	Cambisol	1; 9
		2-1 Control	48,070890° N	1,109390° E				
		2-3 AMP	48,068970° N	1,108080° E	Pasture intensive	Cows	Cambisol	
		2-3 Control a	48,068390° N	1,105920° E		Cows		
Portugal	Mediterranean temperate	3.2	40,237883° N	8,466333° W	Arable land	Maize	Fluvisols	8
		Control	40,220333° N	8,48125° W				
		3.7	40,422117° N	8,485689° W	Permanent crops	Vineyards	Cambissols	13
		Control	40,422667° N	8,485667° W				
Spain	Mediterranean semi-arid	4.5	38,164218° N	0,712572° W	Permanent - fruit trees and berry plantations	Pomegranate	Regosol	2; 3
		Control	38,190709° N	0,687498° W				
		4.12	37,855917° N	0,830250° W	Arable permanently irrigated	Pepper	Cambisol	9; 7
		Control	37,853980° N	0,831980° W				
Greece	Mediterranean temperate	5.9	35,320803° N	25,236560° E	Permanent crops	Olives	Regosol	1
		Control	35,321462° N	25,236689° E				
		5.12	35,295923° N	24,907333° E	Pastures	A grazing system in which the main grazing vegetation is sowed (cereals and legumes)	Cambisol	18
		Control	35,296190° N	24,907585° E		A grazing system in which the main vegetation consists of schlerophyllous, olive trees and annual natural vegetation		
Slovenia	Southern sub-continental	6.9	46,093771° N	14,495881° E	Non irrigated arable land	Organic farming with diverse rotation; manure	Cambisol	9
		Control	46,093537° N	14,495542° E		Only vegetable crops; compost		
		6.12	46,124762° N	14,495882° E	pastures	Grazing	Cambisol	18
		Control	46,124491° N	14,497139° E		Grass cutting		
Hungary	Southern sub-continental	7.1	46,788694° N	17,489417° E	Permanent crops	Vineyards	Cambisols	5; 8
		Control	46,788611° N	17,488778° E				
		7.5	46,715722° N	16,812917° E	Non irrigated arable land	Cereals; Maize; Oil crops	Luvisols	2; 8; 9; 11
		Control	46,703139° N	16,817944° E				
Romania	Northern sub-continental	8.8	45,229629° N	27,579469° E	Non irrigated arable land	Maize	Chernozems	14
		Control	45,197142° N	27,580508° E				
		8.11	45,284859° N	27,850021° E	Pastures extensive		Chernozems	18
		Control	45,304876° N	27,835111° E				
Poland	Northern sub-continental	9.1	51,993824° N	22,550696° E	Non irrigated arable land	Maize	Podzols	7
		Control	51,996773° N	22,547874° E		Cereals		
		9.3	51,313861° N	22,450944° E	Permanent crops	Hops	Cambisols	12
		Control	51,302610° N	22,422940° E				
Estonia	Boreal to sub-boreal	10.12	58,99181° N	24,871640° E	Grassland; conventional; intensive	Grassland for silage	Eutric Histosol	18
		Control	58,99232° N	24,874360° E	Non irrigated arable land; conventional	Cereals		
		10.14	58,2844° N	26,491210° E	Non irrigated arable land; conventional		loamy sand Stagnic Luvisol	2; 3; 5; 9
		Control	58,2861° N	26,493190° E				9
China - Qiyang	Central Asia tropical	11.4	26,761111° N	111,865278° E	Permanent crops		Acrisols	6; 7a
		Control	26,758333° N	111,871390° E	Permanent crops			

CSS	CLIMATIC REGION	PLOT Nº	GEOREFERENCED	coordinates	FARMING SYSTEM	FARMING SYSTEM DETAIL	SOIL TYPE	AMP Nº
China - Suining	Central Asia tropical	12.1	30,613067° N	105,022033° E	Arable land	Maize-Wheat rotation	Plaggic Anthrosols (Eutric)	8
		Control	30,613067° N	105,022033° E				
China - Gongzhuling	Middle Temperate	14.1	43,6125° N	124,794440° E	Non irrigated arable land		Phaeozems	8
		Control	43,6125° N	124,794440° E				
		14.4	45,258333° N	124,896389° E	Irrigated arable land		Chernozem	8; 14
		Control	45,262778° N	124,875560° E				

The future work consists in: 1) to correctly calculate the different Soil Quality Indicators based on each threat that ultimately conduces to the calculation of the Soil Quality Index. After this first evaluation, new parameters should be introduced, if the 'in situ' results show that more detail is required; 2) Offer suggestions concerning better management practices to be included in the tool (SQApp), depending on the soil threats most significantly affecting the soil. In this way, the end-user will not only obtain the evaluation of his/her farm/plot Soil Quality, but might also receive suggestions on how to improve it.

Future deliverables for WP6 are:

Deliverable 6.1 Internal report on performance of promising land management practices to populate recommendations of SQAPP [Month 48].

D6.2 Report on the performance of key and site-specific parameters and indicators for all monitored sites [Month 58].

Task 6.4: Organize demonstration events at selected field sites

From the existing long-term experiments and on-farm field sites some will be selected to organize demonstration events in order to communicate the impact of specific management practices on soil quality as well as on crop performance. At these events, the use of SQAPP will also be demonstrated. Local and regional, as well as European stakeholders will be involved in these events to guarantee the maximum outreach of the innovative practices and the tool capable to assess soil quality.

1.2.7 Work Package 7

Summary

The upscaling analysis will be based on definition of indicators that define the agricultural systems (WP2) and agricultural practices (WP3) in each pedo-climatic zone. Trends will be evaluated and the appropriateness of extrapolating these trends spatially (into main agricultural regions) and temporally (into the future) will be explored. In doing this, due attention will also be given to policies aiming at restructuring the European agricultural sector (developed in WP8). The case studies (WP5, WP6) will inform and validate the continental-scale indicators. The analysis will support SQAPP (WP4). The dynamic component of the evaluation is essential for the analysis. Over the past decades agricultural management in Europe and China has changed considerably driven by various economic, social and demographic factors and changes in consumer preferences and demand. It is to be expected that these changes in farming systems and agricultural management will continue into the future.

Specific objectives:

1. Define typical farming systems in Europe and China (geographical zones, management practices) and their effects on soil quality (Task 1);

2. Identify key management practices affecting soil quality and their applicability in various farming systems in Europe and China (Task 2);

3. Develop scenarios of future farm and soil management systems in Europe and China for improved productivity (crop yield and yield stability) and enhanced soil quality (Task 3);

4. Evaluate scenarios of changed soil environmental footprint for a range of policy scenarios using the model tools in Europe and China (Task 4).

Task 7.1: Define typical combinations of farming systems and agricultural practices and their effects on soil quality (Lead partner: UPM, partners: JRC, UP, ISS)

Task 1 will identify and characterize a relatively limited number of typical European and Chinese farming systems with relevant soil quality indicators and management building on work from WP2 and WP3 and the information of previous projects such as SmartSOIL, CATCH-C, and RECARE. Elements of the characterization of these typical farming systems will include: geographical zones, spatial extent, productivity level and intensity of land and resource use, management practices, and water availability. The farming systems characterized will provide a broad overview of the different types of systems that are common in Europe and China. Due attention will be given to finding an appropriate balance between the maximum number of farming systems that can be distinguished and the minimal number of systems that should be considered in order to obtain a representative view. These generalised results for Europe and China will be compared with inventories conducted in the case study regions (WP5).

Activities and results

Numerous technical improvements and agricultural management practices have facilitated the improvement of soil ecosystem services with an improved environmental footprint. It is to be expected that these changes in agricultural practices will continue into the future. Based on historical records of crop and soil management practices in Europe and China and models of the main ecosystem services, WP7 will estimate the future environmental footprint under different climate and policy scenarios. In doing this, due attention will also be given to global environmental and climate policies.

WP7 upscales the effect of agricultural management practices on representative farming systems to evaluate the soil environmental footprint in Europe and China. Current and future scenarios will be evaluated. The work relies on the extensive and comprehensive work developed in WPs 2 to 8 (Figure 2). WP7 also develops a socio-economic analysis to represent the social, economic and demographic changes that induce changes in farming systems and management practices. WP2 provides detailed pedoclimatic analysis, that is the basis of the spatial analysis in WP7. The background information on farming systems, agricultural management practices and soil quality indicators developed in WPs 3 and 5 supports the assessment with rich data and analysis of the process at the site level. The effect of agricultural systems in soil quality is based in the data provided in WPs 5 and 6. The scenarios for policy are based on interactions and ongoing discussions with WPs 4 and 8. WP7 captures the real farmers and policy knowledge by co-developing a dynamic model with stakeholders; the interaction will take place by informal consultations and in a formal workshop (Figure 31).

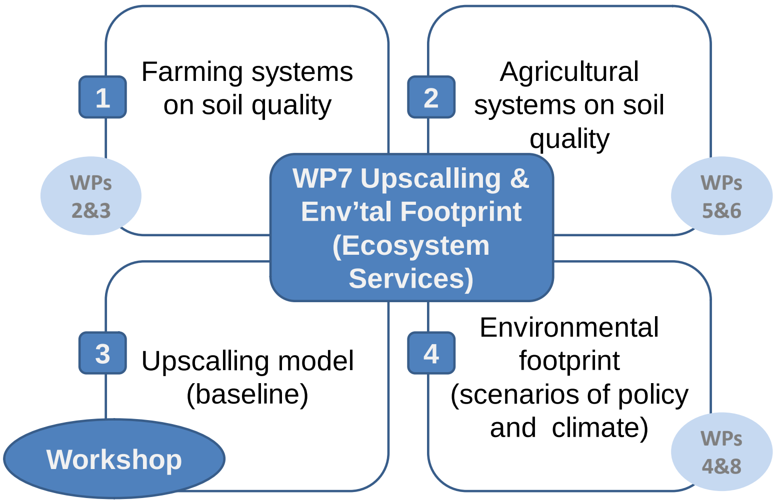


Figure 31. Approach to evaluate the environmental footprint in WP7

A main effort in D7.1 is to identify and characterize a relatively limited number of typical farming systems in Europe and China with relevant crop and soil management practices building on work from previous WPs of the iSQAPER project. In this document we present the proposed methodology for upscaling in the iSQAPER project. Upscaling intends to assess soil environmental footprint and therefore it is focused on three main ecosystem services linked to soil quality: food provisioning, water provisioning and regulation, and climate regulation. The analysis is based on three categories: farming systems, agricultural management practices and soil quality factors.

The work in WP7 builds on elements and resources for the characterization of the soil threats, pedoclimatic zones, typical farming systems, and typical agricultural practices, that have been analysed and reported in WP 2, 3, 5, and 6. Many aspects and data have been mainly collected from different iSQAPER partners, official databases (such as Eurostat) and also from global datasets (JRC, MapSpam, EarthStat, ISRIC, FAO). We build from these publicly available datasets on soil, agriculture, physical context and socioeconomic context. These data have been compiled, processes and projected on a common geospatial framework that allows for cross-data analyses.

The categorization of farming systems, agricultural management practices and soil quality indicators is based on work carried out in iSQAPER and previous projects concerned with soil health. This work has been carefully reviewed and analysed in order to extract the most relevant features for upscaling. In each agricultural region there may be a very large number of indicators for upscaling. In our methodology, we provide a balance between the maximum number of indicators that can be distinguished and the minimal number of systems that should be considered in order to obtain a representative view of the effect of soil management practices on the environmental footprint. As a result, a proposal is made to consider seven categories of farming systems (cereals, rice, maize, soybean, vegetables, pasture and permanent crops), five categories of agricultural management practices (soil management, crop management, nutrient management, water management and organic agriculture) and three categories of soil quality indicators that can be linked to ecosystem services (crop yield, organic carbon and water holding capacity). All these categories are based on analyses carried out in WP3, 5 and 6 of the iSQAPER project. Based on these studies the categories have been properly defined and characterized.

The farming systems selected in Deliverable 7.1 provide a broad overview of the different types of systems that are common in Europe and China. These farming systems are characterized in Deliverable 7.1, including: geographical zones, spatial extent, productivity level (e.g. Figure 32) and intensity of land and resource (fertilizer and manure) use, management practices, and irrigation. We have compiled data from all categories of farming systems, management practices and soil quality indicators and present a spatial representation of the available information for Europe and China. It includes, spatial location, intensity of resource use and crop yield for farming systems, degree of implementation for agricultural practices and available information on soil quality status. These generalised results for Europe and China will be compared with inventories conducted in the case study regions. This will be done in Task 7.3.

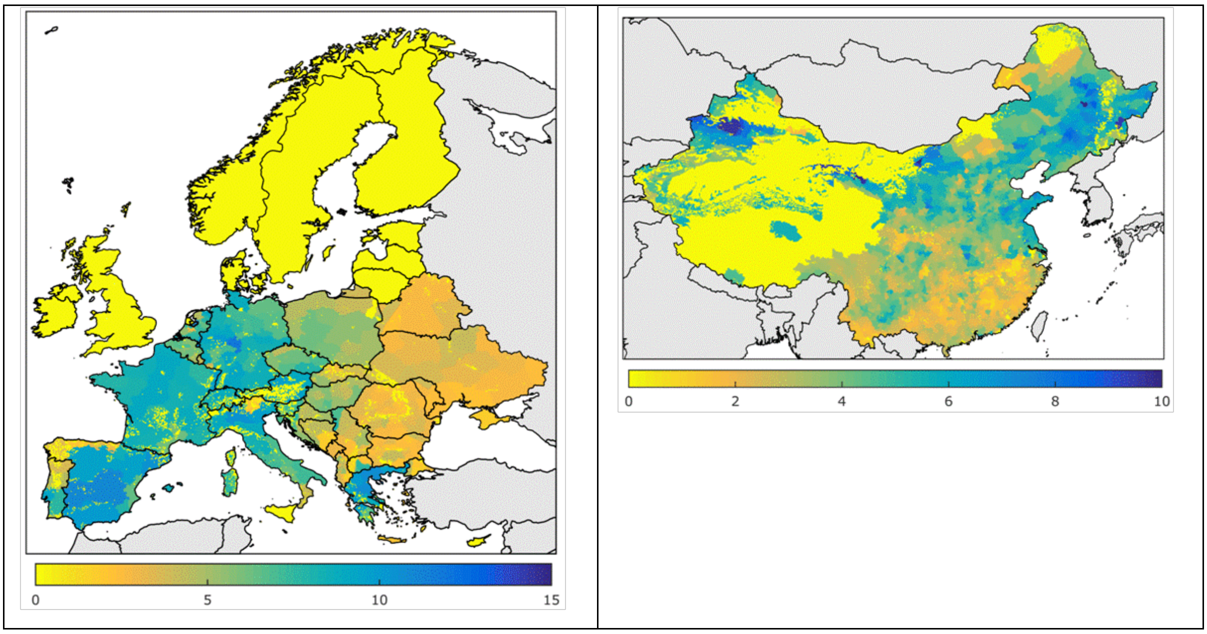


Figure 3. Maize yield in Europe and China (t/ha)

We present an analysis of the combinations of farming systems and agricultural management practices in Europe and China, together with an estimation of the influence of AMPs on soil quality, based on geostatistical inference derived from the spatial datasets and on iSQAPER project results derived from the long term experiments and from the case study sites (e.g. Figure 33). This approach will be validated in bottom-up expert assessment through a questionnaire that will be circulated among project partners.

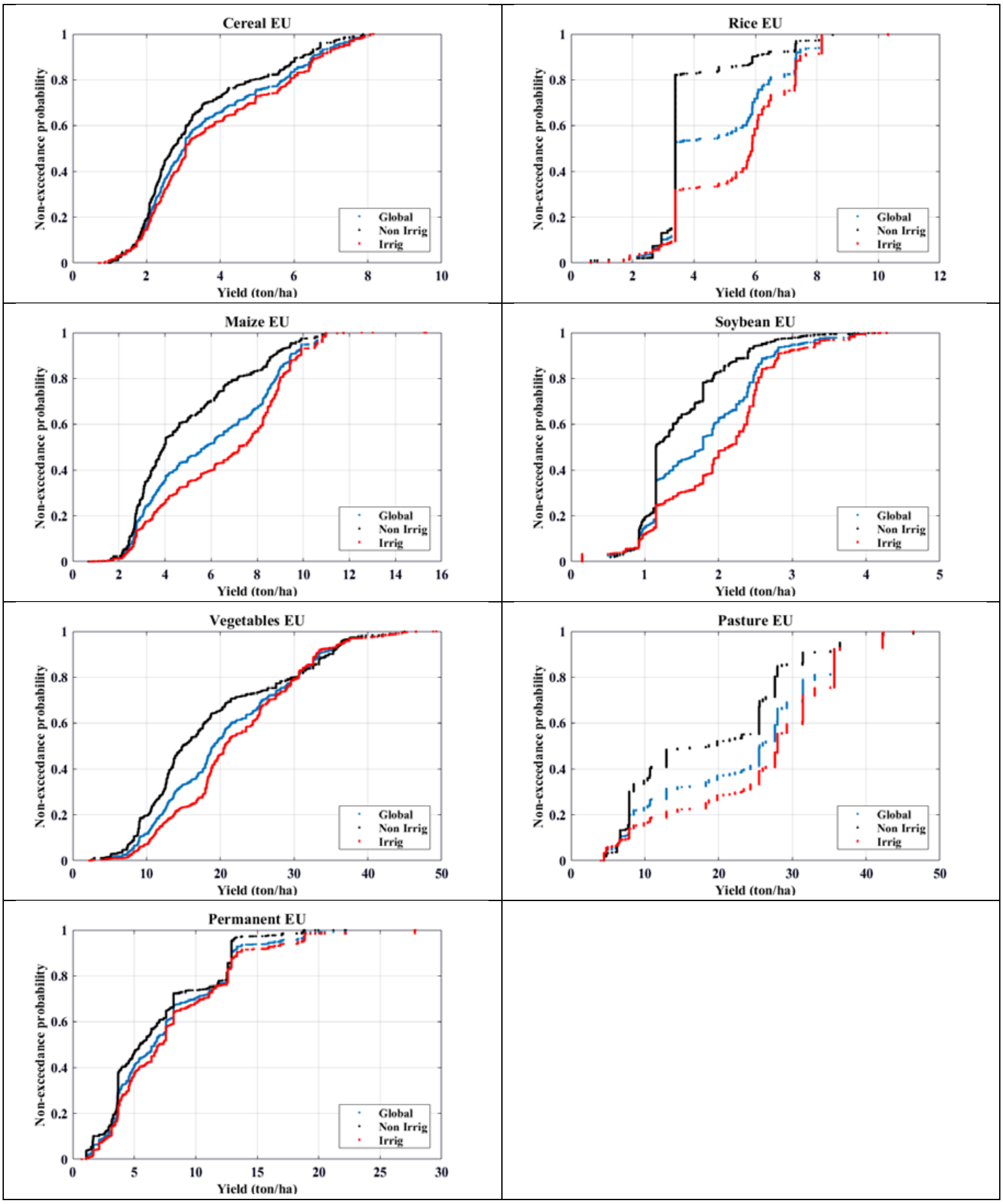


Figure 33. Results of the conditional probability analyses performed on crop yield as a function of irrigated area for the seven farming systems in Europe: Cereal (1st row left), Rice (1st row right), Maize (2nd row, left), Soybean (2nd row, right), Vegetables 3rd row, left), Pasture (3rd row, right) and Permanent crops (4th row)

1.2.8 Work Package 8

Summary

The purpose of this WP is to identify ways in which the data, increased understanding, specific tools and indicators and more empirical insights from the project as a whole can be deployed in policy relating to soils, with particular reference to the CAP. It is widely understood that the pressures on agricultural soils in Europe can be detrimental, both environmentally and to the productive capacity of farmland. However, there are a number of barriers to the design and implementation of policies to ameliorate these pressures and to improve management. These barriers include the difficulties of accessing scientific and agronomic data and deploying it at the appropriate level in order to design policy measures which are valid and efficient in a range of different agricultural conditions. The costs and practicalities of monitoring soil characteristics on more than a small scale have inhibited policy making in many Member States. It can be difficult to specify those management practices required to meet soil quality objectives in a way which is both precise and relevant to variations in soil, cropping patterns, farming practices, climate and weather conditions, etc. There is a lack of credible low cost tools which farmers can use to appraise soil conditions and plan management changes in relation to variable requirements including, for example, enhanced carbon sequestration.

The project will generate both data and accessible, cost efficient tools (i.e. SQAPP) which farmers will be able to utilize in order to monitor and respond to changes in the critical parameters of the soil on their holdings. These insights and outputs can be applied to policy at different levels, from the broader European scale/level down to the individual farm. Lessons will be drawn from the different WPs to help design policies which introduce obligations on farmers, such as the GAEC component of cross-compliance, and those which involve voluntary agreements, such as agri-environment schemes. Given the timing of the project we will both comment on the existing CAP infrastructure and future models proposed post 2020.

Soil monitoring tools have the potential to allow a more proactive role for farmers in meeting defined objectives and will assist the capacity of public administrations to evaluate the efficacy of different management practices. Policy measures then can be better calibrated to the most effective forms of management and progress made towards a predominantly results-based approach in agri-environment policy. The analysis will support wider policy conclusions relevant to measures in the current programming period and to the design of the next set of CAP reforms to be completed by 2020.

It should also be noted that a further important policy nexus of interest for the work package is the the implementation of soil relevant Sustainable Development Goals, particularly SDG 2 (zero hunger) on sustainable agriculture (target 2.4) and SDG 15 (life on land) on land degradation (target 15.3). Given the international reporting anticipated under the SDGs it is anticipated that governments from all around the world, will (start to) report on their implementation against the relevant soil protection and agricultural sustainability indicators. Indicators relevant for iSQAPER like “proportion of agricultural area under productive and sustainable agriculture” (2.4.1) and

"proportion of land that is degraded over total land area" by comparing land cover change, net primary production and soil organic carbon (15.3.1) may create increased awareness of the challenges and policy needs. They also represent an important outlet for work on indicators and monitoring ie to demonstrate compliance. These issues will also be considered within the WP8 analysis.

Work Package Objectives and Progress

The following table summarises activities completed under the different objectives of the work package. It should be noted that the objectives are closely linked to the deliverables and tasks under the work package. The first deliverable was completed during the programming period ie Deliverable 8.1. Work has been systematically completed in line with the objectives, as set out below; however, none of the objectives are yet completed in full. While the objective to deliver a stocktaking has been undertaken, and deliverable 8.1 submitted, it was agreed with Commission officials at the first review meeting in February 2017 that the policy analysis elements should continue throughout the project rather than halt in month 27. This is intended to ensure a rolling programme of relevant policy information emerging both to inform other iSQAPER work packages and experts, and policy makers. Moreover, the timing of iSQAPER in terms of the CAP reform process and other key political debates, for example on the role of soil management in delivering greenhouse gas emission reductions, means it is helpful to retain upto date policy inputs.

Table 23 – A summary of Progress Towards the Objectives as set out for WP 8

Objective	Description	Summary of Progress
Undertake a stocktaking of existing policy measures aimed at improved soil management and the scientific foundation on which they are constructed	This objective essentially translates into Task 1 of the WP and deliverable 8.1 due in month 27. Deliverable 8.1 will now be supplemented by Deliverable 8.1b in June 2019 to capture the work completed on an ongoing basis and inform the D8.2-8.4	The following activities have been completed and incorporated into Deliverable 8.1 – • A review of the literature relating to policy needs for soil protection has been completed, along with a review of policies active at EU level relevant to soil protection on agricultural land. This analysis has been compiled into a book chapter and accepted for an upcoming publication, developed in collaboration with the RECARE project. • A detailed analysis has been completed on the existing CAP policy instruments and their role in protecting agricultural soils and the limitations associated. These are examined in D8.1 and were also published in a policy briefing in December 2017, which was distributed at COP23 of the UNFCCC and launched online on world soils day. - https://ieep.eu/uploads/articles/attachments/63232170-4433-45c8-835c-cfec96a3951b/iSQAPER%20Joining%20the%20Dots_briefing%20paper_FINAL.pdf?v=63679624158 • A detailed review of national policies in the EU 28 Member States relevant to the protection of agricultural soils has been completed and included in D8.1; this will be complimented by a parallel analysis of policies in China (already progressed, see below). It is hoped that some form of either policy briefing or paper will be developed based on the national review of European policies and the Chinese review in 2018. • Briefing paper "Grounding Sustainability: Land, Soils and the Sustainable Development Goals", which is an analysis of the UN Sustainable Development Goals in relation to the protection of (agricultural) land and soils and the governance environment needed. The briefing paper which was published and presented during COP 13 of the UNCCD in Ordos, China and made available online - http://www.bothends.org/en/Publications/document/188/Grounding-Sustainability-land,-soils-and-the-SDGs • Promotion to policy makers of the results of a study led by WUR on the presence and concentrations of glyphosate in European soils and the impact on soil health https://www.wur.nl/en/newsarticle/High-levels-of-glyphosate-in-agricultural-soil-Extension-of-approval-not-prudent.-.htm • Dialogue with EU and Dutch policy makers concerning the environmental footprint of EU's large-scale agricultural feedstock imports, the environmental footprint of EU agricultural system and its impact on soil health, local farmers and climate in the EU and in countries of origin. Policy asks to the EU on reducing the EU footprint of supply chains of agricommodities: http://www.bothends.org/uploaded_files/inlineitem/1180321_ENGLISH_Amsterdam_Closing_Gaps_recs_February.pdf At the meeting (Nov 2017) of the WP8 team and following discussions at the WP leaders meeting (Jan 2018) a list of priority issues for examination in the subsequent period under the WP8 was identified – see table 24 below. Work has already commenced on some elements including the review of policies in China,

		the analysis of SDG 2.4 with reference to SDG15.3 on land degradation and other relevant SDG targets and the question of sustainable and productive agriculture in the context of soil protection. These will be published as a series of briefing papers over the next 18 months and combined to form D8.1b to compliment the analysis in D8.1.
Draw on earlier WPs, extracting policy relevant data and insights for the design of specific measures addressing agricultural soils	This objective essentially translates into Task 2 of the WP and deliverable 8.2 due in month 50 (June 2019).	While the main focus of work will be later in the project initial discussions have been undertaken both in terms of understanding and inputting to the design of data collection and the use of data in the project. Specifically, discussions have been held with Task 5 and Task 7 regarding the inputs and outputs likely. We have also started discussions with Task 3 on indicator information and how to combine this with the findings of Task 5 to produce more reliable indicators overall and communicate this to policy makers. Training completed for all iSQAPER participants on the CAP and on the SDGs was intended to provide insights on tailoring of analysis to be relevant to the political and policy context.
Demonstrate how SQAPP can be utilized for different policy purposes, e.g. in cross compliance and agri-environment measures	This objective essentially translates into Task 3 of the WP and deliverable 8.3 due in month 56 (Dec 2019).	While the main focus of work will be later in the project initial discussions have been undertaken both in terms of understanding and inputting to the design and data collection for the app. Training completed for all iSQAPER participants on the CAP and SDGs was intended to provide insights on tailoring of app to be relevant to the political and policy context.
Draw wider policy conclusions relevant to the green components of Pillars 1 and 2 of the CAP aiming at the design of more efficient and effective measures, particularly post 2020	This objective essentially translates into Task 4 of the WP and deliverable 8.4 due in month 58 (Feb 2020).	While the main focus of work will be later in the project initial discussions have been undertaken across partners in WP8, WP9, WP7 and with project coordinators to try to pulling out common themes and policy areas that can provide a thread throughout the work under iSQAPER and provide for coherent conclusions. Moreover, at the WP leaders meeting (Jan 2018) some topics and elements around indicators emerging from WP3 and WP5 were discussed. Training completed for all iSQAPER participants on the CAP and SDGs was intended to provide insights on tailoring of analysis to be relevant to the political and policy context.

Details for each Task under WP8

Task 8.1: Undertaking a stocktaking of existing policy measures aimed at improved soil management (Lead partner: IEEP, partners: Case Study Site partners)

This creates a baseline for further work in following tasks. It elucidates the measures now being taken specifically to address soil related concerns in different farming systems, including organic agriculture. The purpose is to establish how far policy measures could be informed and enhanced by the results of earlier WPs and the scope for initiating innovative approaches in future. The stocktaking survey is selective rather than comprehensive but covers a range of different Member States and farming systems, so that it is sufficiently representative of the EU as a whole, also taking account of experience in China as appropriate. Problems identified in designing, implementing and monitoring policy measures at different scales will be documented and key cross-cutting issues identified.

Task 8.2: Drawing on earlier WPs to extract policy relevant data for the design of specific measures addressing agricultural soils (Lead partner: IEEP, partners: BothENDS, UNIBE, UE, MEDES)

WPs 2-7 will generate a range of insights, specific data and documentation of the experience of multiple stakeholders in different parts of Europe and China, and other information, which will potentially be applicable in different policy settings at different scales. This needs to be assembled in such a way as to have the greatest direct relevance to policy practitioners, including farmers, extension workers, and those engaged at the field level. This will take a number of forms, including short summaries of key findings, illustrations of best practice, and selective references of readily digestible research findings to be prepared, presented and disseminated in collaboration with WP9. Guidance on the utilization of new approaches, implications for monitoring, administration, and public expenditure, and insights into engagement with stakeholders will be prepared.

Task 8.3: Demonstrating how SQAPP can be utilized for different policy purposes, e.g. in cross compliance and agri environment measures (Lead partner: IEEP, partners: UPM, UE, Case Study Site partners)

Once SQAPP has been refined and assessed under different conditions in Europe its practical application in monitoring soil quality for policy purposes will be explored in this task. Applications might include roles in ex-ante and ex-post assessments of soils where policy interventions are being concentrated, broader assessments of the need for and potential scope of changes of management, allowing fine tuning of policy measures and possible applications at farm level, where farmers are obliged or incentivised to undertake more focussed analysis of soil conditions and develop remedial measures. These applications will be summarised in a report identifying the key issues arising from the perspective of different stakeholders, who have been introduced to the tool, including public administrations.

Task 8.4: Drawing wider policy conclusions relevant to the green components of Pillars 1 and 2 of the CAP aiming at the design of more efficient and effective measures, particularly post 2020 (Lead partner: IEEP, partners: BothENDS, UPM)

The final analysis will apply the results of the foregoing tasks to the policy agenda at the time of the completion of the project, around 2019. This includes an overview of ways in which policy could be more finely tuned to a range of concerns about soil quality and functionality from the local and regional up to the European scale. It will help to sharpen policy design and strengthen assessments of the scale of management change which might be required to meet key soil objectives in different regions and systems and so inform a new generation of policies which will be in the process of being developed towards the end of the current CAP programming period as draft legislation is prepared for policy after 2020.

Description of the Work Completed

Tasks 2 through 4 are focused primarily in the latter end of the iSQAPER project, resulting in deliverables between month 50 and 58. Therefore activities under these tasks have been limited during this period; however, preparatory work has been completed to set the scene for the work including:

- Building on internal training on the CAP and analysis within D8.1 IEEP developed a short policy briefing explaining key elements of the current CAP relevant to soil protection. This was circulated internally as a resource within the consortium, as well as externally at COP 23 of the UNFCCC and part of communications around World Soils Day 2017.
- Webinar on SDG target 15.3 on land degradation November 2016 - Policy brief and summary of the analysis of land and soil related SDGs, including a workshop with the iSQAPER consortium on the role of academics and iSQAPER partners in the SDG implementation and monitoring, three areas of outcomes were identified: on knowledge development, advice to governments and monitoring.
- At the plenary meeting in Beijing, BothENDs providing training on the SDGs and coordinated a discussion on their relevance in the context of the iSQAPER project based on the policy briefing they had prepared on the SDGs, soil and governance issues – circulated at the UNCCD COP 13. This was intended to allow space to discuss the relevance of the SDGs to the iSQAPER project and an opportunity for partners to think how we might make links to the work.
- At the WP leaders meeting in Evora (Jan 2018) a discussion was held to examine emerging issues and topics on the political agenda relevant to iSQAPER. This was based on discussions of the WP8 team in November 2017 and was intended to provide a coordinated direction of policy analysis and a horizon scanning to ensure outputs of the project are considering the emerging policy agenda.

Task 1 has been the focus of activities, with the development of training materials, policy briefs and the knowledge base presented in D8.1. Task 1 under Work Package 8 of iSQAPER is to 'Undertake a stocktaking of existing policy measures aimed at improved soil management and the scientific foundation on which they are constructed'. The intention is that this analysis will create a baseline for further work both within WP8 and other work packages. It also provides a basis for communicating with policy makers and coordinating messages on key themes to highlighted in the work emerging from iSQAPER. For example, the use of briefings produced by BothENDS and IEEP at relevant COP for the UNCCD and UNFCC respectively. Moreover, incoordination between

WP8 and WP9, BothENDS supporting the promotion of WUR-led analysis on glyphosate in soils. Moreover, IEEP and BothENDS have been coordinating with the WP9 team in order to provide consolidated, targeted messages around key timely events to communicate messages from iSQAPER to policy makers and beyond. This included coordination of messages on plastics around World Environment Day and the development of a complimentary policy brief by IEEP.

The stocktaking looks at key elements of policy relevant to iSQAPER at the International, EU and national (and on some occasions regional) level to understand the nature of support for soil management now and into the future. Given the need to scope out the key policies of importance to the iSQAPER team and the future of soil protection, a selective approach to determining the topics of focus was adopted (as per the original project specification). This was based on discussions with all members of the consortium, including responses to a questionnaire discussed with all partners either before or during 2016 plenary meeting. On this basis the subjects of most use and relevance to our work were identified. Based on this and an understanding of the issues of political importance and relevance to wider work packages the first deliverable under WP8, Deliverable 8.1 focused on:

- the challenges of policy making for soil protection and possible solutions;
- policy developments at the international level, specifically the evolution of the Sustainable Development Goals and the concept of Land Degradation Neutrality;
- policy at the EU level relevant to soil protection on agricultural land;
- analysis of the role of the EU's Common Agricultural Policy in soil protection and opportunities for improving soil quality; and
- policies existing at the national level in Europe relevant to securing the protection of agricultural soils outside of formal agricultural management provisions – which are controlled by the national implementation of the CAP.

The above analysis will be, or has already been, published as a series of iSQAPER policy briefings to communicate the key messages to the wider academic and policy community.

Deliverable 8.1 represents the first collation of policy analysis under iSQAPER. However, in addition a further collation of work will be completed to complement this report and take forward themed analysis identified as next steps (presented here Table 24). This second report will be prepared ahead of the project's conclusion and will draw together analysis and research concluded after February 2018 (to be termed Deliverable 8.1b). Building on the analysis in Deliverable 8.1 it was further agreed to take forward additional analysis based on the key areas and issues of interest identified. Importantly, the proposed research is intended to cover the international, European and Chinese policy context. It was decided, in consultation with Chinese partners, that it was first best to develop the national analysis for Europe and then use this as a template upon which to build the analysis of Chinese policies. This work commenced as of October 2017, based on Section 3.4, in collaboration with all willing partners. This analysis will be concluded in the summer of 2018, following discussions at the project plenary taking place in June.

Table 24 – Summary of next steps in the analysis of policy issues (under Task 1) relevant to agricultural soils and the delivery of iSQAPER – Determined based on the analysis completed so far, and discussions with both partners and stakeholders, regarding useful and usable outputs from WP8.

Title of Analysis	Coverage	Reason for Selection	Output/Timeline
Analysis of soil protection policies in China	A comparable analysis will be conducted of policies relevant to soil protection in China, based on the methodology and policy classifications used to analyse national policies in EU Member States	The project explicitly needs to span international, EU and national laws in Europe and China. At the plenary session in Sept 2017 partners expressed a desire to engage with this work collaboratively and develop analysis that can be read in conjunction with the EU analysis.	To be combined with analysis of EU national policies and national case studies to produce a policy briefing looking at key tools used in policy making to protect agricultural soils – June 2019
Linking management practices to policy	Reviewing the Agricultural Management Practices considered in WP5 of the project and other relevant examples based on the WOCAT materials and identifying the policy tools that could or already promote them.	Connecting policies at the international, EU and national level to AMPs that deliver change in on farm soil management.	To be combined with analysis of EU national policies, Chinese policies and national case studies to produce a policy briefing looking at key tools used in policy making to protect agricultural soils – June 2019
Understanding indicators and monitoring for SDG delivery – a specific focus on the definition of sustainable agriculture linked to the implementation of SDG 2.4 with reference to SDG15.3 on land degradation and other relevant SDG targets	This analysis will look in more detail at the indicators relevant to soil protection important to assessing the delivery of the SDGs. In particular, it was noted that under SDG 2.4 there is an important concept that is yet to be defined i.e. sustainable agriculture and the proportion of agricultural land considered to be managed sustainably.	During the SDG training session in September 2017 and during subsequent WP planning meetings it was identified that given iSQAPER's focus on monitoring and indicators this is a potentially important issue to engage with and also defining 'sustainable agriculture' in the context of soil management and iSQAPER findings could facilitate effective policy development. A discussion and training session is scheduled to focus on this in June 2018.	Briefing paper on wider definitional issues and the needs for soil protection related to sustainable agriculture; possible discussion session with key iSQAPER partners on this concept – Autumn 2018

Title of Analysis	Coverage	Reason for Selection	Output/Timeline
Reviewing the soil protection opportunities associated with the CAP post 2020	To review final proposals and measures for the CAP post 2020, once adopted, to understand the opportunities, needs and risks for soil protection on agricultural land and how these differ or are comparable to existing measures analysed in Section 3.2 and 3.3.	The policy brief, internal training and analysis on the CAP were considered by iSQAPER partners as highly useful and important to their understanding of context for the use of project outcomes. This analysis would provide understanding of opportunities in the forthcoming CAP period.	Training and discussion session for all iSQAPER consortium members - Estonia 2018 plenary meeting including a discussion and brainstorm session focused on crop rotation and nutrient management plans and needs in terms of soil quality in a future CAP.; subsequent webinar if needed on detailed questions on the future CAP in winter 2018. Policy briefing in standard format when final CAP proposals are fully published - Dec 2019 to replicate explanation of the existing CAP and support iSQAPER conclusions – December 2019. Possible interim analysis on key aspects of future CAP for soil protection ie crop rotation and nutrient management concepts.
Understanding the potential role of climate policy in protecting soils – opportunities, risks and limitations	Review of action related to climate mitigation and adaptation internationally and in Europe relevant to soil protection (Chinese examples to be included if possible). To examine more the emerging role of climate legislation, likely importance for supporting soil protection and the potential opportunities and limits to delivering land management change. The analysis will look explicitly at the	Within the analysis in Section 3.1, during discussions with iSQAPER partners and within the wider global debate on soil health, climate policies and the role of soils in sequestering carbon has been highlighted as an opportunity. This analysis rather than looking at the high level would review in depth the potential polices of relevance and how change can be delivered through land management	Internal webinar and launch of report potentially linked to UNFCCC COP 24 December 2018 side event to be organised by IEEP. Standard briefing format and launch on social media – December 2018

Title of Analysis	Coverage	Reason for Selection	Output/Timeline
	role of the protection promotion and monitoring of soil organic matter.	practices and improvements to soil quality on agricultural land. To make links to WP7 coverage.	
National EU Member State case studies	Reviewing the policy context in up to four Member States in the EU to understand the drivers and pressures and role of policy in determining land management decisions related to soil management. Understanding the policies in place that drive change and why.	Several national case study experts have expressed a desire to engage with the policy analysis. Moreover, based on analysis in 3.1 and 3.4 there is a desire to explore further the drivers of land management change, the role of policy and to link this to wider messages within iSQAPER on AMP adoption	To be combined with analysis of EU national policies and Chinese policies to produce a policy briefing looking at key tools used in policy making to protect agricultural soils – June 2019
Review of monitoring approaches to soils and indicators	Working collaboratively with WP3, WP4 and WP5 to understand the indicators emerging as important under iSQAPER for understanding soil quality and comparing these to monitoring approaches adopted at the EU, international and national level.	At the WP leaders meeting in January 2018 it was identified that there are potentially common messages highly relevant to policy makers emerging.	To be linked to wider outputs from iSQAPER on data (Task 8.2) - Autumn 2019
Consideration of contamination in the context of agricultural soils including plastics	Review of polices that exist targeting agricultural soils at the EU and national level in Europe	This was informed by discussions at the WP leaders meeting 2018 where a desire to better understand policies specifically focused on contamination of agricultural soils including protection in place to address the question of pesticide content of soils.	Focus on plastics policies, June 2018 - World Environment Day, wider pollution briefing World Soil Day – December 2018

Key Messages/Findings Emerging from Deliverable 8.1

Agricultural soils are multifaceted and heterogeneous, the product of natural processes combined with the land management practices to which they are exposed. When seeking to improve already degraded soils, limit future degradation, and promote associated ecosystem services it is important to recognise the diversity of potential intervention points. On the one hand this can prove challenging, as there can be multiple drivers placing pressure on natural systems (economic, environmental and social) that interact to potentially threaten soil quality. Yet it also represents an opportunity, with soil quality linked closely to the delivery of numerous other environmental goals, potentially offering multiple routes for change. For this reason, soil protection cannot be achieved through a single policy intervention.

Figure 34 conceptualises the question of soil quality and the delivery of soil health in terms of the environmental threats, outcomes and services associated with its delivery. Each of the different outcomes, threats and services may act as a point where policy intervention may be possible, whether this be to combat a threat or maximise a service to society. However as demonstrated in Figure 34 the ultimate goal or outcome might not be soil health or quality, but motivated by a need or goal in a different policy sphere. Moreover, multiple threats, functions and outcomes can be delivered by the same policy intervention.

The multiplicity of end points, goals and achievements based on a given intervention means that there are potentially significant opportunities and motivators to deliver soil protection on agricultural land. Moreover, there is added value across a number of policy spheres and end points associated with particular interventions. The challenge for delivering soil protection is connecting these elements, the actors, the stakeholder and the value associated with intervention.
The analysis of EU level policies and national policies adopted by Member States has identified numerous policy goals and types of policy instrument that either protect soils directly or contribute indirectly to soil protection (i.e. through the pursuit of other goals or objectives). The analysis identified that soil is commonly being protected as a means to deliver an alternative goal; whether climate change mitigation, climate adaptation, biodiversity protection, water quality and availability or resilient and sustainable agricultural production. To deliver soil protection in this context it is important to recognise the positive changes needed to support improved soil condition and fully integrate these priorities within wider policy goals.

The SDGs offer an opportunity to make links between policy areas and highlight the relevance of soil protection to the achievement of sustainable development. The 17 SDGs represent the heart of the 2030 Agenda, signed up to by 193 nations[1]. While non-binding, there is a weight of expectation that signatories will seek to deliver on and implement the goals[2]. SDGs divide responsibilities across both developing and developed countries. At their core the SDGs are a set

[1] On September 25th 2015, countries adopted a set of goals to **end poverty**, **protect the planet** and **ensure prosperity for all** as part of a new sustainable development agenda. Each goal has specific targets to be achieved over the next 15 years - https://www.un.org/sustainabledevelopment/sustainable-development-goals/ .

[2] Generated by the international community and also wider actors, the SDG development process sought to bring other actors beyond governments to support the SDGs including civil society and the private sector.

of interlinked objectives with soil protection and improved land management necessary for the delivery of multiple Goals. For example, the second SDG links hunger, food and nutrition security with sustainable agriculture[3]; illustrating the connection between environmental sustainability and social inclusion in the SDGs. The SDGs provide targeted commitments and a new language that can be used by all actors to discuss progress towards sustainable development, including the protection of agricultural soils.

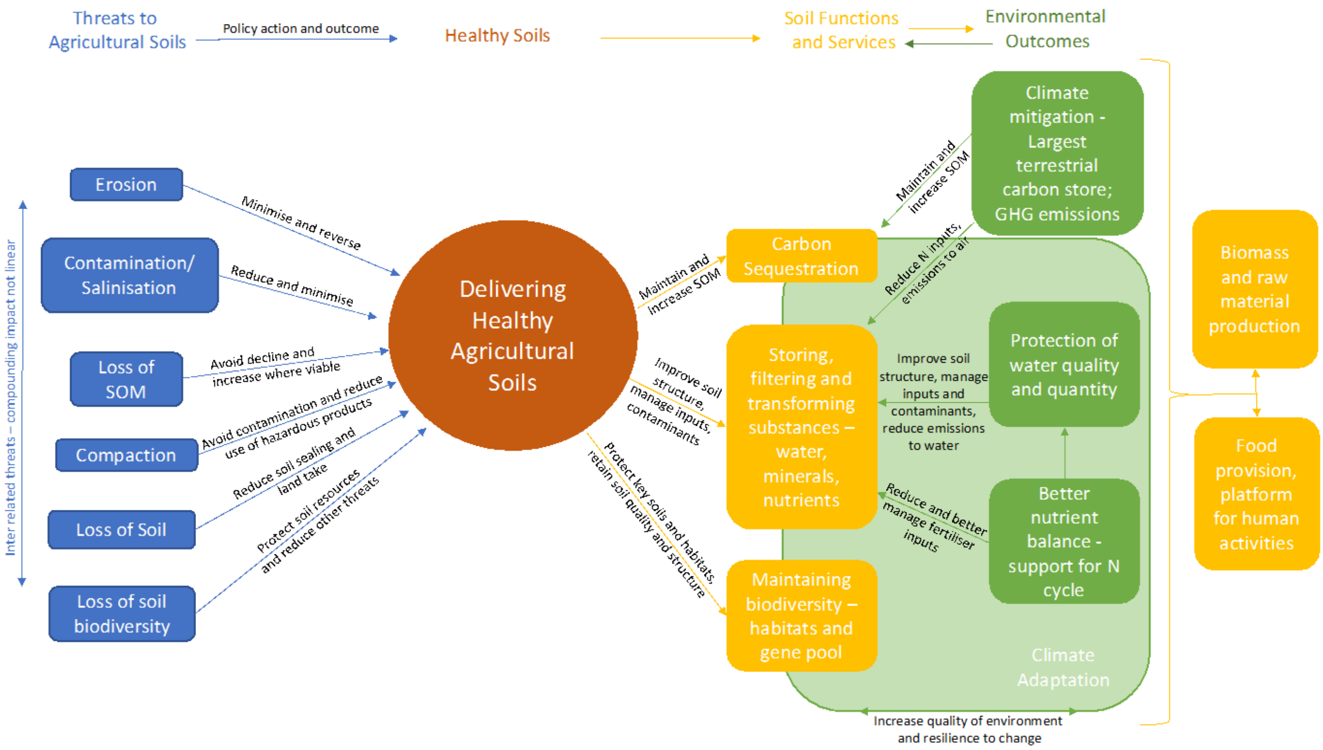


Figure 34 – Interpreting policy demands and needs based on the goal of delivering soil health on agricultural land, addressing key soil threats and delivering soil functions, services and wider environmental goals (Own compilation based on threats, functions and outcomes discussed in the Soil Thematic Strategy, FAO key documents and definitions)

The 2030 Agenda sets out ambitious targets for global transformation, yet in order to achieve change requires action in all signatory countries. To succeed, SDGs need to be integrated into national policy, central to policy implementation and monitoring frameworks. In Europe, EU Member States have in place a combination of policies and instruments adopted in response to EU level commitments (for example the Nitrates Directive), complimented by nationally initiated policies. The dual origins of policy priorities and instruments (i.e. EU and nationally initiated) are particularly significant in the case of soil protection. Compared to other environmental fields, nationally initiated laws and policies play a greater role given the lack of a common EU law focused

[3] FAO' vision of sustainable food and agriculture is "of a world in which food is nutritious and accessible for everyone and natural resources are managed in a way that maintain ecosystem functions to support current as well as future human needs. In this vision, farmers, pastoralists, fisher folks, foresters and other rural dwellers have the opportunity to actively participate in, and benefit from, economic development, have recent employment conditions and work in a fair price environment. Rural men, women, and communities live in security, and have control over their livelihoods and equitable access to resources which they use in an efficient way." http://www.fao.org/sustainability/background/en/ (accessed 6 July 2017)

on soil protection and the limitations placed on EU intervention in relevant policy spheres (such as land use planning). These national policies interact with EU laws and policies relating to water protection, nature conservation and pollution control and EU funding and support measures under the Common Agricultural Policy (CAP).

At the EU level a list of 35 key policies of importance for soil protection was analysed[4] to determine their relevance to the protection of agricultural soil specifically. Only 9 of these policies were identified as highly relevant to agricultural soils including: three measures related to the CAP (Cross Compliance, Greening and Rural Development Programmes; three measures related to the reduction of pollution (environmental liability, national emission ceiling and sewage sludge Directives); two related to the protection of water bodies (Water Framework Directive and the Nitrates Directive); and one linked to funding environmental and climate related projects (LIFE+). None of the policies identified as 'highly relevant' is specifically focused on soil protection. These findings highlight the importance of fully integrating soil needs into other spheres of policy action.

The importance of the CAP is highlighted in the analysis. While actions under the CAP were identified as important for soil in their own right, they are also key to delivering goals across multiple other policies that are highly relevant for soil protection. For example the CAP is used to support delivery of the Water Framework Directive and the Nitrates Directive.

An analysis of soil protection requirements linked to the current CAP policy framework was undertaken examining provisions for: Good Agricultural and Environment Condition set out as part of cross compliance; the greening of Direct Payments; and the more targeted support provided through Rural Development Programmes. The analysis shows that provisions exist within all three measures that offer potential to support the protection of agricultural soils[5]. The Regulations governing the funding, support and scope of the CAP are set at the EU level, with detailed decisions about how and which measures and instruments to implement made at the national and regional level; therefore, agricultural soils across EU Member States are subject to subtly different criteria and consequently potentially different levels of protection. When considering Member State implementation of CAP rules, it was concluded that Member States appear to be addressing soil erosion using a range of measures, offering opportunities for a similar range of positive interventions. The picture for the promotion and retention of soil organic matter is different; national and regional choices implementing support for soil organic matter protection and promotion appear to lead to less comprehensive coverage.

In addition to the implementation of EU laws and policy actions, Member States have also adopted a body of nationally initiated policy measures relevant to soil protection. 252 policies were identified as potentially relevant to soil protection on agricultural land and reviewed. The review confirms that there are a number of Member States that have comprehensive or dedicated policies for soil protection or management of agricultural soils and are promoting their protection

[4] the list of 35 policies important to soil protection determined based on earlier research conducted by IEEP and partners and informed by discussions with the lead European Commission officials. For details see Frelih-Larsen et al, 2016
[5] The CAP also offers a potential basis for the protection of forest soils, but this is not the focus of this analysis

as a key priority. The vast majority of Member States, however, rely on environmental policies either not dedicated to soils or not specifically focused on agricultural soils to address agricultural soil quality issues. This includes policies focused on land use planning, biodiversity protection, water management, sustainable development, climate change mitigation and adaptation, energy and waste.

1.2.9 Work Package 9

Objectives

The objectives of this WP are:

1. to coordinate and facilitate contact and communication with the different groups of actors and target audiences who will be involved in iSQAPER, potential users of SQAPP and the wider public and
2. to ensure efficient and effective dissemination of knowledge generated in the project using a variety of media and methods as appropriate for the different actors and target audiences.

Summary of progress towards objectives

During the second reporting period, activity has focused on four of the five tasks.

Task	Title	Summary of progress towards objectives
Task 9.1	Development of the iSQAPER Dissemination and Communication Strategy (PEDR)	The PEDR has been updated (Deliverable 9.2 v2 25May2018)
Task 9.2	Development of methods of knowledge transfer and dissemination	A training event on the Use of Social Media for Dissemination was held at the Plenary meeting in Beijing in September 2017. (Deliverable 9.3). Social media dissemination activity has been launched.
Task 9.3	iSQAPER information system	Content from a number of deliverables has been added to the iSQAPER information system.
Task 9.4	Promotion of SQAPP	Not active in this period
Task 9.5	iSQAPER – visual impact	Around 18 short videos have been made on a range of themes

Details for each Task

Task 9.1 The development of the iSQAPER Dissemination and Communication Strategy (PEDR)

This task covers the specifications for what knowledge will be transferred and disseminated, to whom and when. It includes:

i. identification of the key messages resulting from the research programme
ii. identification of the target audiences for those messages

iii. scheduling the communication activities

(These three points concerning **details of the iSQAPER exploitation and dissemination of results** for each work package and study site are reported in Chapter 4 of the PEDR v2).

iv. management of knowledge and intellectual property rights in accordance with the Consortium Agreement and Data Management Plan.

(This point concerning **Open Access and the Data Management Plan** is reported in Chapter 5 of the PEDR v2.)

Details of the iSQAPER exploitation and dissemination of results for each work package and study site

While the project as a whole has a number of general key messages to deliver, each work package and study site has distinct and different messages according to the research theme and local situation of each and the particular audiences the messages are intended for. Consequently details of exploitation and dissemination of results are reported separately for each WP and study site.

Work packages:

- WP01&09 Coordination & Dissemination and communication (this section refers to the project and iSQAPERiS websites, social media and project-wide dissemination products such as the project leaflet)
- WP02 Analysis of crop and farming systems across pedo-climatic zones
- WP03 Existing soil quality indicator systems
- WP04 Development of SQAPP
- WP05 Stakeholder inventories of soil quality and innovative practices
- WP06 Measures to improve soil quality
- WP07 Upscaling practices and assessing environmental footprint
- WP08 Policy analysis and recommendations

Study sites:

- SS01 De Peel, NL
- SS02 Argentré du Plessis, FR
- SS03 Cértima, PT
- SS04 Costera, ES
- SS05 Crete, GR
- SS06 Lubljana, SI
- SS07 Zala, HU
- SS08 Braila County, RO
- SS09 Trzebieszów, PL
- SS10 Tartumaa, EE
- SS11 Qiyang, CN
- SS12 Suining, CN
- SS13 Zhifanggou Watershed, CN
- SS14 Gongzhuling, CNSS01

Each report follows the same common format, listing:

- **Key messages** the 3 or 4 main pieces of information (partly derived from the objectives stated in the work package descriptions but also (for the study sites) from asking

stakeholders what information they are interested in getting from the project (Milestone 5.1).
- **Stakeholder groups and individuals**, grouped according to the spatial scale at which they operate and identified as specifically as possible. Again, for the study sites, this information has been obtained from interviews (Milestone 5.1).
- (for the study sites) **Work package tasks that provide dissemination opportunities**
- **Dissemination strategy** a simple summary of the level (local, national, EU-wide) and sources of information and the principle dissemination methods.
- **Record of dissemination** listing information provided, target audience or stakeholder group, format or media, date delivered.
- **Scientific publications**

The reports are all stored as Google Sheets and are accessible to the consortium partners for regular update.
During the second reporting period, the dissemination plans for each work package and study site went through two iterations of revision, the first following the plenary meeting in Beijing (September 2017), the second at the end of Reporting Period 2 (May 2018). See Chapter 4 of the PEDR v2 for the current version.
This task will continue in the next period.

Open Access and the Data Management Plan

The project has committed to the principal of Open Access to research data. To date 9 scientific publications have been in Open Access journals. The coordinator will review the issues with the partners at the Plenary meeting in June 2018 to understand better what difficulties they face in complying. The first draft of the Data Management Plan (Deliverable 1.2) was published in December 2016. An update is provided as Chapter 5 in the PEDR.

Task 9.2: The development of methods of knowledge transfer and dissemination

Task 9.2 covers the specifications for how knowledge will be transferred and disseminated. It builds on methods developed and successfully used in earlier projects DESIRE and CASCADE. It includes:

i. design of document and presentation templates for project-wide use in all types of dissemination including newsletters and factsheets, posters, press-releases and presentations;

(This point concerning iSQAPER **visual identity** is reported in Chapter 2 of the PEDR v2)

ii. methods of preparing/rewriting/reorganising project deliverables for dissemination to different target audiences or for different purposes (such as a press release);
iii. methods for communicating with and maintaining the engagement of the target audience and those involved in developing SQAPP over a number of years. This will include the use of email lists, meetings, video clips and podcasts and workshops;
iv. training project participants in the use of the different methods of knowledge transfer and dissemination.

(This point concerning **building dissemination and communication skills in the consortium** is reported in Deliverable 9.3)

iSQAPER visual identity
During the second reporting period, work focussed on using the already established logo and design elements to set up the social media platforms (Facebook, Twitter and YouTube) and create templates for newsletters, video clips, policy briefs and infographics.
See Chapter 2 of the PEDR v2 for details and examples of the project's visual identity. This part of the task is now complete.

Building dissemination and communication skills in the consortium
The iSQAPER Grant Agreement states that "a variety of formats and media, including a web-based information system, will be used to inform and engage targeted stakeholders who will range from land users to high-level policy makers and the general public".

The main (but not only) sources of results and information for dissemination and communication are the project deliverables. During this period, our thinking has clarified about the range of formats in which we will communicate that information, as well as the digital platforms that will be used.

Source	Format	Platform
Deliverables	Executive summary, complete deliverable text, poster	iSQAPERiS website
Deliverables and additional material from study sites	Key messages explained in infographics and video clips	Social media (Facebook, Twitter, YouTube), newsletters
Deliverables	Academic papers	Scientific journals, ResearchGate, LinkedIn.

Consortium members are very familiar with writing material for the iSQAPERiS website and scientific journals. Therefore, during this period, we have concentrated on building skills to enable us to use social media more effectively.

A training event on **Using Social Media for Dissemination** was delivered on Wednesday 13 September 2017, at the Third iSQAPER Plenary meeting in Beijing. The meeting was attended by some 70 members of the iSQAPER consortium and all work packages and study sites were represented. The training session had 3 tasks:

- revise the key messages that are emerging from each study site and work package,
- plan **infographics** for each message,
- start making **short videos** to illustrate each message (see Task 9.5 below).

The training event is fully reported in Deliverable 9.3.

Following the training event some 20 infographics have been produced by members of the consortium to date.

Number	Infographic title	Date posted on iSQAPERiS
1	De Peel as an example: focus points for sustainable soil management in the Netherlands_EN	14Dec17
2	Aandachtspunten voor bodembeheer_NL	14Dec17
3	Prácticas Agrícolas sostenibles del sureste Español_ES	14Dec17
4	Land management practices and soil threats in the island of Crete_EN	14Dec17
5	Converting cropland to grazing land_EN	14Dec17
6	Fertilising with farmyard manure_EN	14Dec17
7	Biochar and zeolite: integrated soil fertility management_EN	14Dec17
8	Organic farming_EN	14Dec17
9	Ekolosko Kmetijstvi_SI	14Dec17
10	Biodiversity in organic farming_EN	14Dec17
11	Soils in Poland: how to improve & save_EN	14Dec17
12	Earthworms indicate healthy soil	14Dec17
13	Sustainable farming practices to mitigate soil threats_EN	14Dec17
14	Catch crops - importance to soil quality_EN	27Feb18
14	Catch crops - importance to soil quality_SI (Prezimni dosevki - pomen za kakovost tal)	27Feb18
15	Land use in Estonia	9May18
16	Soils of Estonia	9May18
17	Land management in Zala county	
18	Soil quality indicators	
19	Nutrient cycle in organic farming_EN	
19	Nutrient cycle in organic farming_SI	
20	Biochar as soil amendment_EN	
20	Biochar as soil amendment_SI	

Infographics are posted on the Key messages section of the iSQAPERiS website (www.isqaper-is.eu/key-messages/infographics), on the iSQAPER Facebook page, Twitter and in the newsletter. For details of their use to date see Chapter 3 of the PEDR v2.
This task will continue in the next period.

Task 9.3: iSQAPER Information System (iSQAPERiS)

The iSQAPERiS website is the project's major dissemination product. In contrast to the project website (which is used for internal organisation and management of the project), iSQAPERiS presents the key messages and scientific results making them available and accessible to all the stakeholders and target audiences.

iSQAPERiS is built in Joomla! an open source content management system with powerful functionality. The iSQAPER DOW described the likely specifications for the website as follows:

- A “Quick start guide” incorporating video clips to enable the user to familiarise him/herself with the key contents of the system;
- A menu structure adapted from iSQAPER’s organisational structure with sections for each research theme and Case Study Site and designed to provide answers to questions such as “What are soil quality, agricultural productivity and environmental resilience?”, “Why are they important?” “How can soil quality be assessed?” “What can be done to improve soil quality?” “How can improving soil quality increase agricultural productivity and environmental resilience?”The explanations given will be in more depth and in addition to that provided by SQAPP and will support SQAPP users and others in their understanding of the issues surrounding soil quality;
- The content organised hierarchically, with the degree complexity of information increasing with each level.
- All complete deliverables will be available for downloading and many will be reformatted for on-line reading. However the user may choose to read only the summary/poster introductions;
- Interactive tools will be used to simplify the presentation of complex information, as will Powerpoint slideshows, short video clips or animations;
- Basic website functionality will be extended to include: a document management component which provides an interface for downloading all documents; a photo gallery with titles and captions for every image; a fully-integrated glossary; interactive Google maps; a facility for translating and reading as much content as desired in the Case Study Site local languages.

The iSQAPERiS website (www.isqaper-is.eu) was set up in the first reporting period. Full details of the design, structure and organisation of the website were given in Deliverable 9.1.
In this period, effort has concentrated on adding content from the deliverables as they have become available:

Key messages:	2 briefing papers, 16 video clips, 17 infographics
Assessment:	Concepts of soil quality indicators (D3.1); Soil quality indicators (D3.2); Visual soil assessment methods
Indicators:	Pedoclimatic zones of Europe (D2.1a); Pedoclimatic zones of China (D2.1b); Crop and livestock systems (D2.2); Spatial analysis (D2.3)

Important: some content is currently restricted to registered users only. To view it enter
Username: iSQAPERER
Password: soilquality

See Chapter 3 of the PEDR v2 for full details of the indicative content iSQAPERiS
This task will continue in the next period.

Task 9.4: Promotion of SQAPP

This task will promote the widespread uptake of SQAPP and will be reported in the Dissemination and Communication Strategy. It will include:

i. providing a dedicated download facility for SQAPP on the iSQAPERiS.

ii. feature articles on iSQAPERiS about the development of SQAPP including, for example, feedback and preliminary analysis data from the beta-release version to demonstrate its uptake and use;
iii. video clips in iSQAPERiS showing the use of SQAPP in different areas and by different users;
iv. providing links between the SQAPP development fora and the iSQAPERiS;
v. making use of the network of target audiences and stakeholders to promote SQAPP.

This task was not due in this reporting period.

Task 9.5: iSQAPER – visual impact

This task is to develop a number of different video or film products which explain the scientific issues underlying soil health. Following the training event on Using Social Media for Dissemination some 18 short videos have been produced by members of the consortium to date.

Number	Video title	Date posted on YouTube	Views to date
1	Organic dairy farming at the iSQAPER study site in Brittany v2	7Nov17	283
2	Organic hop production at the iSQAPER study site in Poland	7Nov17	68
3	Assessing soil quality at the iSQAPER study site in Suining, China	7Nov17	71
4	The importance of maintaining good soil quality	4Dec17	188
5	Impact of soil management on physical soil properties, Slovenia	4Dec17	83
6	Effect of agricultural management on soil life	7Dec17	35
7	Physical characteristics of iSQAPER study site on Crete	11Dec17	49
8	Soil threats and approaches for their mitigation	8Feb18	96
9	Land management practices that protect Crete from degradation	26Feb18	16
10	Benefits of straw return	28Feb18	25
11	Alternatives to liming for reducing soil acidity	28Feb18	34
12	Introducing the iSQAPER project	27Feb18	30
13	Benefits of using catch crops	27Feb18	52
14	Rock fragments and soil conservation	15Mar18	45
15	Soil quality		
16	Introducing the Tartumaa study site, Estonia	9May18	18
17	Soils of Estonia	9May18	11
18	Nutrient cycle in organic farming		
19	Biochar as soil amendment		

Video clips are posted on the Key messages section of the iSQAPERiS website (http://www.isqaper-is.eu/key-messages/video-clips), on the iSQAPER Facebook page, YouTube, Twitter and in the newsletter. For details of their use to date see Chapter 3 of the PEDR v2. Next to the short videos, a professionally produced film will also be made of the iSQAPER project. Several shootings have already taken place. The script intends to show the search for co-developing SQAPP with and for stakeholders. This task will be continued in the next period.

Dissemination indicators

Some dissemination indicators for different communication channels and products:

Today Pageviews	Yesterday	Last 7 days	Previous Period	Last 30 days	Previous Period	Total Pageviews
14	39	263	556	1,389	727	35,640
		Jun 1st - Jun 7th	May 25th - May 31st	May 9th - Jun 7th	Apr 9th - May 8th	Since Oct 28th 2015

Figure 35 Visitor statistics during several periods for the iSQAPER website

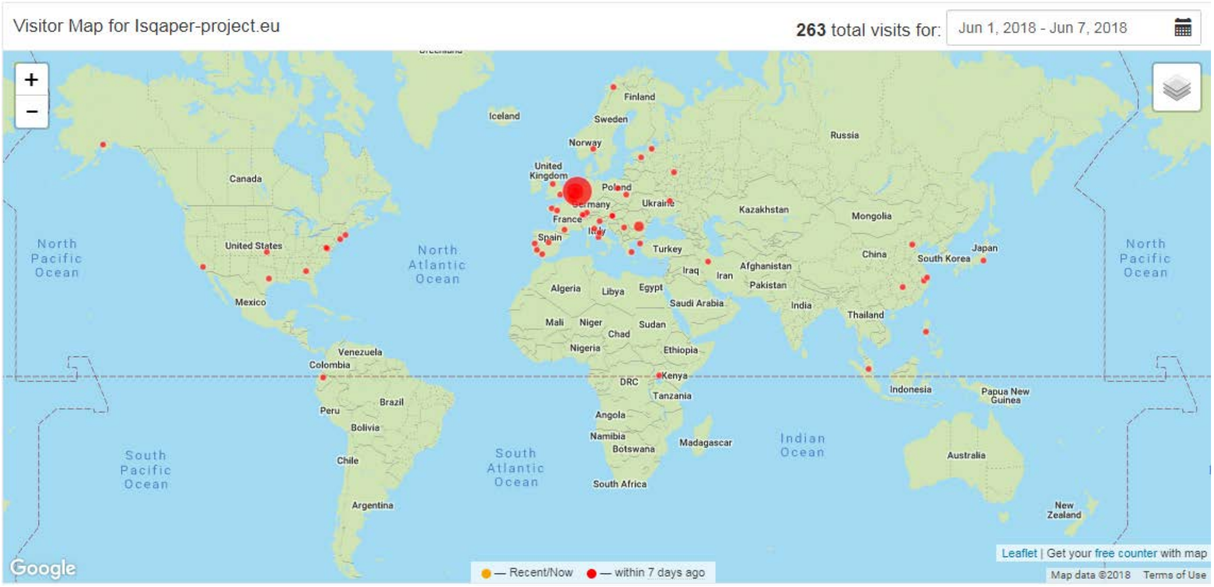


Figure 36 Visitor map of 263 visits during the first week of June 2018.

Figure 37 Visitor map of almost 10 000 visits during the period 1 Jun 2017 – 31 May 2018

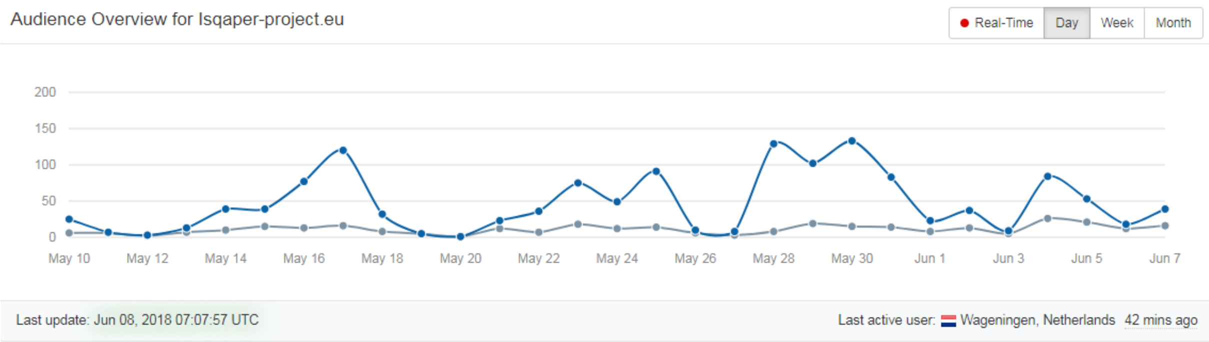
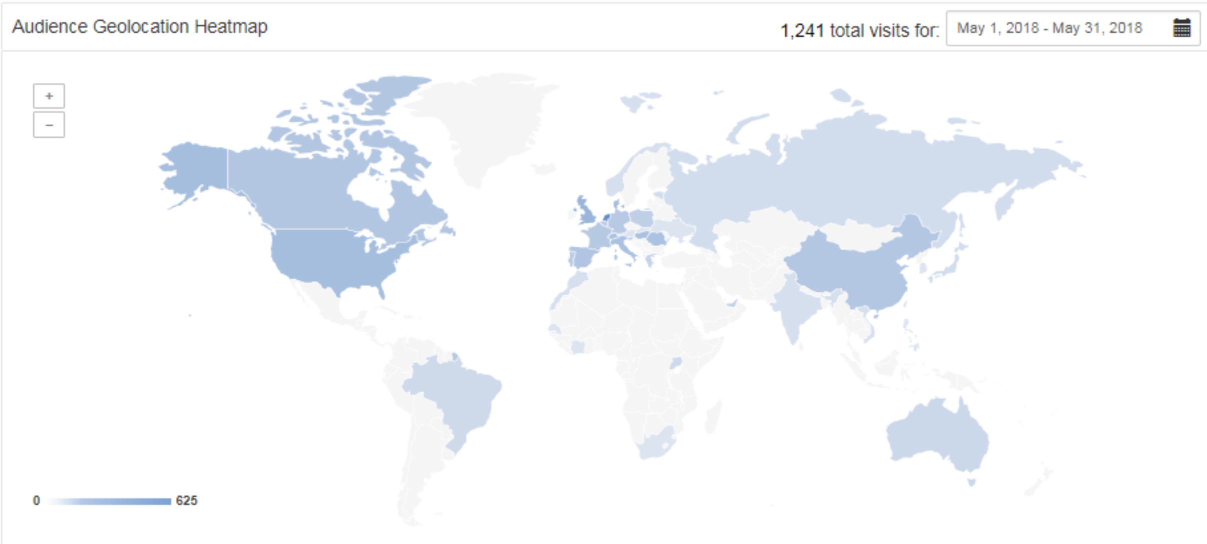


Figure 38. Audience overview of the iSQAPER website for the period 10 May – 7 June, 2018



Country	Locations	Visits	Uniques	Visit Depth	Visits/Uniques	Last Visit
Netherlands	6 Locations	625	60	10.42	—	—
United Kingdom	4 Locations	89	20	4.45	—	—
Denmark		51	3	17	—	—
United States	18 Locations	50	35	1.43	—	—
Switzerland	6 Locations	42	11	3.82	—	—
Hungary	3 Locations	40	6	6.67	—	—
Italy	4 Locations	38	7	5.43	—	—
Romania	Bucharest	36	3	12	—	—
Spain	6 Locations	28	8	3.5	—	—
Canada	4 Locations	27	6	4.5	—	—
China	8 Locations	25	21	1.19	—	—

Figure 39. Audience geolocation heatmap and the number of (unique) visits per country.

Leaflets

Leaflets of the iSQAPER project are available in diffe

Documents

- ISQAPER leaflet SI (1100 downloads) Popular
- ISQAPER leaflet CN (1200 downloads) Popular
- ISQAPER leaflet DE (1083 downloads) Popular
- ISQAPER leaflet EE (1161 downloads) Popular
- ISQAPER leaflet EN (1104 downloads) Popular
- ISQAPER leaflet ESv2 (831 downloads) Popular
- ISQAPER leaflet FR (977 downloads) Popular
- ISQAPER leaflet GR (1002 downloads) Popular
- ISQAPER leaflet HU (980 downloads) Popular
- ISQAPER leaflet IT (989 downloads) Popular
- ISQAPER leaflet NL (988 downloads) Popular
- ISQAPER leaflet PL (1028 downloads) Popular
- ISQAPER leaflet PT (978 downloads) Popular
- ISQAPER leaflet RO (947 downloads) Popular

Figure 40. Popularity of the leaflets

Title	Author	Hits
Article: Effects of agricultural management practices on soil quality	Written by Klaas Oostindie	Hits: 25
4th plenary meeting, Estonia	Written by Klaas Oostindie	Hits: 215
Final Pegasus conference highlights	Written by Klaas Oostindie	Hits: 279
Soil Quality - a critical review	Written by Klaas Oostindie	Hits: 404
Cultural cross-fertilisation article	Written by Klaas Oostindie	Hits: 450
Info video iSQAPER project	Written by Klaas Oostindie	Hits: 834
iSQAPER WP-leaders meeting Évora	Written by Klaas Oostindie	Hits: 549
WP leaders meeting in Evora, Portugal	Written by Klaas Oostindie	Hits: 382
World Soil Day 2017	Written by Klaas Oostindie	Hits: 524
Joining the dots	Written by Klaas Oostindie	Hits: 707

每页显示条数 10

名称	作者	点击数
项目最新研究成果：农田管理措施对土壤质量的影响	作者：Klaas Oostindie	点击数: 12
通知：iSQAPER项目第四次全体会议将在爱沙尼亚举行	作者：Klaas Oostindie	点击数: 135
Pegasus会议精彩集锦	作者：Klaas Oostindie	点击数: 193
土壤质量述评	作者：Klaas Oostindie	点击数: 257
文化融合应对土壤问题	作者：Klaas Oostindie	点击数: 234
iSQAPER 项目视频介绍	作者：Klaas Oostindie	点击数: 235
iSQAPER 项目课题负责人会议在葡萄牙召开	作者：Klaas Oostindie	点击数: 259
通知：iSQAPER项目课题负责人会议将在葡萄牙埃武拉举行	作者：Klaas Oostindie	点击数: 220
世界土壤日-2017	作者：Klaas Oostindie	点击数: 374
节点-土壤健康，农业与气候	作者：Klaas Oostindie	点击数: 469

Figure 41. Number of hits on English and Chinese news articles

1.3 Impact

For each of the five expected impacts (italic headings below) set out in the work programme under the call topic, the main impact results are summarized and categorized into scientific (**S**), technological (**T**), agro-environmental (**AE**), and policy (**P**) related ones. These impacts have not changed relative to the DoA, but have still been summarised below. In addition, the European – Chinese partnership in iSQAPER is generating significant opportunities for co-learning and integration of knowledge, which is likely to extend beyond the project. This is an additional impact not yet fully anticipated during the development of the DoA.

Improved capacity and methods to assess soil-management interactions and their impact on soil functions

iSQAPER aims to explore, in more detail than currently available, the interactions between land management practices and changes in soil properties and function. The principal expected impact will be i) a harmonized scientific approach describing the cause and effect relationships of different land management practices on soil properties and function, covering different farming systems and pedo-climatic zones across Europe and China, for practitioners and beyond (**S**), ii) a set of rules, that will be the central element of the soil quality assessment tool, enabling comparison of results across time and space (different sites, farming systems, etc) (**S**), and iii) compilation of targeted land management options for different farming systems capable of improving soil quality while maintaining or even increasing crop productivity and yield stability (**S**).

Widely accessible and cost efficient tool to monitor the 'health status' of agricultural soils by practitioners in the agricultural sector

Within iSQAPER WP4, a widely accessible and cost effective tool to assess and monitor the quality of agricultural soils is being developed based on integrating state-of-the-art soil physical, chemical and biological knowledge with site specific data, indicators, and modelling approaches. The main expected impacts will be generated through i) the technological environment that will be constructed, based on wireless applications, background databases, and a dedicated mobile web platform, integrated to provide practitioners and other potential end-users with a user friendly application to assess the quality of soils in use for agricultural production (**T**), and ii) easy access and cost-efficient use of the soil quality tool by ensuring its use on a range of different electronic devices, independently of type, operating system, and geographical location (**T**).

Increases in crop productivity, quality, and yield stability in conventional and organic farming systems through improved practices for soil husbandry including crop rotations

One of the main aims of iSQAPER is to maintain and preferably increase crop productivity and yield stability through introduction and adoption of agricultural land management practices which ensure a certain level of soil quality. The main impacts foreseen are i) multi-stakeholder selection, implementation and evaluation of promising land management practices within each of the iSQAPER Case Study Sites (**S,T,AE**), ii) demonstration of best agricultural land management practices to Case Study Site stakeholders aiming at knowledge exchange, awareness raising, and stimulating other land users within and outside the Case Study Sites to also adopt alternative land management practices in order to improve the quality of agricultural soils and concurrently increase crop productivity and yield stability (**AE,P**).

Enhanced climate and environmental performance of agricultural activities (e.g. through reduced adverse impacts on agricultural soils)

Within iSQAPER, the relationship between soil quality, crop productivity and yield stability, and ecosystem services (among others) will be investigated, analysed, and quantified for agricultural activities deployed by land users in different farming systems across major pedo-climatic zones of Europe and China. The main impacts to be expected from iSQAPER are i) insights and guidance for farmers across Europe and China on selecting agricultural activities that contribute to enhanced climate and environmental performance, soil quality stewardship (including crop productivity and yield stability) (**S,AE,P**), ii) uptake and implementation of agricultural activities by farmers inside and outside the Case Study Sites enhancing climate and environmental performance while providing quality for soil and livelihood conditions (**AE,P**).

Support to CAP environmental objectives and development of further policies in the area

The agricultural sector is expected to expand in the face of increased demands for food, fibre and energy. iSQAPER will offer insights into how best to use the opportunity of the on-going reform of the Common Agricultural Policy (CAP) to improve the sector's resource efficiency and environmental performance and reduce its impact on soil, water, air, biodiversity and landscape. The main impacts foreseen are i) improvement of agricultural resource efficiency and environmental performance across the iSQAPER Case Study Sites, and beyond (**AE,P**), ii) targeted policy recommendations at regional, national, European, and Chinese level contributing to the on-going reform of the CAP (**AE,P**).

1.4 (not applicable to iSQAPER)

2. Update of the Plan for Exploitation and Dissemination of Results (PEDR)

The PEDR is a dynamic document that will be updated regularly during the implementation of the project. It is divided into 6 chapters

Executive summary
Chapter 1. Orientation (what new information will be generated by iSQAPER, who will use the results and how will the results be disseminated.
Chapter 2. iSQAPER visual identity (established to ensure consistent, memorable and attractive visual presentation of all the information products delivered as part of the project).
Chapter 3. Digital dissemination and communication platforms created and their use to date.
Chapter 4. Details of the exploitation and dissemination of results for each work package and study site.
Chapter 5. Open Access and Data Management.
Chapter 6. Evaluation of the effectiveness of the PEDR.

During this reporting period the PEDR has been substantially revised and updated as Deliverable 9.2 v2 (date 25May2018).

3. Update of data management plan

The Open Access and the Data Management Plan (DMP) is reported in Chapter 5 of the iSQAPER PEDR v2. Provisions have been made to comply with the new European GDPR rules.

4. Follow-up of recommendations & comments from previous review(s)

General comments

iSQAPER is a very ambitious project with many interlinked activities covering several disciplines and including a variety of methods and approaches. This integration is not easy to be obtained but is key to reaching the project goals. The general impression is that the partnership is committed towards reaching the project objectives but that their level of integration should be further improved. There is a perception that some key issues the project is centred upon, e.g. the participatory approach and the concept of innovation that are highly relevant across many WPs, are not yet fully appraised and implemented by all partners and in all tasks. The partners should duly reflect on this, since there is still enough time to sharpen methods and adjust activities in order to make them better aligned to the stated objectives. On the scientific side, it is not fully clear what are the key novel scientific findings that are expected. Also, the part on ecosystem services seems a bit detached from the rest of activities: it is not evident how it is going to be addressed and how the outcomes will be communicated to a variety of end users.

Participatory approach: The project is designed in 4 stages: data mining, tool development, tool application and validation, and potentials for improving soil quality. The work done in the first reporting period mainly focused on WP2 and WP3 which are part of the data mining phase where stakeholder involvement was not planned. The participatory process is central to WP5 and WP6. So far stakeholders have actively been involved in the assessment of soil quality and the impact of already implemented AMP on soil quality with the Visual Soil Assessment methodology (in Task 5.2). Stakeholders were also involved in the selection of promising technologies for testing in WP6. More involvement of stakeholders is planned for the testing, evaluation and further improvement of the SQAPP.

Concept of innovation: Beside the development of the App which is a highly innovative element of the project, there is also innovation within the agricultural management practices (AMP) trialled and evaluated in the case study sites. From a glance the ones selected might not seem innovative, but there are new combinations of AMP elements. We have, based on reviewers' comments elsewhere, also clarified what we understand innovation to be about.

Expected key scientific findings: 8 overall objectives have been defined for iSQAPER in the project's DoA. While not all of these can directly be translated in key scientific findings, there are two strategies that will drive scientific findings: 1) the integration of previously unconnected or loosely connected fields of knowledge (e.g. bringing together spatial soil data and enhanced understanding of soil quality) and 2) testing of innovative methods and measures (e.g. innovative soil quality indicators and AMP's.

> **Integration of ecosystem services:** the soil quality concept is underpinned by the need for soils to be managed sustainably, i.e. to continue to provide sufficient levels of soil-based ecosystem services. The SQAPP will be developed such that it can guide users about specific concerns they have with soil threats which are linked to specific ecosystem services, and/or be able to alert them to specific ecosystem service trade-offs they should be aware of when deciding on soil management. Such impacts will also be monitored and evaluated when testing AMP's. At a higher spatial level, WP7 will take the potential for improved soil management to contribute to a lower soil environmental footprint, which will be assessed through ecosystem service impacts. How and to whom the outcomes will be communicated will be decided on the basis of WP5 and 8 and WP9 guidance on the best communication products and channels to use to reach them.

Results

So far the main scientific and/or technological achievements of the project are (i) the pedoclimatic map of Europe and China, and (ii) the review on concepts and indicators of soil quality. The first should be amended in terms of graphical output to be made clearer and consequently improve its usefulness. The second may potentially result in a high quality and highly cited review paper.

No clear innovation outputs have been produced so far.

> Chapter 1 of the PEDR synthesises the expected innovation from iSQAPER under several different headings, and we also discussed the matter of innovation when we met in Madrid. The easy, interactive soil quality assessment tool is the project's core innovation which will help to increase adoption of management practices which have been around for long and are known to have positive effects on soil quality. The work on innovative indicators is also promising to identify easily applicable and cheap soil quality assessment indicators. We will identify specifically what our further innovations (methods, products, knowledge, ...) will be in order to be able to say what we have and have not produced so far (for the next progress reports).

The project concepts and methods have potential to contribute to the advancement of the state of the art but need to be sharpened and homogenised.

> The timing of the review meeting coincided with the transitioning phase of the project from its data mining to its soil quality assessment tool development phase. As such, relatively rough versions of project concepts and methods were available, which indeed needed further sharpening through testing and validation. Importantly, as mentioned by the reviewers, the integration of stakeholders' knowledge and information needs still need to be more fully captured. These aspects were incorporated in the review paper on soil quality (Bünemann et al.). Concepts have been and stakeholder information will be further integrated in the design and functioning of the core product of the project, the SQAPP.

The scientific and/or technological quality of the results is on average good.

It is too early to foresee whether iSQAPER will have a clear impact on technology and/or society.

The project may have a positive impact on researchers career perspectives by providing training and insights on new skills for young scientists wishing to pursue an academic carrier.

The dissemination activities and results are presently rather limited. The dissemination plan is very good but the actual quality of dissemination tools and actions (e.g. project websites and exposure on social media) should be improved.

> More attention has been given to dissemination activities and results in the second reporting period. Actions are presented later on.

Since SQAPP will be provided free of charge to a variety of users, the IPR issue is not highly relevant for iSQAPER.

Progress of the activities

In general the project workplan is in line with the programme. There are no major delays and some tasks have been anticipated to align them better to the overall rhythm of activities. This is a good sign of flexibility in the project management.

As said above, some corrective actions are needed to minimise the risk of not meeting in full the high project expectations and the stated objectives. Details on these and extensive recommendations are given in section 2.

The project milestones and deliverables for the period have been submitted with no major delays and do not need major amendments.

The use of resources is generally in line with the DoA but some explanations are required.

Recommendations

No major risks of failure can be envisaged so far.

Extensive recommendations on key issues to reflect upon and on how to better align concepts, methods and activities to the objectives and expectations of iSQAPER are given in section 2 of this document.

Amend content of D2.1 and D2.2 (see below).

Pedoclimatic map of Europe (D2.1)

Make it more intelligible by e.g. using 8 colours for the climate zones and numbers (1 to 23) or letters (A to W) for the first level soil type categories. An improved map should be included in an amended version of D2.1.

A more intelligible map has been included in an updated version of D2.1. This map aggregates the 23 soil types in 8 broad groups, which are subsequently juxtaposed over the climate zones in different colour schemes. The first level soil type categories are presented with labels based on their two-letter naming conventions (AC, AN, etc.).

Classification of farming systems (D2.2)

Expand it by including the farming system typologies suggested in section 2 of this document, to better align it to the stakeholders priorities. A more comprehensive classification is expected in an amended version of D2.2. As a consequence, this would probably require including additional case studies.

Categories of vegetable and agro-forestry have been added to the classification system in the revised report (D2.2.) (see also section 2). As the stakeholders in the study sites came up with these categories, they are already represented in the case studies. The activities of WP5 and WP6 include soil quality assessment and testing of AMPs in these farming systems.

The method proposed for soil extractable P needs to be re-checked (why Olsen P is preferred for all regions?)

This comment concerns the 2016 LTE sampling campaign conducted in WP3.3. We decided to analyse all samples using the Olsen method to determine available P since it is a wide-spread method which is well suited for calcareous soils but also reasonably effective for acidic soils (Fixen and Grove 1990; Pierzynski 2000). It has been shown to extract mainly isotopically exchangeable phosphate rather than dissolving slowly or non-exchangeable P, in contrast to other soil P extractants (Demaria et al. 2005). Nevertheless, since results obtained using different extractants are usually closely related, other soil P methods can still be used in other parts of the project.

Demaria P, Flisch R, Frossard E and Sinaj S. 2005. Exchangeability of phosphate extracted by four chemical methods. Journal of Plant Nutrition and Soil Science 168, 89-93.

Fixen, P.E. and J.H. Grove. 1990. Testing soils for phosphorus. p. 141-180. In R.L. Westerman (ed.) Soil Testing and Plant Analysis. SSSA, Madison, WI.

Pierzynski. 2000. Methods of Phosphorus Analysis. Sourthern Cooperative Series Bulletin No. 396. http://www.soil.ncsu.edu/sera17/publications/sera17-2/pm_cover.htm

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Given the objective of this online platform, it is suggested to reorganize the content including sections for each typology of users (farmers/advisors, students/researchers, policy makers, etc.). This implies the production of digests for each issue of common interest (e.g. indicators) to be tailored to the users' needs and expectations. This should be done as soon as possible.

We are at this point not convinced that reorganisation of the content according to user type is the best way forward. Our experience is that, while researchers may be interested in (for example) the full experimental detail, any or all user types may be interested in the broader key findings or recommendations. We would therefore prefer to keep the content organised according to theme (e.g. soil quality assessment, indicators, multi-actor approaches ...) and then, within each theme, provide material at different levels of detail, or from specific angles (e.g. a page outline of management of soil quality through agricultural policy).

However, since we are using a content management system for iSQAPERiS, reorganisation of content by user or theme, or study site area should be relatively straightforward if we want to change it at a later date. We will hence start developing the content first and then look again to see if the organisation by theme is working or not.

Objectives and worplan

Overall, the project is in line with the objectives and workplan but both would need some sharpening, as indicated below. Hereafter, some issues to reflect upon regarding ongoing and future activities are highlighted, broken down by WP and related tasks.

WP1

There is no detailed information on the composition and engagement of the Project Advisory Board. It is said that it will be recruited and consulted regularly on an ad-hoc basis: this needs to be clarified, because the impression is that so far there is no external steering of iSQAPER activities, which poses a serious risk of self-referential approach.

Indeed, the Project Advisory Board consists of several key experts who have been consulted on an ad-hoc basis: Dr Harold van Es, Professor at Cornell University; Dr Jeff Harrick, USDA-ARS; Prof Rogier Schulte, Wageningen University; Ms. Veronica Yow, RARE; Prof. Tinglu Fan, Gansu Academy of Agricultural Sciences). Furthermore, the formal review process set up by REA provides a further safeguard to steer clear from a self-referential approach.

Task 1.3: It is not clear how the gender equality work is going to be conducted.

After a first inventory about stakeholders and gender roles, gender-specific questions will be included in the feedback questionnaire for SQAPP. A gender disaggregated needs assessment about land use practices will be a source for developing the SQAPP application and for a gender friendly local stakeholder communication and dissemination policy advice about gender balanced improvement practices.

Task 1.5: It is not clear how 'multiple bilateral partner exchanges' are expected to ensure smooth completion of iSQAPER activities.

'Multiple bilateral partner exchanges' referred to several meetings organised in-between plenary meetings with sub-sets of partners, in the framework of specific or multiple WPs as well as visits that were used to discuss about project progress and planning. This e.g. included the WP2-WP4 workshop in Frick, separate WP1 and WP2 visits to discuss with

Chinese partners, WP8-9 joint meeting in Amsterdam, and visits of a number of partners to Wageningen.

WP2

Task 2.2: The objective 'to conceptualise the scale-dependency of different levels of pedo-climatic zones, taking into account the differences between- and inside main climate regions' is unclear.

Scale dependency of different levels of pedo-climatic zones is twofold. One is the spatial scale. In this context spatial delineation of soils within climate zones was needed. The more detailed (regional to field scale) the spatial assessment is, the more specific the soil management practice can be. The other aspect is the semantic content of pedoclimatic zones. In this context hierarchical levels of soil (taxonomic) types are concerned. In a detailed spatial representation, a lower level of taxonomic soil classes can be handled.

'Cropland data of different crops was obtained at 5 arc-minute resolution while gridded livestock data was obtained at 3 arc-minute resolution': this is unclear.

Crop data of the MapSpam Cropland dataset (http://mapspam.info/) is used, which has a 5 arc-minute resolution. For livestock data we used the Global Distribution of Livestock dataset (http://www.livestock.geo-wiki.org), its resolution is 3 arc-minute.

Task 2.3: it is basically impossible to use the map of pedoclimatic zones in Europe because the colours are too many. See suggestions in section 1 of this document.

Thank you for the suggestions, the visualization of pedoclimatic zones has been improved by grouping the WRB Reference Soil Groups based on Driessen et al. (2001) in the revised report on D2.1.

Driessen P, Deckers J, Spaargaren O, Nachtergaele F. 2001. Lecture Notes on the major Soils of the world. ISRIC; ITC; Catholic University of Leuven; Wageningen Agricultural University; FAO: Rome.

It is said that 'numerical approaches are applied to characterise the spatial extent of pedo-climatic zones in a comparable manner in China and Europe' but the respective maps actually show that different classification systems have been used. It is perceived that there are margins for homogenisation, which should be accomplished.

It is not fully clear how soil water budget and nutrient dynamics are going to be estimated. By measurements? By modelling? How? How often? At what depth? The possible application of relevant remote sensing approaches (e.g. NDVI) should be considered, as well as the opportunity to use data from agricultural censuses in WP2 activities.

For the harmonization of the pedological component a great effort has been done by Chinese partners. They have harmonized the Chinese soil spatial dataset to match those of pedoclimatic zones of Europe. Harmonization of climate zones is limited, because of differences in climatic conditions between China and Europe. A clustering method has been tested to use continuous climatic and soil variables to create pedoclimatic zones, but present results that are not meaningful for the purpose of the iSQAPER project. WP2 has developed some further research on numerical approaches to analyse if further improvement of the zonation can be achieved, including by a integrating a new soil hydraulic map of Europe at 250 m resolution at seven soil depths up to 2 m depth (Tóth B. et al., 2017) (http://mta-taki.hu/en/eu_soilhydrogrids_3d), which was also included in the clustering. Thank you for the suggestions for possible input parameters.

For the development of SQAPP, a simple harmonised and global approach to defining pedoclimatic zones was applied to avoid problems of limited homogenisation and expand the analysis beyond Europe and China (see Deliverable 4.1).

Tóth B, Weynants M, Pásztor L, Hengl T. 2017. 3D Soil Hydraulic Database of Europe at 250 m resolution. Hydrological Processes: in review

Task 2.4: In the farming system classification work it is unclear what is it meant by 'including plant and animal breeding'. As to the work resulted in D2.2., the impression is that iSQAPER is proposing just another classification of farming systems on top of those already developed. If, in principle, this might be justified by the need to align the classification to iSQAPER objectives, there seems to be a nonalignment between this classification and the farming systems listed as priority by stakeholders. Additionally, it would be good to align as much as possible this classification to well recognised ones, e.g. Eurostat.

From the viewpoint of the iSQAPER project, which aims to deliver spatially explicit solutions for sustainable land management, only those classifications could be realistically considered, which are supported by spatial data of continuous coverage. Therefore none of the available classifications of farming systems could be applied for the iSQAPER project without any modification. We structured our classification system based on existing FS classification schemes and available datasets. The cropping system used for the iSQAPER project is mostly in line also with the first level categories of EUROSTAT (EC, 2000), and a comparison has been added in Annex of D2.2. This clarification is included in the revised report. In the revised classification – and revised report – all classes prioritised by the stakeholders are included.

'Different approaches to farming system classification were analysed and the best-for-purpose classification was integrated with the pedo-climatic zones concept': it is not clear how this has been done. In Table 1 some important categories are missing, e.g. vegetable crops, herbs and spices, biomass crops (including trees and shrubs), glasshouse production, abandoned farmland. How are cropping systems and livestock combined in the classification? How about Agroforestry and agro-sylvo-pastoral systems? See also previous comment on alignment to Eurostat categories.

Categories of vegetable and agro-forestry have been added to the classification system in the revised report (D2.2.). This was possible, because continuous spatial data is available for these, either from CORINE or Mapspam Cropland dataset. Spatial analysis of livestock is quite limited due to lack of spatial data.

Task 2.5: it is said that 'the analysis will cover comparative assessment of current farming systems on regional and continental scales including soil resource utilisation of different farming systems' but there is no information on how this is going to be accomplished. Is the effect of agricultural (and wider economic) policies on land use and soil quality going to be considered? If so, within which time scale?

This task is due after the first reporting period, therefore was not included in the report. Further details on this task are given in Deliverable 2.3. The effect of agricultural policies is going to be addressed in WP7.

WP3

It does not seem that the DPSIR system, a well recognised standard for indicators selection and classification, has been considered in iSQAPER. Why?

The DPSIR system is a general classification system for environmental indicators and not specific for soil. Nevertheless, we think it is a good suggestion to consider it in iSQAPER, and we have incorporated this during the revision of D3.1 as a manuscript for publication. The new section reads:

Because soil quality plays a role in decision-making in the face of soil threats, the DPSIR (driver–pressure–state–impact–response) scheme, often used in EU policy for considering resistance and resilience of ecosystems (http://www.eea.europa.eu/publications/92-9167-059-6-sum/page002.html) is a meaningful framework regarding soil quality. Applying this framework to soil, "drivers" are pedoclimatic conditions; "pressures" are the soil threats mentioned before (European Commission, 2002; Montanarella, 2002) associated with land use and management, whose variabilities and interactions determine the "state", i.e. is the biophysical appearance of the soil; "impacts" are the effects on soil and ecosystem functioning; and "responses" are the natural reactions in terms of delivery of ecosystem goods and services and the human reactions in terms of adaptive management.

Likewise, partners do not refer to the Millennium Ecosystem Assessment for the classification of ecosystem services, which is another well recognised standard. Why?

We discussed the classification of MEA (2005) during our workshop in Frick in October 2015 and decided to use a more soil-specific classification instead. We should have mentioned this in the D3.1 and have considered this during revision of the deliverable for publication.

Besides soil-based indicators, partners should also consider the opportunity to use plant- and management-based indicators as proxies for soil quality. This may be considered in the case studies work.

> In WP3, we are already using yield and disease incidence as plant-based indicators. The Soil Quality Assessment conducted in WP5 is focusing on management-based impacts on soil quality, as it evaluates the change in soil quality due to different agricultural practices. So far the focus was indeed on soil-based indictors, but the list of indicators will be complemented with plant-based indicators (e.g. vegetation cover, rooting depth, plant health, etc.) based on the outcome from the LTE review of indicators (WP3). The final selection of the indicators used (minimum data set of indicators) will be established after the repeated application of the soil quality assessment. We are also considering to test if remote sensing and plant nutrient status can be used to assess nutrient availability.

Task 3.1: In Figure 3, does the number associated to soil-based ecosystem services refer to a ranking in e.g. order of importance?

> No, the numbering was remaining from the group exercise done at the workshop in Frick in October 2015 and was not meant to suggest an order of importance. We have removed it from the figure during revision of D3.1 for publication.

Exercises like the one reported in Table 2 (collective selection of indicators in a dedicated workshop) are interesting but always incomplete and highly subjective, as they typically reflect the participants' background.

> Yes, we are aware of this limitation, but it was still a very valuable activity.

Since the lab and field assessments of parameters likely resulting in novel improved indicators (see Table 4) is a key point for the development of SQAPP, it is extremely important to be very rigorous in compiling this list. The partners should avoid gaps that would later results in gaps in the ability of SQAPP to serve its purpose. For example, microbial activity is clearly related to erosion control through its soil structuring function, but this is not considered in Table 4.

> Most likely, the reviewers are referring to Table 14 rather than Table 4. Yes, indeed, more relations between soil parameters/indicators and soil functions/ecosystem services could have been indicated, but here we tried to show only the most important ones in order to make sure that all soil functions and ecosystem services were reflected. Nevertheless, we are now reconsidering these relationships.

Apparently, non-scientific stakeholders did not participate in this exercise. If a really participatory approach is to be pursued, target users should be involved from the very beginning of the process. Since (Figure 5) they have not been involved in the definition of the objectives, it is urgently required that partners seek their engagement as quickly as possible.

While WP3 is working more on theoretical grounds, we agree that the involvement of target users is very relevant for WP5 and 6. The outcome of WP3 (indicators based on LTE review) were taken into account to refine the selection of indicators used in WP5. In Task 5.2 the stakeholders were already requested to value the importance of the different indicators to them in order to evaluate soil quality. This exercise will be repeated the following years to complement and finalize the list of indicators with high relevance to the stakeholders and their appreciation of soil quality.

Task 3.2: Who is deciding what are the knowledge gaps? Only scientists? If so, this seems in contrast with the participatory selection of indicators and is likely to have consequences on the way SQAPP is going to be developed. This needs to be corrected.

Indeed, the focus of Task 3.2 is scientific. This has been clarified during revision of Deliverable 3.2. The review in WP3 is based on literature and scientists' input only, while the identification and selection of indicators in WP5 will integrate stakeholder knowledge regarding research gaps and indicators. The outcome of WP3 is integrated in WP5 and the final selection of indicators should thus reflect scientific and stakeholder knowledge.

What is the novelty compared to already existing info and datasets? (e.g. the ISOFAR LTE network). Which criteria were used to characterise and choose the LTE included in the database? A definition of what is an LTE in the context of iSQAPER is missing.

How are the data of LTEs from countries not participating in iSQAPER going to be used to fulfil the project objectives (indicators – SQAPP)?

These points have been clarified during revision of Deliverable 3.2. In detail, we collected data of 30 long-term experiments from the project partners in Europe and China. We collected additional data of 42 long-term experiments across China and data from the EU-funded project TILMAN.ORG. The minimum duration of LTEs included was 5 years.

Answers to some of the questions can be found in the report of Milestone 3.1: Overview of major existing field trials across various pedo-climatic zones in Europe and China and database of research results in the field of soil quality indicators.

Which were the criteria for selecting the 5 practices and the 6 indicators used in the meta-analysis? A series of pairwise comparisons is understandable from a meta-analysis perspective but does not give any information on the importance of a system approach to achieving better soil quality. This way of conducting a meta-analysis impedes to evaluate the effect of the cropping system (= combination of crops and practices) on the selected soil quality parameters. The partners should try to aggregate the cases by typologies of cropping systems based on the individual factors they have used so far and repeat the analysis (considering, of course, the requirement of having a minimum number of cases per typology). This approach would yield a more innovative and valuable perspective and would reduce the risk of misinterpreting results due to the effect of hidden relevant factors that have not been considered in the present analysis.

The criteria for the selections are explained in Deliverable 3.2 (sections 2.1 and 2.2). We broke down the analysis to different cropping systems during revision of D3.2 and gaining further insights in the interactions is also a central goal of Task 3.3.

In the meta-analysis presented, 'organic matter addition' is a rather vague concept. Also, 'crop rotation' is far too general as a concept. It is suggested to break it down by e.g. considering factors like duration and functional diversity of component crops. This would probably help explaining the 'mixed effects on earthworm numbers' observed, and how the effect is unfavourable (a plausible explanation for this unexpected effect is needed).

These comments have been addressed during the revision of D3.2, and the ensuing paper published in Agriculture, Ecosystems & Environment (Bai et al., 2018).

Partners should consider the opportunity of matching their meta-analysis with a systematic review on soil quality indicators, rather than doing a narrative review and a meta-analysis as stand-alone activities. The first option would imply some additional work but would result in a much more valuable paper.

We found the guidelines for systematic reviews developed by EFSA which the reviewer was referring to. In the revision of D3.2, and in particular the selection of material covered in the Bai et al (2018) AGEE paper, systematic review was adopted as method.

Task 3.3: Regarding the indicators to be assessed at central labs, the partners have decided to focus on two management factors, namely tillage and fertilization treatments, and to include only arable cropping and permanent crops. This may be due to budget constraints but how are these limited data going to serve the overall purpose of the project (i.e. feeding SQAPP)?

Indeed, these restrictions for examined management factors and land-use categories in the sampling campaign conducted for task 3.3 were due to budget constraints. It was also the best possible selection from the available LTEs, considering spreading over climates, minimum number of years running, and scientific set up. We decided to investigate a limited number of management contrasts in order to be able to provide conclusive results. Nevertheless, this campaign will provide us with exemplary data to assess the suitability of the selected indicators, to develop an approach for interpretation (e.g. scoring curves or threshold values), and to evaluate interactions of management and pedoclimatic zones on the indicators.

In the case study sites (WP5 and 6), a much broader range of management factors and cropping systems is included. Recommendations in the SQAPP may reflect different levels of confidence (= proven efficacy) in AMPs, e.g. a distinction between measures that 'have been proven to work' and measures that 'are likely to work'.

Which were the criteria used for selecting the 'set of novel soil quality indicators'? How are these data going to be used in SQAPP? It is unlikely that these could be cheap and easy-to-handle type of indicators, which may seriously limit their uptake by practitioners.

The criteria for selecting the novel soil quality indicators to be tested in task 3.4 were developed based on an extensive literature review and conceptual evaluation done in the frame of the PhD project of Giulia Bongiorno. After examining in particular the functional roles of different groups of organisms in soils as well as the alleged relations between so-called "active carbon pools" and soil functions, she decided to focus on the main categories dissolved organic carbon, nematodes, and fungi.

Some of the novel indicators proposed in the literature or under development by ourselves are not part of any existing soil quality assessment procedure, although they may potentially be applicable. We are testing the full range from very simple field indicators via near-infrared based estimations to sophisticated laboratory methods, with the vision that SQAPP should be able to handle data on different levels - either cheap (and often more variable) indicators, or more precise and reliable indicators for a better estimation. See further under Task 3.4.

Task 3.4: A major objective here is 'to screen and evaluate a range of newly developed indicators of soil quality in long-term trials'. What should they be built upon?

We are evaluating the novel indicators in relation to the more commonly used indicators determined in task 3.3, and in relation to measured soil functions and ecosystem services.

Please provide examples of which indicators with clear linkages to targeted soil functions and ecosystem services should be selected. How about soil health indicators, e.g. presence/abundance soilborne pathogens, pests, nematodes, weeds, pollutants? They are probably very important from a farmer's perspective.

Indeed, a soil suppressiveness test was developed and tested in task 3.4 as one of the novel indicators. Furthermore, we investigate indicators based on various measures of labile carbon, namely DOC (dissolved organic carbon), POXC (permanganate oxidizable carbon) and HWEC (hot water extractable carbon) and on nematode and fungal (including arbuscular mycorrhizal) community and abundance studied with DNA (sequencing and quantitative PCR) and ergosterol and their quantitative relationships to soil functions. The novel indicators will be linked with nutrient cycling and carbon sequestration (labile carbon and nematodes and fungal community), pest and pathogen regulation (soil suppressiveness test and nematode community), and soil structural stability (fungal community and labile carbon). Moreover, the biodiversity function will be investigated through the study of nematodes and fungal communities. Results obtained during the second reporting period are included in the progress report for task 3.4.

WP4

SQAPP is meant to 'accommodate operation at different levels of complexity'. Is there any idea of the best software interface needed to reach this goal? What are the answers needed by the stakeholders? What are their expectations about SQAPP? Would it be possible to use it for a more research-oriented scope side by side with a more practically-oriented scope? All these issues need to be clarified and well pondered upon, also considering the consequences in terms of user interface (e.g.: 'what do you want to use SQAPP for?').

> The SQAPP is intended to be useful for a variety of users and has been designed in such a way that it does not put off those seeking simple usage, while catering for those seeking a more in-depth assessment. Whether the current design works for stakeholders is going to be assessed in iterative testing and evaluation phases of the SQAPP with stakeholders. An initial assessment of stakeholder expectations was made in Milestone report 5.1 and mostly pointed to the need to couple soil quality assessment to management advice. Stakeholders' wishes with regard to SQAPP functionality will be continually inventoried during the interactive testing phase.

The objective of integrating different methods and tools within SQAPP is unclear, especially regarding to modelling. Which models will be used? How are they going to be integrated in SQAPP? It does not seem that partners have so far duly considered this.

> The input for SQAPP concerns basically spatial soil information and indicator data, and soil management information from the user. Cumulative probability density functions of indicator values are calculated for each pedo-climatic zone. Local values of soil property indicators are assessed based on relative frequency (low, medium, high). For soil threat indicators reference values were established based on the work in WP6.

Another important think would be to apply some methods related to uncertainty analysis because quality of the various data used in SQAPP is expected to be highly variable.

> The idea of including uncertainty analysis is good. The approach has been to develop cumulative probability density functions of soil quality indicators within pedo-climatic zones. This gives a good initial estimate of variability. With additional site indication and management information, the confidence interval of indicator values should be narrowed down and can in principle be given.

Task 4.1: From Figure 15 it seems that all these operations could be done from the desk, but SQAPP is meant to be used on-field. What are the actual data that must be recorded on-field to justify that? How? Is the use of sensors foreseen? If so, which ones and for which purpose?

> Indeed, the app can be used from behind a desk. The first reason for an on-field assessment is the indication of location. The global data can be taken for granted, but if the user wants to update these with lab results or field assessment, that will be possible. Options to provide user input and base the SQAPP recommendations on might be easier to do in the field. Follow-on questions about the site conditions to give higher confidence to soil data predicted for a specific location based on observable features in the field would warrant direct observation in the field. For further indicator info, visual soil quality assessment methods such as a spade diagnosis would certainly require information from the field, and links may be provided to guidelines on how to conduct these. Detaills will be defined gradually and iteratively during the app development and testing phase. Sensors

are not foreseen within iSQAPER but could be a useful addition to SQAPP in the longer term.

Soil characteristics may change abruptly at a very small scale (e.g. on reclaimed land). Are the soil maps and other relevant data able to tackle these cases? If not, it is very important to clearly and honestly declare under which situations SQAPP can or cannot work.

The global soil data are given as a first estimate. As indicated before, some of the uncertainty may be tackled with additional user input to refine predictions. In any case, user input of better data is always possible to get more tailored recommendations. User feedback can provide information on where estimates are considered by the user to be unrealistic or unreliable.

Task 4.2: It is unclear what is the implementation status of SQAPP. This is important to know because the first release is expected next month (M24).

At the moment of the review meeting, the SQAPP was purely conceptual. Now a beta-version has been released (Milestone 4.1).

The impression is that so far there is no clear distinction between synthetic indicators and analytical indicators that are meant to match the simpler and more advanced use of SQAPP respectively.

Indeed, the choice of indicators to be used as a minimum dataset, for modular extensions, and specific interests of the user is not yet finalised and will be part of WP3 and WP5. Also, from a data-perspective, WP4 may not always be able to predict specific indicators. In the current beta-version of SQAPP emphasis has been put on those soil indicators for which spatial information is available. In the final version, a decision tree approach may be built in where simple indicative indicators can inform the need or suggestion to use other more specific (types of) indicators.

WP5

It is said that 'associating changes in soil quality with agricultural management practices is a challenge due to slow responsiveness of soil characteristics'. This is not necessarily true in all cases. For example, incorporation of green manure temporarily increases SOM and available N (if legumes) of upper soil layers to a large extent. The important thing is to pick up indicators (and associated optimum measurement conditions) that actually reflect more stable changes in soil quality.

The list of indicators include such indicators that do not change quickly or vary across season, such as soil colour (under dry conditions), soil aggregates (slacking test), susceptibility to water and wind erosion over the long term (information taken from farmers), existence of ploughing pan (visible in soil profile), etc. This list of indicators will also be improved based on the WP3 review of LTE, specifically taking into account this issue of indicator stability over time. To capture seasonal variation in certain indicators (especially for certain soil conditions), these will be assessed and repeated several times per season (e.g. in the case of fluvisol in Slovenia).

Table 9 (deliverables and milestones): it is suggested to anticipate D5.3 (Stakeholder feedback ready for SQAPP improvement), e.g. in the form of a milestone like '*ex ante* inventory of actual and potentially innovative practices'. This would be more in line with what described in the following paragraph of the 18-month report.

We might not clearly understand this comment, but would suggest to rather consider M5.2 as an '*ex ante* inventory of actual and potentially innovative practices'. M5.3 is testing the SQAPP together with stakeholders in order to get their feedback for further improvement of the App (regarding its architecture, design, usefulness, etc). This is not related to the selection of innovative agricultural management practices. See also the explanations under 'deviations': Task 5.3 (which corresponds to M5.2) has been changed into a multi-stakeholder process of evaluation of AMP *after* the field testing (rather than a selection process).

A brief description of WOCAT methods would help clarify the intended approach.

See also details described under Task 5.2: The aim of using the WOCAT method is to document and evaluate 3-5 of the practices per case study site with their details (see www.wocat.net/en/methods/slm-technologies-approaches.html). The WOCAT questionnaire addresses the specifications of the practice (purpose, classification, design and costs) and the natural and human environment where it is used. It also includes an analysis of the benefits, advantages and disadvantages, economic impacts and acceptance and adoption of the technology. Impacts are approximated through simple scoring by experts, but supplemented with data where available.

Task 5.1: It is said that the multi-stakeholder testing of SQAPP 'will be done in a systematic way, using standardized protocols to identify data quality as well as benefits and disadvantages of different aspects and features of the tool': more details are needed to fully appraise the intended approach.

The idea is now that stakeholders will provide feedback on the beta version of the SQAPP and then respond to a standard set of questions regarding the architecture, applicability, usefulness, design, user-friendliness, quality of the data provided by the app, whether it meets their needs, etc. Although standardized, the protocol will allow the stakeholders to provide their ideas, suggestions and general comments in a participatory manner and in interaction with to the local study site researchers. The questionnaire for the user feedback is currently being elaborated.

The criteria used for selecting the first-level stakeholders in the snowball sampling approach should be better explained because they are critical for the remaining part of the stakeholders engagement exercise. More details on how this initial step has been carried out are required.

Because the loop of identifying new stakeholders is repeated until the overlap between already interviewed stakeholders and new suggestions increases significantly, it is not relevant with which 'sample' the snowball started. The aim of the stakeholder identification process was to identify all types of potentially relevant stakeholders for each case study. Depending on the different tasks of the project, a subset of these is considered, such as the farmers for the soil quality assessment in the field. In a next stage, all stakeholders will be involved again, such as for the evaluation and testing of the SQAPP.

Table 10 shows that a very good variety of stakeholders were included but only 17% of them are women: this gender unbalance should be addressed and corrected. Partner 21 (COREPAGE), which has been selected just because of this type of expertise, is expected to take the lead on this.

Realizing that there are more male stakeholders in this agriculture related project we will look per study site if more women have a stake in the project (i.e. affect or be affected by the project). Through in-depth interviews in different study sites, we want to gather more understanding of both genders' needs, roles, and attitudes concerning soil quality and we want to assess how we can have more women informed and involved in the project.

Open field vegetables, which scored third among the farming systems prioritized by the stakeholders, are not included in WP2 classification. This should be corrected.

As indicated before, this category has been included in a revised version of D2.2. It was already used in Milestone 6.1 too (termed 'flowers, vegetables and fruits').

From the survey it comes out that the information the stakeholders want to know from the project is mostly about soil improvement practices: this must be duly taken into account for the development of SQAPP and of the whole project.

This is certainly being done – see also responses under WP4.

Task 5.2: Regarding the criteria used for selecting the fields (farms?) included in the inventory of case study sites, it is said that 'comparing the soil quality status with farmers' interviews about their historical changes in management will help to identify those management practices which have improved soil quality'. It would be important to consider also the opposite approach: identifying the factors (management, socio-economical, etc.) which have determined the actual or perceived reduction in soil quality.

There have been many research projects in the past focusing on soil degradation and their drivers, while iSQAPER considers it important to focus on the possibilities to maintain or improve soil quality through different management practices (new and innovative ones, but also existing and already practiced ones).

'For the soil quality and agricultural management practices inventory at case study sites a manual was developed in order to standardize and facilitate the task': some details on its content are required.

The aim of the manual was to give simple, rapid and clear advice how to use the soil quality assessment questionnaire. For each indicator, a short introduction, the way of assessing and of scoring is given. A manual and the questionnaire have been developed as project guidelines (report).

Who selected the agricultural management practices (AMPs) for the different case studies? Partners or stakeholders? Actually, it is said that innovative and promising AMPs were identified in a transdisciplinary approach but it is not said by whom. The most identified innovative AMPs in

Europe that were picked up are: manuring & composting, min-till and crop rotation. In China the most identified AMPs were: manuring & composting, residue maintenance/mulching and no-till. Although the concept of innovation is context-dependent, it is hard to call them innovative from an agronomic viewpoint.

The info included in Table 11 is just a list of Best Management Practices based on good agronomy principles. Whether or not they represent potential innovations strictly depends on local context. A potential innovation at one site may be a standard practice at another site. This is why the info on this table is only relevant if contextualised to case study areas. Who compiled the list of impacts & benefits? Partners or stakeholders? Some of the statements included in this table are questionable: e.g. stating that no-till improves disease and weed suppression is highly questionable.

> Due to the corrections that had to be taken regarding Task 5.3 as explained under 'deviation' in the 18-month report, the list of innovative AMPs was established without involving the stakeholders. The selection of the 3 AMP per study site was done by the study site partners in collaboration with selected farmers that were contacted during the stakeholder identification process. Some study sites already have a long collaboration with their farmers from before iSQAPER.
>
> Regarding the selection of innovative AMP (M5.2) a large list with a variety of AMP was given to the study sites for them to select. This list was based on the vast experience of WOCAT, including the knowledge of any variety and innovation found across the world regarding land management practices, in order to trigger a broader thinking of options than the ones usually found in Europe and China. We therefore agree that the innovative character is only true if contextualized to the case study area. The impacts and benefits were included by the lead partner of WP5, based on long-term experience and WOCAT. As the list is a categorization of AMPs, there is some generalization done, which also affects impacts and benefits. The real impacts and benefits are always site-specific and will be measured at the case studies.
>
> However, we acknowledge that the initial selection done by the study sites was not reflecting new and innovative practices. We therefore identified and included new options for them to add, as well as made an inventory with local stakeholders for their ideas on innovative (i.e. promising) practices., e.g. by choosing a combination of different AMPs (See progress report WP5). The issue of innovation has truly ben taken into consideration (see also the discussion about the definition of innovation below under WP6).

It is said that compiling this info '… requires a team of land management specialists – including land users – with different backgrounds and experience, who are familiar with the details of the AMP (technical, financial, socio-economic)'. To be more effective, it also requires clear engagement of stakeholders with an active role, not just as recipients of the questionnaires.

> Study sites were asked to engage with stakeholders for completing the WOCAT questionnaire in a discussion about perceived and measured impacts where possible/available. In order to more effectively engage with stakeholders, this means that the information obtained for the relevant questions should be based on a mutual understanding from a discussion with land users, rather than simply interviewing them. This process is also being followed for the second version of the soil quality assessment inventory (Task 5.2).

WP6

It is not clear what is the concept of 'innovation' in the context of iSQAPER. In economic terms, innovation is considered to be *the process of translating an idea or invention into a good or service that creates value* or for which customers will pay. *Innovation helps create new methods for alliance creation, joint venturing*, etc. (www.businessdictionary.com). Partners are required to specify what is their notion of 'value' in the context of iSQAPER and whether they are aiming at evolutionary innovation, revolutionary innovation or both.

In WP6 Agricultural management practices (AMP) are selected to evaluate the corresponding effect on soil quality. While using this selection of AMP's and its effects in situ to develop and calibrate the Soil Quality Indicator, it is also important to select AMP's that are **expected to improve soil quality**. This becomes crucial in order to recommend alternative AMP's to farmers when soil quality is decreasing in soils where conventional practices are in use.

As such, the innovation in WP6 relates to the soil quality assessment of management practices that are *promising*. The main emphasis is not in the development and testing of completely new or 'revolutionary' AMP's (although in some specific cases it will be worthwhile to test specifically new AMP's and its effects on soil quality), but instead on the building of knowledge regarding effects on soil quality under local pedoclimatic zones of known but not mainstream AMP's that have shown potentially beneficial impact elsewhere. Yet, the soil quality impact assessment of these selected promising AMP's using an integrative soil quality indicator must be considered an innovative approach with high added value for scientist and farmers.

Partners should consider the opportunity to develop a participatory Decision Support System based e.g. on the DEXi open access platform, which is becoming of widespread use for many issues related to agricultural sustainability.

WP6 will consider the use of DEXi in operationalising the soil quality index.

The role of biochar experiments on lysimeters (to be carried out by partner 15, IPC), which are said to contribute to documenting the performance of AMPs, are unknown also to project partners. Since this part has no relationship with the rest of iSQAPER activities, it must be deleted from the workplan. Accordingly, no budget claims for these experiments could be justified.

The reviewers possibly overlooked that one of the long-term experiments that is being analysed by iSQAPER's WP3 precisely involves the application of biochar (and compost and a mixture of both) in a vineyard, as the referred lysimeter experiment is a complementary experiment that addresses the possible role of biochar in erosion reduction (which is still largely unknown). The lysimeters were actually built in a previous project; they are about 2m^2, set in a slope, and function as a plot, with apparatus for splash, erosion and overland flow, and throughflow. It is also possible to insert probes inside the soil to monitor several parameters.

Task 6.2: 'At all sites, independent of pedo-climatic conditions and farming system, the same set of key parameters will be observed': The need to identify a minimum set of common parameters is understandable but whether or not a parameter is 'key' depends on local conditions at the case study sites. Will there be a weighting procedure to reflect this?

The weighting procedure to assess key parameters/indicators in specific locations will take into account farmers' specific concerns. Local conditions in each case study site, as well as specific soil threats encountered in each location will be used for the soil quality indicator.

Task 6.3: 'Environmental resilience will be assessed based on the study indicators assessing natural capital (soil, water, climate, and vegetation)', but it is not clear how.

It is was not yet addressed at the time of the review meeting, but the methodology on assessing environmental resilience is reported under the progress report or Task 6.3. This assessment is implicitly integrated in the selection of the parameters to be used for the establishment of the composed soil quality index.

WP7

Although this WP has not yet started, the partners are asked to explain how tasks 7.1 and 7.2 are going to differentiate from ongoing similar activities in other WPs.

Task 7.1 focuses on defining typical combinations of farming systems and agricultural practices and their effects on soil quality. Key in this task is to identify the management options available/applicable in the most important farming systems. Task 7.2 focuses on identifying the key management practices affecting soil quality and their applicability in various farming systems. This task builds on WP5 work, but also considers the wider applicability of AMPs.

WP8

Is the farm level the best to address policy issues related to e.g. climate change or ecosystem services? Aren't any measures at the agricultural system, regional or water catchment level needed? How does it comply with governance rules (e.g. bodies responsible for CAP application) set forth in different member states?

WP8 indeed has a wider system level focus. It considers 'a range of insights, specific data and documentation of the experience of multiple stakeholders in different parts of Europe and China, and other information, which will potentially be applicable in different policy settings at different scales'. It will also specifically look at options to bring soil quality considerations into specific policies for greening under CAP pillars 1 and 2.

Also, choice of the most appropriate scale is highly relevant when addressing ecosystem services. One important issue would be to define what is the most relevant territorial level for the implementation of improved policies. For example, is the NUTS concept going to be utilised in iSQAPER?

> The analysis will take into consideration the different levels of governance ie. International, EU, national, regional. It will also take into account the different levels spatial spheres at which action can be required taking identifying where policies impact on management practices at a field scale, farm scale, catchment or landscape scale or based on administrative boundaries. It is appreciated that the spatial impact and application of policy is critically important for soil protection given the heterogeneous nature of soils and the different management practices that suit different soil types. The point regarding the relationship between scale and ecosystem service provision is noted and space will be given to administrative approaches and how to deliver improved soil policy. This emphasis is reflected in the scoping analysis completed for Deliverable 8.1 and will be examined in materials and briefings produced later in the project as well to feed into Deliverable 8.4 regarding the projects conclusions and the upscaling work under WP7.

Will farmers unions be engaged in policy improvement activities? When and how?

> Yes we are engaging with them, particularly at the level of study sites, regarding their position on the protection of soils and the types of measures they consider to be workable and important that contribute to soil protection. In particular it will be important to engage with them about how specific management practices (really the focus of ISQAPER) can be supported and promoted and how the spatial question of where the best apply can best be addressed with farmers ie. How can messages about applying management practices and deciding on the most appropriate management practices be communicated. This can either be done as some form of survey or in combination with potential policy case studies looking at policy development in different MS and regions.

Which factors (e.g. related to farm structure) will be taken into account for the calibration of policy measures?

> This point seems less relevant to the analysis, the emphasis of the project is more related to management practices and how policy can promote uptake. We are not seeking to model policy adoption etc. However, this question will be explored with WP7 in relation to upscaling messages.

Explanation are needed for scoping meetings. Provide details on content and attendance. What would be the goal and content of the training sessions?

> Two scoping meetings were held in relation to WP8. Soil protection and policy to protect soils stem from a wide range of policy fields. The first scoping meeting was held with IEEP's experts who are respected experts in the fields of agricultural policy (Kaley Hart, Clunie Keenleyside, David Baldock), delivery of public goods and ecosystem services through

agricultural management (Ben Allen, Anne Marechal, Graham Tucker), water protection and the role of soils/nutrient management activities (Andrew Farmer), Climate policies and the role of agriculture (Martin Nesbit), experts on soil protection policies in Europe (Catherine Bowyer, Silvia Nanni). The first meeting consisted of: examining and mapping the policy areas of particular importance to the protection of soils in the EU; identification policy narratives and themes of key importance up to 2020 to inform the relevance and decisions regarding focusing on different aspects under WP8; to identify known examples of studies, policies or other work that examines these issues and ensure linkages were made with in particular work on ecosystem services and water protection.

The second WP8 scoping meeting was a workshop with partners involved or related to the work package organised in collaboration with BothEnds in Amsterdam. This consisted of representatives from BothEnds (Karin van Boxel, Paul Wolverkamp), IEEP (Catherine Bowyer, Silvia Nanni), Wageningen (Luuk Fleskens) and from the WP5 team from the project (Heleen Clarringbould). In addition scoping discussions were held with WP7 and WP9 leads but for personal reasons they were unable to attend the scoping meeting itself. The scoping meeting consisted of examining the role of policy within the wider context of the ISQAPER project. WP8 interrelates with many of the other work packages and at the kick off meeting of the project it was identified that the policy work packages was particularly important in making links. This meeting set out a list of points to emphasis within WP* relevant to the wider project and the priorities identified by different partners.

Training is highlighted as an important element of delivery under H2020. Training is being used as a tool within WP8 to ensure that all project partners are aware of the core policy issues of importance in the context of ISQAPER and how these policies are anticipated to evolve over the project's duration. This is both capacity building to an important set of researchers active in soil protection and specifically up skilling the project team to facilitate the consideration of common policy issues and themes across the workpackages.

As the project progresses the intention is to host webinars/training events that continue to reflect on key themes and questions for consortium members. This would build on the policy briefings produced. In addition it is proposed to host open webinars that could be attended by externals linking up with key groups of policy actors such as farmers unions, organic associations etc to examine issues emerging from the policy briefs. The first such session is planned for the winter of 2017. This would link into world soil day in early December and also be timely in relation to both the CAP and debate around the future climate package ongoing in the Council and the Parliament.

Two training sessions were hosted focusing on the CAP:

- the first focused on explaining the CAP ie what it is, what it covers, why it operates in the way it does, how the policies are structured etc, this first session was run as a webinar open to all participants in ISQAPER including students and experts at all participating universities;

- the second was a face to face session where more active discussions took place focusing in on the role of policy in promoting action on soils and specially the tools and support mechanisms available under the CAP relevant to soil protection.

A third training session was held in Autumn 2016 examining the concept of land degradation neutrality. This session was intended to offer a platform for discussing the evolution of LDN and ensuring that ISQAPER takes account of emerging thinking that will drive international priorities into the future.

Whom policy briefs will be aimed to?

The text of the policy briefs has been presented in D8.1 as a package. These will then be developed into designed, stand alone information documents. These briefs will be 10-15 pages in length and three of them have already been prepared. They are intended for a wide audience of experts who for example may be interested in agriculture and agricultural production but are less expert in specific soil needs, requirements and rules relevant to this sphere of work. This would include academics interested in ensuring that their work relates to policy needs, the policy community at large is NGOs, private sector actors, regional and national civil servants trying to understand soil's role and the nature of soil protection and the evolution in the debate on going. These longer briefs are not aimed at politician's per se but at the wider community of experts active in the policy debate to improve understand and expertise regarding the state of policy, policy successes, policy opportunities.

To engage with policy makers more directly and potentially political activists in this arena based on the policy briefings up to 2 page summaries of key points to note will be developed where relevant. These will communicate more succinctly the messages for this subtlety different audience.

The briefings in D8.1 are essentially the building blocks of information sharing and communication that can be tailored to different audiences. It is felt important to retain depth of knowledge in these longer briefing forms, followed by shorter communication based documents due to the varied nature of the debate on soils. At present there are discussions ongoing on the role of soil protection in the context of CAP implementation, CAP reform, Climate mitigation, Climate adaptation, the role of biomass for delivering carbon neutral energy sources, the role of land and the services it should supply to society. To name a few. These are important debates but experience has shown that soil is so multifaceted few understand the issues in a coherent way. Moreover, different interest groups approach the debate in differing ways. There are few independent materials on the question of policy for soil protection that go into detail on the role of policy, the scope and extent. This is meaning that potentially divergent discussions are occurring in different policy fora and the question of soil health as a holistic concept is risks being poorly taken into consideration.

Task 8.1: How far will the alignment and nonalignment among different policy domains (e.g. agriculture, environment, urban/territorial planning) in the different regions be taken into account? Findings from previous EU-funded projects (e.g. FP7 RUFUS) may be a source of inspiration for iSQAPER.

> The scoping of policies has been based on the widest possible interpretation of policy relevant to soil protection on agricultural land this will take into account policies linked to spatial planning etc, fertilisers, plant protection products, waste etc and agriculture focused policies. The aim was indeed to understand how policies from different spheres operate to deliver soil protection, or conversely the issues that arise. The information from RUFUS will be reviewed and the suggestion of making linkages is appreciated. The interaction of different policy priorities is important as soil can be influenced by activities in multiple spheres with variable outcomes for the holistic picture of soil health.

WP9

The objective of WP9 is to coordinate and facilitate contact and communication with the different groups of actors and target audiences, the potential users of SQAPP and the wider public. It is not fully clear how this is going to be achieved. Who will take care of the translations from English into local languages?

> Any material that is provided in local languages will be translated by the project partners as and when it is needed for each task. This has already been done for the project leaflet.

It is said that 'a variety of media' will be used to meet the dissemination & communication objectives but it is unclear whether or not the use of social media or blogs will be an important part of it. No mention is done on specialised social media that are widely used to popularise research projects, e.g. LinkedIn, Research Gate, or a dedicated YouTube channel. iSQAPER has a Twitter account (@iSQAPER) activated in June 2015. As to 6 February 2017 (i.e. 20 months later), it has produced 11 tweets, has 20 followers and 0 likes: this is a very poor performance. An Horizon 2020 project on similar themes started on March 2016 has a Twitter account which to date has released 192 tweets, has 406 followers and 107 likes.

> The reviewers are correct that we had not yet made widespread use of social media in the first reporting period. However, we developed a plan to increase the number and type of platforms we use and on a strategy and schedule for providing them with suitable posts, and have in the second reporting period significantly improved on this aspect – see the updated PEDR.

Task 9.2: What would be the topic of the 'partners training event'?

> This was left deliberately vague in the proposal because it was unclear what capacity building would be necessary. The training event took place at the Plenary Meeting in September 2017 and focus on a workshop on how to make short video clips for use on the project websites and social media platforms.

Task 9.3: is iSQAPERis meant for internal use or also for external use? In the latter case, seeing a lot of empty pages/sections (like it is now) could drive people away from the site rather than attracting it.

iSQAPERiS is intended for external use and (eventually) full public access. It is to be the main long-term repository of the project's findings and conclusions. Although the preliminary structure is in place, the reviewer is correct that it did not have any content yet. This is because, in the first instance, the content will be derived from the completed project deliverables. Work on extracting information from deliverables is proceeding on a gradual basis.

The ultimate solution to the reviewer's concern about people being deterred from an empty site would simply be to take it offline until a significant amount of content has been added. Instead, we included a clearer disclaimer about the website's purpose and temporal development, and refer the interested user to the project website which focuses more on the currently ongoing research.

The intention is that 'the content is organised hierarchically, with the degree complexity of information increasing with each level': this is not quite evident so far.

The intention is to provide, for each deliverable

- A short video clip in which the authors explain their main findings
- A summary abstract, or infographic illustrating the 3 or 4 key findings
- EIP-type practice abstracts for each key finding
- An 2 or 3 page executive summary.
- Access to the full deliverable.

The intention is that this mix of video, visual and text based material will meet the information needs of a wide range of user types. As well as being put in iSQAPERiS it will also be posted on the various social media platforms.

It would be good to summarise the information generated by the project in the form of practice abstracts as to the EIP requirements.

Thank you for that suggestion, we will follow it up.

The main project website is rather confused. First, the graphic is not very appealing. Second, there is too much (small) text which has often been copied and pasted from the proposal text. Third, there is a mixture of open and reserved info (often in lengthy lists) without clear distinctions between these parts: when one accesses the site as external user finding a lot of 'denied access' notifications is quite annoying and increases the risk of not coming back.

Thanks for this critical but genuine remark. We are taking the feedback at heart and have made an effort to develop more appealing graphics and content, and cater for the needs of external users. As part of the strategy we transferred the more general posts that were envisaged to be provided on iSQAPERiS at first to be placed on the project website initially in order to make it into the kind of soil quality portal that the reviewer suggests below. Anything that is not time-dependent could be transferred to iSQAPERiS towards the end of the project.

Impact

The work carried out has potential to turn into significant impact. Whether or this potential impact will become actual would largely depend on the next 1-2 years of the project.

SQAPP – the key deliverable of iSQAPER – is expected to be cost effective. From which perspective? Of the developers or of the users?

SQAPP will need to be cost-effective for the users in order to have a future, so that is the main focus. However, for other users such as scientists and policy makers, it may also be a cost-effective way of reaching target audiences (app users) with specific recommendations and policy information.

Gender balance

In the workplan, the gender issue is duly taken into account, as there is a partner which has been involved just for this type of expertise. There is a good gender balance within partners (females participating in the project are 76 out of 171 individuals, i.e. 44%) but the composition of stakeholders groups is highly skewed towards males (83%). This needs to be corrected wherever feasible.

> Yes, this is explained by the partners in the Gender Equality report-period 1, page 9. Approach issued here on page 9 of the review report.

As to the gender report (PR_QUESTIONNAIRE_1.pdf, p.6), the responsible partner is asked to apply this partitioning analysis also to the stakeholder groups engaged in iSQAPER, breaking down these data by country.

This comment will be taken up in the stakeholder feedback questionnaire on SQAPP.

Only one publication has been produced so far (http://europepmc.org/articles/PMC4772185). EU funding is acknowledged as 'This work was supported by the European Commission Programme Horizon 2020 project (635750)'

Dissemination

The dissemination plan is theoretically good but the related tools and activities should be definitely improved.

The planned generation of information from the deliverables on iSQAPERiS. together with improved dissemination through social media, in combination with the various WP tasks (workshops, interviews, field trials etc) taking place in the study sites should help the dissemination plan reach its potential.

So far there is not much to communicate in terms of results but the tools envisaged as to this should be improved. Effective communication on project concepts, methods, approaches and target themes is expected in due time since this can start well before actual project results are available. This could also help populate iSQAPERis and make it a kind of portal on soil quality, including also links to relevant resources like reports, websites, etc. selected by project partners. The project would greatly benefit from such an action in terms of increased contacts and international recognition.

> As stated before the project strategy towards communication channels and messages has been reviewed in response to the reviewers' comments. This suggestion will be followed on both iSQAPERiS and the project website.

The 'Funding' menu in the iSQAPER website acknowledges EU funding for this project ('The project is funded by the European Union's Horizon 2020 Programme for research and innovation').

During this reporting period a first version of the PEDR has been prepared and submitted as D9.2. The PEDR is expected to be updated regularly during the implementation of the project. It is still too early to ascertain whether or not it has been appropriately executed.

As to the type of audience reached in the context of all dissemination & communication activities (PR_QUESTIONNAIRE_1.pdf, p.2) the criteria used for estimating the number of persons reached need to be clarified.

> We will include an estimate of the number of persons reached on the Record of Dissemination part of the PEDR for each study site and work package. The aggregate numbers of these activities will then inform the questionnaire questions for reporting period 2.

As to the Impact on SMEs (PR_QUESTIONNAIRE_1.pdf, p.5), it is not clear who is Claringbould Heleen Elsa, what are her main fields of activities and how iSQAPER results are expected to impact them.
Claringbould Heleen Elsa is the EU identity in name of SME Corepage with as main fields of activity: gender equality, diversity and inclusion and stakeholder participation, awareness raising, monitoring, reporting and communicating through website, presenting and joining at project meetings and articles especially in environmental subjects. iSQAPER results may lead to better understanding (by the project and COREPAGE) of gendered needs in agriculture in the different involved cultures and may lead to modern ways to keep gender equality on track with new sustainable land management approaches and techniques. And the other way around, to help the sustainable land management developments with the diversity results that comes from insights from the gender needs interviews and assessments.

The first full version of the DMP has been delivered at the end of the reporting period (D1.2), and contains guidance on how to develop FAIR data management details for datasets when they are being prepared. According to this report (No. 08), the DMP will also be covered as one of the chapters in the PEDR (Brandt et al., 2016 – D9.2) which places data management in a broader context of dissemination. Formal updates of the iSQAPER DMP will be made on a regular basis at each periodic reporting when it concerns adding details about datasets.

The DMP plan is good but would need to be tested against results of the oncoming activities.

Resources

Overall, resource spending is in line with the activities, but some explanations are needed:

Partner 1: in the periodic report (WP9) it is said that the idea of the film will be discussed at a later stage. So what was this money spent for?

> The periodic report is not very clear on this point. Activities related to film making and shooting of film segments have in fact started from the beginning of the project. What still remains to be discussed is the actual narrative that will be told throughout the movie. Details about what the money was spent for were already provided through ECAS.

Partner 5: please explain what is the 'itinerary bulletim' fur which cost reimbursement is claimed.

> 'Itinerary bulletin' usually refers to expenses incurred with travel and accommodation/daily allowances by the project staff. Besides project meetings it also was used for:
>
> - The participation at the International Conference 'Conservation Agriculture and Sustainable Land Use' in Hungary was considered an excellent opportunity to inform the scientific community about the work that is being developed in iSQAPER in general and, with special focus, of WP6.
> - Covering partially the participation at the 'end of project conference' of the SmartSoil project (which took place after another meeting in Luxembourg), as this project and its results do have a strong interaction with the work to be developed in WP6 of the iSQAPER project.

Partner 9: please explain what kind of 'other goods and services' have been used as to 'long-term experimental data compiling'.

> Allowance for the student helping the project, data-compiling, literature research + good-buy drinks

Partner 11: please explain what kind of 'other goods and services' have been used as to 'agrotechnical services at the study site' and 'materials'.

- AGROTECHNICAL SERVICES AT THE STUDY SITE IN TRZEBIESZÓW AND determination of the spatial distribution of the yield of plants on the experimental field were done twice that is in growing seasons 2016 (for maize). The agrotechnical services consisted of: tillage, crop protection and harvesting operations.
- AGROTECHNICAL SERVICES AT THE STUDY SITE IN TRZEBIESZÓW AND determination of the spatial distribution of the yield of plants on the experimental field were done twice that is in growing seasons 2015 (for triticale). The agrotechnical services

consisted of: tillage, crop protection and harvesting operations

Partner 15: the Biochar experiment is unrelated to this project therefore no related costs can be claimed.

The reviewers possibly overlooked that one of the long-term experiments that is being analysed by iSQAPER's WP3 precisely involves the application of biochar (and compost and a mixture of both) in a vineyard, as the referred lysimeter experiment is a complementary experiment that addresses the possible role of biochar in erosion reduction (which is still largely unknown). The lysimeters were actually built in a previous project; they are about 2m2, set in a slope, and function as a plot, with apparatus for splash, erosion and overland flow, and throughflow. It is also possible to insert probes inside the soil to monitor several parameters.

Partner 23: there are several costs on mobile phone devices and services for which reimbursement is claimed. Are they justified? Should not they be included in the overheads?

- cost of mobile phone Xiaomi Redmi for SQAPP testing, Tamás Kismányoky (professor emeritus)
- cost of mobile phone Lenovo for SQAPP testing, Brigitta Tóth (assistant professor)
- mobile phone subscription of Brigitta Tóth (assistant professor), Tamás Kismányoky (professor emeritus), Tamás Hermann (assistant lecturer)
- cost of mobile phone Xiaomi Redmi for SQAPP testing, Tamás Hermann (assistant lecturer)

5. Deviations from Annex 1

5.1 Tasks

Work Package 5

D5.1 (Report on stakeholder feedback to soil quality assessment tool, Month 32) and M5.3 (Stakeholder feedback ready for SQAPP improvement, Month 28) have not yet been accomplished because the approach in WP4 focused on internal feedback first to tackle the major issues with the pilot version of the app before asking stakeholder feedback (to avoid negative user opinion risking a decline in stakeholder interest in the app while it is still in a premature stage). We are now designing the feedback questionnaire, soliciting user feedback on the beta-version of the app rather than the pilot version as originally planned.

Work Package 6

Task 6.3

The definite selection of the demonstration sites is still pending as it will be based on the soil quality assessment carried out for WP6 during spring/summer 2018. As the demonstration events will be performed only in 2019, this small delay in the final definition of the demonstration sites is of minor relevance. In any case, all testing sites were declared by case study site (CSS) leaders as potential demonstration sites, but depending on the means available only one of the testing sites per CSS will be selected for demonstration events.

Case study site 13 (Zhifanggou, China) has been removed from the list of study sites where agricultural management practices are being tested. The study site coordinator (ISWC) could not identify relevant matched pairs of observation sites according to the criteria established as most farmers in the area apply very similar agricultural management practices.

Work Package 8

Task 8.1
To ensure the effective and timely consideration of policy needs throughout the project and a collaborative approach to policy understanding within iSQAPER, it was concluded that policy analysis activities under Work Package 8 would be spread across the entire project timeline. This was agreed in discussions with the core team and European Commission in Madrid at the first project review meeting for iSQAPER. This is intended to ensure that relevant policy issues are being reviewed and assessed as core legislation emerges and evolves. In particular, the EU's Common Agricultural Policy and climate policy specifically relating to agriculture in Europe are under review at present.

The consequence of this change has been more consistent analysis and tracking of policies throughout the project timeline so far.

5.2 Use of resources

Partner 1: WU

The role of partner 9 (ISRIC World Soil Information) in the development of SQAPP has been larger than initially planned, and has been accommodated by transferring budget from WU to ISRIC. So far, during the second reporting period, the additional staff input of ISRIC amounts to ca. 2 person months. In mutual agreement, further input to WP4 of ISRIC can be solicited at the reduction of personnel cost for WU.

Partner 5 (UE):

Only minor deviations from the foreseen P*M efforts were necessary, except WP5 and WP6. For WP6 additional time-consuming contacts and exchanges with the case study sites (CSS) were necessary to verify the information on the testing sites. Regarding WP5, more coordination work between WP5 and WP6 was necessary in order to elaborate the joint questionnaire for the soil quality (SQ) assessment for WPs 5 and 6 by the CSS, and also the guide for the SQ assessment for WP6.

	Planned person months in reporting period	Actual person months in reporting period
WP1	0.5	0.8
WP2	0	0
WP3	1	1.7
WP4	0	0
WP5	2	3.3
WP6	12	15
WP7	0	0
WP8	0	0
WP9	1	1.7

Partner 7 (IEEP):

The change is a consequence of the decision to extend the coverage of the policy work package across the full extent of the iSQAPER project. This was decided at the Madrid meeting along with iSQAPER WP leads and overseeing officials from the European Commission and the Review Panel. This has resulted in the WP8 efforts extending beyond and into more detail than originally anticipated post month 28 (the deadline set out in the proposal for Deliverable 8.1 on policy scoping). Despite the change in months worked IEEP input is still running in line with the original monetary budget as the nature of the ongoing review work means that more junior staff can be employed. Moreover the senior input on the project has been taken on by Clunie Keenleyside rather than IEEP's former Director David Baldock following his part retirement. We anticipate these changes will mean more time is needed overall to complete IEEP's commitments, but will remain within the total IEEP project budget.

	Planned person months in reporting period	Actual person months in reporting period
WP1		1.89
WP2		
WP3		
WP4		
WP5		
WP6		
WP7		
WP8	6	11
WP9		0.16

Partner 8 (MEDES):

Resources have been used according to the DoW and no major deviation occurred during the current reporting period. The table below reports details per WPs.

	Planned person months in reporting period[a]	Actual person months in reporting period
WP1	0,59	0,67
WP2	-	-
WP3	-	-
WP4	0,74	0,74
WP5	1,40	1,40
WP6	0,50	0,50
WP7	0	0
WP8	0	0
WP9	3,21	3,40

Partner 16 (UMH):

80% of Personnel resources assigned to UMH in iSQAPER Project have been consumed developing the activities required by the Project during the first and second period. It was necessary to develop more trials than initially foreseen. As examples, as you know in the 2nd Plenary meeting in Hungary it was decided to expand study plots to 12 + 12 for the Visual Soil Assessment (VSA) of WP5, and also our team were in charge to do Basal Soil Respiration for all partners for WP3, and now to complete WP5 and 6 the leaders ask to us to do in next months a new VSA including additional parameters for the same sites but also in this case do it in triplicate, also some additional parameters for WP6 in 2 sites and probably our team together with Estonian will have to do Microbial Biomass Carbon analyses for some other partners which are not familiarized with that. It is clear that initially we underestimated the quantity of work to do in our case study sites.

Accordingly, the initially planned personnel resources seem to be insufficient to cover both the work yet reported and the remaining activities planned until the end of the project. For this reason, we will need 12 PM more to complete the foreseen work by our group in the project during the remaining project time. It means to pass to 44 PM (6 PM more than initially foreseen). If necessary, we can pass budget from our other direct cost to personnel item without modifying UMH global budget in the project.

	Total PMs for UMH	Actual person months in 1st reporting period	Actual person months in 2nd reporting period
WP1	0	0	0,09
WP2	2	0,24	2,06
WP3	4	3,41	3,34
WP4	4	0,08	1,06
WP5	12	8,19	6,66
WP6	12	0,37	3,16
WP7	1	0,08	0,06
WP8	1	0,08	1,13
WP9	2	0,2	2,18

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